Gender, and other variables, affecting graduation outcomes and the future of science. Male vs. female students 1995-2003 Rochester Institute of Technology’s College of Science

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Male vs. Female students
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Rochester Institute of Technology’s
College of Science

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Abstract: This thesis focuses on the impact of retention of undergraduate students on the future of science. If there are insufficient numbers of science students pursuing and succeeding in Science, Technology, Engineering and Mathematics education and careers, it has been argued that the United States will lose its innovative, competitive, and technological edge. The focus is on the challenges of retaining students, both male and female, in the sciences at Rochester Institute of Technology from 1995-2003. This thesis will describe and analyze existing data in an effort to develop a case specific understanding of retention metrics, student retention dynamics, and consideration of possible strategies.
Dedication and Acknowledgements:

This thesis is dedicated to my husband, Patrick, and our daughters, Courtney and Taylor; my sources of support and inspiration throughout this journey.

It is also dedicated to my valued colleague and friend, Eileen Marron-Keating, for her constant encouragement and mentorship that I will value forever.

My immense gratitude and respect to Dr. James Myers and Dr. James Jacobs, my thesis advisors, for their wisdom, guidance, and esteemed advice.

Any errors or omissions in this thesis are my responsibility.
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Chapter 1: Introduction

“The mind is not sex-typed.”
Margaret Mead, Blackberry Winter (1972)

Background

The debate over the existence of a U. S. science crisis has been waged for quite some time, which, in this thesis, becomes entwined with the retention of students, specifically studying male and female students in science programs at Rochester Institute of Technology’s College of Science. Historically, when science crises are debated, the mention of how educational institutions must play a major role in providing solutions always follows. Furthermore, traditionally more men than women have pursued and succeeded in science education and careers. The future of education, science and innovation is dependent on the pursuit and success of both men and women.

More directly, Rochester Institute of Technology’s College of Science presents an opportunity to explore the challenge of retaining students, both male and female, in the sciences from 1995-2003. This thesis will describe and analyze existing data in an effort to develop a case specific understanding of retention metrics, student retention dynamics, and consideration of possible strategies.

In order for educational institutions, including RIT, to play a major role in providing solutions they must understand the intricate necessities that will retain students in undergraduate science programs. Various impact perspectives considered are test scores, number of students studying sciences, government funding for basic scientific research, global competition, and the increase in women and ethnic minority groups. In actuality the list is extensive. The conduit to
understanding retention issues does not begin when students enter college. Investigative studies will show this pathway to begin much sooner and must continue throughout their college careers and beyond. Awareness and understanding of the factors that affect retention of males and females in science majors will have an impact on educational administrators, as well as future employers, every student considering sciences locally and globally, and the U.S. economy. Kodrzycki, (2002), notes that “competent management of educational institutions by principals, superintendents, deans, and presidents is no longer sufficient. Just as in the corporate arena, bold leadership is necessary” (p. 295).

If there are insufficient numbers of science students pursuing and succeeding in Science, Technology, Engineering and Mathematics, also known as STEM, education and careers, it has been argued that the United States will lose its innovative, competitive, and technological edge. Business Wire, (May 2006), survey reveals that CEO’s of several top emergent science and technology companies are concerned about the reported deficit of scientists and engineers produced in America, the increase in competition for these professionals and the loss of America’s global leadership position in science and technology. The article revealed, “in addition, CEOs are concerned about this rising competition for scientific and technical workers and fear their company's international competitors, having access to this same talent, will gain a competitive advantage” (p. 1).

Retention experts acknowledge that there isn’t a one-size-fits-all answer for retaining students, let alone for retaining male and female students in the sciences. However, as eloquently explained by Tinto, (1993) a retention factor “that would work in all cases is having institutions assess the needs of each and every individual and treat those needs on a person-by-
person basis… that the institution exists to serve the needs of the individual, not the group” (p. 191).

**Purpose Statement**

The purpose of this thesis is to provide a comprehensive analysis of gender as a function of retention of male and female students enrolled in three of the biological science programs at Rochester Institute of Technology’s College of Science.

**Significance**

This research will increase the body of knowledge regarding gender impacts and retention in post-secondary institutions. As noted in Psychology of Women Quarterly (Steele, James & Barnett, 2002), undergraduate institutes enroll more freshman males than females in science and engineering programs. (National Center for Education Statistics, 1997). Females that do enroll as freshman in science and engineering programs are less likely to continue through their senior year. (National Science Foundation, 1999). The Quarterly report continues that in 1994 women received 46%, 34% and 16% of the math, science and engineering undergraduate degrees, respectively, and they earned even fewer doctoral degrees; 22% math, 22% science and 11% engineering. (National Center for Education Statistics, 1997). The Quarterly report also notes, “in short, women are leaving these male-dominated academic areas at a much faster rate than men” (p. 46).

Furthermore, the 2004 ACT Policy Report, The Role of Academic and Non-Academic Factors in Improving College Retention, explains that sustaining global competitiveness is reliant on a larger portion of college-age students having the opportunity to attend postsecondary institutions and completing their education in reasonable time. Considerable improvements have
been made in high school graduation rates; however, more progress is needed in retaining students in college.

**Limitations**

Limitations of this study include: other variables such as ethnicity, receipt of financial aid and student departure was voluntary were not considered. Gender was self reported. The study was based on Rochester Institute of Technology’s, specifically biological sciences, data. Therefore, the findings can not be applied to any other postsecondary institutions.

**Sciences**

Research has defined non-traditional sciences to include physics, mathematics and engineering, and traditional sciences to include biology, chemistry and allied/medical health; and with the evolution of the computer, expanded to include technology, earning the S.M.E.T. or S.T.E.M. acronym. The challenge this broad definition presents is in the multiple forms of science, mathematics, engineering and technology that exist at RIT and other educational venues. To correlate S.T.E.M. with programs at RIT alone; there are 6 science departments, 5 engineering departments and 4 technology departments housed in three different colleges.

Another challenge present is in studying the data of all the sciences in which male and female students enroll and earn an undergraduate degree. Conventionally, women have chosen traditional life sciences such as medical sciences or biology, and some ventured into chemistry (once known at RIT, in 1916, as Household Chemistry) and men have chosen traditional physical sciences such as chemistry, physics, and engineering.
Retention

Defining retention, also known as student persistence, is perhaps as complicated as solving any of its issues. However, it is important to understand some basic definitions. One definition of retention is the “ability of an institution to keep a student from acceptance to the university through graduation” (Seidman, 2005, pg. 7). Retention is also considered as “student attainment of their academic and/or personal goal(s)” (Seidman, 2005, pg. 296). The federal government’s definition of retention “involves tracking full-time, first-time students over a six-year period of time to see if they graduated in their chosen major at entry to college” (Seidman, 2005, pg. 297). The federal government’s standard for tracking time recently changed from five to six years. Retention can also refer to the percentage of entering students that complete their college degree programs within a six-year period. Rochester Institute of Technology defines retention a bit differently; it is the percentage of entering students, full-time and first-time, that complete their college degree programs within a seven-year period, due to RIT’s historical co-operative (also known as co-op) employment opportunities for students.
Chapter 2: Literature Review

Dr. Shirley Ann Jackson, President of Rensselaer Polytechnic Institute, and 2007 Vannevar Bush Award recipient, explains her reasoning behind the need of immediate action in her address at the 2004 AAAS meeting focused on the future of science and the nation. Dr. Jackson posits that the US will face a national crisis due to the deficiency in the number of necessary talent needed to insure a successful American scientific future. Scientists and engineers comprise a small portion of the national workforce that drives the economic well-being of America through their discoveries. Several of these same workers are close to retirement age. Parallel to this fact is the static or declining number of Americans enrolling and studying in the sciences. Traditionally this country relied on foreign scientists to fulfill workforce needs, however since 9/11, visa applications have declined and are more difficult to obtain. Since 9/11 there has also been a decline in foreign graduate student enrollment in the U.S. This dilemma continues with the fact that on average, it takes over 10 years to educate a scientist. There is a great deal to be done to replenish the scientific workforce, and it needs to be done immediately. (Bender, 2005)

American school children have not performed as well in the International Mathematics and Science Study programs as compared to children in other countries. The workforce that will be needed in the future to maintain, minimally, American scientific ability is not currently in the educational pipeline. Each year China produces 370,000 engineers and scientists. Only 5% of Americans receive bachelor’s degrees for engineering compared to 46% of engineering bachelor’s degrees earned by Chinese students. (Bender, 2005)
According to the College Board Review article, Waking up to the “Quiet Crisis” in the United States, Winter/Spring 2007 issue, institutions are primarily responsible for recruiting and educating the next generation of scientists and engineers, both nationally and abroad. Universities are vital in generating knowledge and innovation, creating opportunities that move discoveries from the classroom and research labs into the marketplace. Universities also produce innovative and globally competitive opportunities that frequently influence economic progress. If universities are to continue being the incubators for innovation three factors must be addressed.

The first factor is basic research funding. Although the United States continues to spend considerably more than any other nation on research, spending in the science fields, particularly mathematics, engineering, and computer science, has decreased progressively since 1970 as a percent of GDP. This continues in spite of the fact that other nations are increasing their research spending. For example, from 1995 to 2005 China doubled its research spending. Notwithstanding bipartisan support for promoting innovation there continues to be fewer federal resources available. Furthermore, President Bush’s proposed budget for fiscal year 2008 does include increases in research funding, especially in the physical sciences. The total budget for basic and applied research decreases by 2 percent from last year’s total due to certain gains that would more than offset cuts in other research funding areas. The American Association for the Advancement of Science, (AAAS), notes that after peaking in 2004 the federal research funding in real terms would decrease for the fourth consecutive year. The second factor to acknowledge is excellence in education. To sustain and advance the human society along with the economic society, universities are obligated to prepare each generation to add value to that society by creating knowledge and opportunities that launch innovation and discovery. At a time when
economic opportunity in a global marketplace is equal for all the participants, universities need to educate each generation of students with a focus on innovation. Students must learn fundamental concepts, immerse themselves in open-ended research and educational challenges, develop and exploit new ideas, and become technologically and culturally experienced students that can understand and solve complicated problems. These same students will need to live and work in a global world and will have the advantage of seeing connections between and within disciplines throughout an expansive intellectual real and virtual environment. It is also critical to increase the number of younger people in the K-12 STEM educational pipeline. The third factor to address is the underrepresentation of women and ethnic minority groups in STEM professions. If America is going to succeed in filling the predicted gap in STEM ability, it cannot ignore the 30 percent of the population they represent. (Jackson, 2007)

*Educational Pipeline*

When training current and future educators to teach science in American elementary schools, Abruscato (1995) noted:

“the image of the scientist held by the most people is a stereotype (of a male). . . If you really believe that all children should have an equal opportunity to receive the best possible education, you have an obligation to correct sex-role stereotyping. . . The persistence of these falsehoods (of sex-role stereotyping) injures our future because in discouraging some from careers in science and technology, we may lose great discoveries that will improve our lives.” (p. 9)
According to Diana Jean Schemo, a New York Times journalist, reporting in 2001 on test scores in reading, science and math among students in 32 industrialized nations; the results demonstrated that students in Canada, Finland and New Zealand lead the world in each category, with American student performance rated at merely average. The Organization for Economic Cooperation and Development administered the tests to 250,000 fifteen-year-olds utilizing questions concerning real-life conditions that assessed their math, science and reading skills. It was designed to measure students’ ability to function in the world as they approached the end of their elementary and secondary school years.

Schemo’s article states that in the reading exams that were nationally administered, and in earlier international tests in mathematics, performance of American students was mediocre at best. The results of the 28 O.E.C.D. member nations that took part in the testing, of which 4 participants were not members, pointed out that the United States performed radically better in science than only four other countries: Greece, Mexico, Luxembourg and Portugal. In math, the United States did considerably better than those four countries and Italy. (2001).

The commentary continued with Rod Paige, the United States education secretary, noting his frustration in the American student results. "In the global economy," Dr. Paige said, "these countries are our competitors. Average is not good enough for American kids." (Schemo, 2001, p. A25).

Schemo’s editorial reported an analysis of the reading test results by the Paris-based organization illustrated that American students performed in the top percentiles when compared
with those in the highest-performing countries. Unfortunately, a large number of American students scored in the lowest percentiles. The Organization for Economic Cooperation and Development’s deputy director for education, Barry McGaw, acknowledged that the U.S. can use the results to improve its standing within the O.E.C.D. and to design programs to assist their lowest performing students. He continued by emphasizing how the results of this report do not support the debate of whether schools could succeed in spite of issues in a child’s home. The results demonstrated that a country like Finland had succeeded in educating students with different backgrounds, such as instability or poor home conditions, unlike in the U.S. or Germany where these issues are considered barriers to student achievement. (Schemo, 2001).

The report also highlighted a variety of differences in performance by sex. In every nation, girls continued to academically outperform boys in reading. In half the participating countries, boys outperformed girls in math, whereas girls underperformed drastically in all O.E.C.D. countries. Boys outperformed girls in science in three of the countries, however girls in New Zealand outperformed boys there (Schemo, 2001).

**Gender Educational Differences in Higher Education**

Although it is important to note that representation among full-time younger students has increased for females and they tend to succeed in college degree completion, females represent over 60 percent of students with traits that create a disadvantage for them to succeed in postsecondary education. Specifically, examining the lowest 25 percent income bracket highlights startling results in that female students are 60 percent of the total; 62 percent of that total are 40 years of age or older; 62 percent of these females have dependents, and 69 percent
are categorized as single parents. All of these distinctions are linked with decreased rates of degree persistence and attainment in undergraduate education (e.g., Berkner, He, and Cataldi 2002) (Peter & Horn, 2006). “Sex bias begins as soon as women apply for admission to college. Women students receive 28 percent less in grants and 16 percent less in loans than do males.” (Susan L. Gabriel, et al. 1990, Introduction section, ¶ 3).

Figure A. Percentage of 25- to 29-year-olds with a bachelor's degree or higher, by gender: March 1980-2003

NOTE: The Current Population Survey (CPS) questions used to obtain educational attainment were changed in 1992. In 1994, the survey instrument for the CPS was changed and weights were adjusted. For more information, see http://www.bls.census.gov/cps.

According to the General Accounting Office Gender Equity report of 2000, Men’s and Women’s Participation in Higher Education, Report to the Ranking Minority Member, Subcommittee on Criminal Justice, Drug Policy and Human Resources, Committee on Government Reform, House of Representatives, the enrollment profile of colleges and universities included 1.5 million more females than male students in 1997. Participation of women in male dominated fields of study, including medicine and law, increased in the 1971-1972 school year. Despite a narrowing gap in fields such as computer science and engineering, women continue to be the minority. Historically, faculty hired in science and technology fields have been predominately male and these fields continue to be underrepresented by women.
Male enrollment in primarily female fields such as elementary education and nursing has increased, however male representation continues to be a small portion in the workforce. When both college costs and student’s financial means were analyzed, it was found that males and females were equally granted financial aid. (G.A.O., 2000).

The Department of Education predicted that women’s enrollment, by 2009, would rise to about 58 percent of the entire post-secondary enrollment. According to researchers, men are not as encouraged to attend college as women. They are often attracted instead, to jobs that on average pay considerably more than those that would be available to college age women. (G.A.O., 2000).

In addition, it was reported that the percentage of undergraduate degrees earned by women in engineering, physical science and computer science continues to be small, and yet women’s percentage of earned degrees in these same fields has increased dramatically since 1971. In 1996-97 women earned 17 percent of engineering degrees, an increase of 1 percent from the school year 1971-72. Additionally, women received double the physical science and computer science degrees over the same period, an increase from 15 to 37 percent and 14 to 27 percent correspondingly. (G.A.O., 2000).
Figure 1: Percentage of Degrees Awarded to Women in Predominantly Male Fields of Study, School Years 1971-72 and 1996-97

Percentage

<table>
<thead>
<tr>
<th>Field</th>
<th>1971-72</th>
<th>1996-97</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zoology</td>
<td>50</td>
<td>49</td>
</tr>
<tr>
<td>Business</td>
<td>44</td>
<td>44</td>
</tr>
<tr>
<td>Political Science</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>Law</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Medicine</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>Dentistry</td>
<td>15</td>
<td>14</td>
</tr>
<tr>
<td>Physical Science</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>Computer Science</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Engineering</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Note: Data shown are for first professional degrees for law, medicine, and dentistry and for bachelor degrees in the other fields of study. For data supporting this figure, see table 5 in app. III.

Table 5: Percentage of Degrees Awarded to Women in Predominantly Male Fields of Study, School Years 1971-72 and 1996-97

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Men</td>
<td>Women</td>
<td>Men</td>
<td>Women</td>
</tr>
<tr>
<td>Physical science</td>
<td>17,663</td>
<td>3,082</td>
<td>12,165</td>
<td>7,255</td>
</tr>
<tr>
<td>Computer science</td>
<td>2,941</td>
<td>461</td>
<td>18,041</td>
<td>6,731</td>
</tr>
<tr>
<td>Engineering</td>
<td>50,638</td>
<td>526</td>
<td>62,510</td>
<td>12,491</td>
</tr>
</tbody>
</table>

Note: We identified predominantly male fields as those in which, in school year 1971-72, (1) women represented fewer than 25 percent of degree recipients and (2) at least 5,000 bachelor or 1,000 first professional degrees were awarded. The 25 percent figure is based on the same criteria used by the Labor Department to define nontraditional occupations.
Many aspects contribute to the sustained prevalence of men in certain science programs. An Education study on engineering, a program that traditionally has a small concentration of women, reported that both male and females were equally prepared with science and math backgrounds when entering college and pursuing engineering studies. Nevertheless, the gap between male and female degree completion persists at 20 percent. The study highlighted that women left engineering due to a high level of academic dissatisfaction when compared to men that left engineering. It went on to suggest that engineering’s underrepresentation of women was directly related to decreased interest in engineering, the anxiety associated with being the minority in that environment and the perception that women are not meant to be engineers. Similar findings were reported in many other studies. More recent studies supply insight into student’s preparation before entering college. These impacts include the students’ self-confidence, their work and family connections, any role models they may have, support from contemporaries and exposure to teaching pedagogy that engage women’s interest and participation in science, math or engineering. These studies emphasize that females in their senior year of high school take fewer science courses, have lower standardized science exam scores, are unenthusiastic toward science, and are not likely to pursue science as a major in college when compared with their male peers. Issues that discouraged women from choosing science education in undergraduate and graduate school included peer pressure, being antagonized by male peers and professors, a shortage of mentors, insufficient support with finances and the lack of commitment from faculty advisors to form advisory relationships with female students. (G.A.O., 2000).
In 1999, a National Science Foundation’s study exposed the different interests between men and women in the physical sciences. For example, surveys of freshmen woman indicated that women were still the minority of the growing proportion that aspired to major in physical sciences at the undergraduate level. In particular, from 1971 to 1998 the percentage of freshman women determined to major in any of the physical sciences increased from 0.8 to 1.6 percent. Conversely, the percentage declined for freshmen men, from 3.1 to 2.6 for the same period. Women also earned a smaller percentage of doctoral degrees in male dominated fields of study. In 1996-97, doctoral degrees earned by women in physical science and science technology totaled 23 percent, engineering and engineering related technologies totaled 12 percent, and a total of 16 percent in computer science. Likewise, full-time faculty members in science fields comprised a small percent of women. The last year for which data were available, in the fall of 1992, women faculty positions were: 32 percent in business, 17 percent in political science, 12 percent of physical sciences, 20 percent of computer science, and 6 percent of engineering. Female full-time tenured faculty encompasses 24 percent of all faculty at 4-year universities for the school years 1996 and 1997.

Research performed in 1972-73 exposed that full-time first-year women received less in scholarships and grants than their male peers. Normally, women would rely on assistance and support from family, friends and loans. On the other hand, men would have more savings and possible earnings from their jobs. Research shows this to be shifting. In 1995-96, freshman females and males were provided about the same average aid in the form of grants and loans. Their difference in monetary need was almost negligible. It was more likely for women to have
dependents other than recognized spouses and men were more likely to obtain aid in the form of veteran’s benefits and athletic scholarships. (G.A.O., 2000).

The latest federal survey on persistence discovered that within five years women aspiring to achieve a bachelor’s degree were more likely than men with the same aspiration to actually earn their undergraduate degree within that time frame. The survey also revealed that more men than women were still enrolled at that time. When merging the data of those that earned a degree with those students still enrolled at a 4-year institute it was revealed that there were not any differences between females and males. “Consistent with the data already reviewed on high school graduation and college enrollment, differences in persistence among racial/ethnic groups are far more pronounced than differences by gender” (King, 2000, p. 11).

**Gender Gap**

Research highlights both girls that have dire gender issues in education and boys that have dire gender issues in education. It makes it more difficult to distinguish what is accurate.

Girls and boys not only perceive differently, they analyze and learn differently. Males and females receive very different educations despite the fact that they sit in the same classrooms learning from the same teachers and given the same textbooks. Furthermore, females perform the same as or better than males on almost all measures of achievement when they enter school. This can not be said of females when they graduate from high school or college. (Sadker, 1994).

Actually, when girls enter school they are educationally equal to or better than boys on almost all metrics of achievement, however, that does not remain accurate when they graduate from high school or college. (Sadker, 1994)
Over two decades of national attention to gender bias and education reform for both girls and boys has enlightened both camps. Math and science courses showed noticeable enrollment increases throughout the 1990’s in numerous high schools. This growth was visible in honors and advanced placement courses. Females enrolled in biology and chemistry while males enrolled in physics. Males were more likely to take core science courses like physics, biology and chemistry. Test results, especially in tests comparable to the SATs, continue to reflect a gender gap. The gap has recently decreased, however males are continuing to outperform females on both the verbal and math portions of the SATs. Although more females than males take advanced placement courses in all areas of academics except math, science and computers, males achieve higher scores and are more likely to receive college credit toward their degree. (Sadker, 2002).

Furthermore, the U.S. General Accounting Office, Gender Equity 2000 report, observed that in math and science test scores men continue to outperform women, however the differences in scores have decreased over the years. Their differences were very small in some instances. In fact, in 1996 the average math scores for male and female 12th graders that took the National Assessment of Educational Progress test were respectively 305 and 303, for science they were 152 and 148. In contrast, other cases illustrated larger differences. In fact, the 1999 National Science Foundation’s study demonstrates that the 1996 Scholastic Assessment Test (SAT) math scores for both males and females increased from 1991 scores. The males averaged 527, an increase from 520 in 1991, while math scores for females averaged 492, an increase from 482 in 1991.
The boy “crisis” according to the Boys Project states that since the late 1970's, young females’ attendance in college climbed as male attendance remained constant. In correlation, young men’s literacy is diminishing. The Boys Project notes that young men are disengaging from school. They are more likely to get D’s and F’s, get suspended, drop out of school, and commit suicide. They are less likely to get involved in clubs or organizations, to achieve honor roll status and be class valedictorians. The Boys Project believes that the nation is losing young men to a sense of failure resulting from schooling that is inadequately tailored to their needs, to depression as a consequence of not feeling needed or respected; loosing young men to life choices that do not include college or other promising endeavors. The nation will not remain vital in the twenty-first century and beyond with a sizeable, depressed and poorly educated group of men. The nation needs the exact opposite, men and women that are energetic and ambitious.

The Boys Project maintains that men’s achievement or lack of achievement in higher education is both genuine and very significant. At undergraduate universities, younger males of all races and ethnicities with low and middle income backgrounds, with the exception of Asian Americans, are the minority of the student body. Older males of all races, ethnicities and incomes are also the minority on campus. In addition, the gender gap for low-income conventional age students continues to increase since the 1990’s. The gap needs to be addressed by educators, administrators, and policy makers. However, existing larger inequalities such as income, race and ethnicity for both females and males should not be ignored. Furthermore, women’s successes should not be viewed as being achieved at the expense of men’s defeat. Increases in degree attainment for both sexes support the notion that male achievement is not a zero-sum contest.
The Boys Project postulates that it is important to examine the gender gap and to target efforts at reaching older minority men of low-income social class who are in the utmost need of assistance. Universities need to identify the groups of men that are not enrolling and those that are struggling with their studies and acclimation, to design and create outreach to their specific needs.

In 2000, the American Council on Education (ACE) published Gender Equity in Higher Education: Are Male Students at a Disadvantage? The Council believed this report would assist campus administrators with gender equity questions and answers. The report took a comprehensive look at the educational achievement of males and females in the United States, disaggregating main values by age, race/ethnicity, and income to establish where the gender gap resided, where it was most extensive, and where concerns about men emerged as justified or not. That report found:

there is not a generalized educational crisis among men, but there are pockets of real problems. In particular, African-American, Hispanic, and low-income males lag behind their female peers in terms of educational attainment and are far outpaced by white, Asian-American, and middle-class men and women. (King 2000, 2).

How has the situation changed since 2000? According to the ACE, the most prominent change is the expanding gender gap amid white and Hispanic traditional-age undergraduates that were 24 or younger, due mainly to the larger female percentage of low-income students. These changes have impacted the decline in the percentage of traditional-age male students from 48 to 45 percent for the years of 1995-96 and 2003-04 respectively. Women
make up almost two times the percent of undergraduates aged 25 or older as compared to their
male peers. In spite of the growth of female undergraduates the number of bachelor’s degrees is
increasing for both men and women. It appears, as in 2000, that women’s success is not coming
at the expense of men but more noticeably that their postsecondary enrollment is increasing
faster than men’s enrollment. The publication paints a picture of increased educational
achievement for two out of three student groups; for men of color and for females of all races
and ethnicities, however not for white men.

The ACE article summarizes the analyzed results of undergraduate enrollment and
undergraduate degree attainment and the evaluation of explanations for the gender gap.
Complete results ranging from high school to graduate degree achievement can be obtained in
Gender Equity in Higher Education: 2006 (see www.acenet.edu).

Differences in gender learning have always existed. When training U.S. educators to
teach science to elementary school age children, Abruscato (1995) noted:

the image of the scientist held by the most people is a stereotype (of a male). . . If you
really believe that all children should have an equal opportunity to receive the best
possible education, you have an obligation to correct sex-role stereotyping. . . The
persistence of these falsehoods (of sex-role stereotyping) injures our future because in
discouraging some from careers in science and technology, we may lose great discoveries
that will improve our lives. (p. 9)

Sadker recently discovered that girls in elementary school are recognized for gifted
school programs more frequently than boys, although by high school there are less girls
remaining in those gifted programs, especially fewer females of Hispanic and African American ethnicity. Gender issues are apparent as females are not as likely to be enrolled in math and science gifted programs. Female student scores have improved in the areas of math and science achievement tests and they currently take more Advanced Placement tests. Nevertheless, females continue to underperform comparable to males on both the verbal and math sections of the well-known placement tests such as the Scholastic Assessment Test (SAT), the Advanced Placement (AP) exams and the Graduate Record Exam (GRE) for masters and doctoral programs. (Sadker, 1999).

Sadker observes that although men continue to earn more money than women, supervise more organizations, rule government offices and sports arenas, many Americans still presume a gender divide does not exist. “In fact, sexism harms both genders” (Sadker, 1999, p. 4).

In gender education research, Horgan, (1995), recognizes gender equity issues for both sexes. Horgan contends that female issues include negative messages that their teachers accidentally give and the awkward way that females describe their successes and failures. This process is known by psychologists as attribution. Teachers walk a tight rope with their messages in the classroom. Teachers can potentially create an environment whereby females doubt their abilities due to receiving less negative criticism than the boys, or receiving too much praise. Male issues include more disciplinary problems, being relegated to special education classes, and having higher grade failure and drop-out rates. Albeit more women are teachers; schools continue to highlight formulaic female behavior. Horgan (1995) continues, this environment can make boys feel like strangers, with expectations similar to sitting quietly, being passive and pleasing their teachers. Gabriel et al. (1990) asserts that although there is a strong link between
learning and interactions between male and female students and their teachers, male students are at more of an advantage in the K-12 grades. This advantage persists even into college. Gabriel’s research was augmented by American University and their study found that “the patterns established in elementary and secondary schools continue in higher education. Male students receive significantly more attention, and sex bias persists” (“Sexism” 33).

Tom Mortenson, Senior Scholar, The Pell Institute for the Study of Opportunity in Higher Education June 25, 2007 presentation, “What’s Wrong with the Guys”, discussed negative impacts on male students. In a market that has consistently employed primarily men for goods production, there is a decline in goods production job opportunities, however for females primarily employed in the service-industry, there is an increase in those job opportunities. Also, median income in the U.S. has declined from $42,000 in 1973 to $35,000 in 2004 for men. Gender differences, at all levels in education, still exist.

**Possible Reasons for the Gender Gap**

King (2006) asserts that there is a lot of speculation as to the reasons why women are now the majority on college campuses, and unfortunately much less research. Economic incentives, social/psychological factors and school effects are among the speculations. These issues are not exclusive to the U.S. Women enter postsecondary education at higher rates than men in most Organization for Economic Co-operation and Development (OECD) countries.

The economic incentive claim implies that female earnings promise to be much higher with a college degree than a high school diploma and therefore females should choose to attend
college. Median income of women aged 25 to 34 with only a high school degree that worked full time for the 12 months of 2004 was only $24,166, as cited by the U. S. Census Bureau. If women that did not work full time for the 12 months are incorporated in the total then the median income drops to only $18,647. The median income of men the same age with only a high school degree was $30,366 and not believed to be low enough to act as an incentive to attend college. In addition, health care and company benefits are customarily given to blue-collar male employees more often than women in the service industry therefore creating an added incentive for women to pursue higher education for potential financial gains. (King, 2006).

Social and psychological theories include the impact of the media and individual maturation rates. The media, using male role models mainly in the music or athletics industry, portrays messages perceived by males that education is not “cool” and maturation rate differences for males has shown that meeting deadlines and conforming is more difficult. Consequently, males tend to fall behind in their studies and are often diagnosed with disorders such as attention deficit. (King, 2006).

Lastly, the school experience has been researched and acknowledged to be different for both sexes. Some research challenges the organization and governing of schools as biased toward males. Other research contends that the design of the curriculum has changed, with an earlier focus on reading and writing. This change may put males at a disadvantage due to brain development and their learning method. (King, 2006).

Unfortunately, as King notes, consensus has not been reached concerning gender gap issues and very little published research to establish unyielding conclusions. However, with the
wide range of conjecture, gender gap issues continue to be viewed as very complex. Other considerations such as ethnicity, age, race and socioeconomic status add to the complexity. Identifying issues and designing successful programs becomes very difficult. As with many issues, they are not unique to America. Gender gap issues are evident in many industrialized countries. (King, 2006).

Vital reform elements currently taking place in teaching science to girls and boys at all educational levels are: debunking stereotypes, eliminating biases, teacher encouragement/feedback, mentoring, integrating technology and allowing “science by doing” with a hands-on approach. This needs to begin very early in students’ educational journey.

Postsecondary Degrees

According to the National Center for Education Statistics (NCES), future projections of undergraduate degrees for the 2004-05 academic year to be awarded were 668,000 associate’s, over 1.4 million bachelor’s, 562,000 master’s and 85,000 first-professional, licensing degrees and over 47,000 doctoral degrees.

The NCES, Enrollment in Postsecondary Institutions, Fall 2004; Graduation Rates, and 1998 & 2001 Cohorts reported that U.S. college enrollment reached a record level of 17.3 million students in the fall of 2004. An estimated record of 17.4 million was predicted for the fall of 2005. Incremental enrollment between 2005 and 2014 was forecasted at 12 percent. College enrollment increased in the late 1980’s into the early 1990’s, in spite of a decline in traditional-age college students during the same time period. The NCES report observed that full time
undergraduate student enrollment rose by 30 percent and part time enrollment rose 8 percent, while the number of males enrolled increased 16 percent and the number of females increased 25 percent between 1994 and 2004.

The U.S. Census Bureau collects and reports annual statistics on the educational achievement of the population. The percentage of the population 25 years or older that received their high school diploma increased 3 percent between 1995 and 2005; from 82 to 85 percent; and the percentage that earned their undergraduate degrees increased 5 percent, from 23 to 28 percent. For the same time period, the percentage of the population 25- to 29-year-olds that earned their undergraduate degrees increased from 25 to 29 percent. In 2005 the percent of 25-to 29-year-olds that earned their high school diploma was equal to the 86 percent reported in 1995.

**Recruitment/Retention**

Other recruitment tools currently implemented are substantial financial aid awards, possible scholarships and connecting students, male and female, with existing students in science courses/majors. Retention efforts that have proven effective are: creating a sense of connectedness and networks through faculty interaction, campus activities, and within a community among students like themselves, also mentoring by upper-class students, strong advising, and possible involvement with industry during their education career. With the renewed, more intense, demand on science and technology professionals in the world, whether we are utilizing the visual representations of measurable properties of persons, objects, or phenomena, or developing new materials and devices for power generation and storage for
microelectronic components and micro-electromechanical systems (MEMS), it is essential to tap into the large portion of the female population. Women can offer diverse perspectives, outlooks and outcomes for future advancement of the global economy that is before us.

**Science Crisis – U.S. Reported Test Scores**

The science crisis theory begins with the reporting of results of U.S. students’ math, science and reading test scores and continues with the low percentage of total scientists and engineers educated and retained to enter the workforce along with the retiree projections of scientists.

The National Defense Education and Innovation Initiative reported that U.S. 4th graders had among the nations highest scores in math and science tests but were not able to maintain that distinction by 12th grade. In the USA Today article, How to Solve the Mathematics and Science Crisis, by Linda Darling-Hammond, (1990), the claim is made that American students rank close to the bottom in testing as compared to other industrialized nations. Usually the gap becomes larger as the students age. Additionally, students in other industrialized nations are more likely than American students to enroll in advanced math and science courses. (2006).

In the most recent International Mathematics and Science Study, for instance, American 12th grade students in advanced physics were ranked ninth out of 13 countries, ranked 11th in chemistry and 13th in biology. Of the 15 countries researched, U.S. 12th graders taking advanced calculus and geometry math courses ranked 12th and in advanced algebra they ranked 14th. Even more disconcerting, the students in the advanced calculus courses represent a mere three percent of American 12th graders as compared to students in most European nations where 15 percent of their seniors are in advanced calculus courses. With these levels of American high school student
enrollment and academic achievement in advanced science fields of study, the numbers of U.S. students that pursue science careers is not sufficient. (TIMMS, 2003).

Research by the National Assessment of Educational Progress (NAEP) 2007, supports this premise with research findings that used a 0-300 scale to measure the science abilities of high school seniors that attend public and private schools since 1996. Nationally, the average science scores of 12th graders diminished slightly from 150 in 1996 to 147 in 2005. There were certain clusters within groups that outperformed other science students in 2005. Males continued to outperform females and both male and female seniors underperformed in 2005 compared to the 1996 scores.

**Importance of Retention**

Vincent Tinto set the stage on student attrition theory with his 1973 breakthrough study based on student’s initial commitment to the institution, student involvement in social and intellectual life of the college (integration), and external and internal forces. He revised his theory in 1993 in response to his many candid critics; namely Bean, Astin, Siedman, Braxton, Cabrera, Pascarella and Tinto himself. Retention research grew in popularity once it was realized that more students were leaving their university before earning their degree. The Educational Policy Institute (June, 2004) acknowledged that postsecondary student retention is not only costly, it is a challenging matter. Although the retention solution has yet to be discovered, postsecondary enrollment has increased since the early 1900s to nearly 14 million and the graduation rate has maintained at 50 percent for most of the last 50 years. Therefore, 50 percent of students that do not persist are not achieving the goals that first led them to
postsecondary institutions. These students may have changed their objectives and may have still become successful, but from a business perspective and personal awareness, it is rather distressing that graduation rates have not increased. It is important to note that attending college is very different now. Furthermore, amid increased enrollment numbers, college and universities face increased student body characteristics and multiple conduits to and through undergraduate education. Bean (1986) deems it important to research retention issues from an ethical standpoint. He argues that it is the responsibility of colleges and universities to afford academic and social integration for their student body that will assist them with persistence and success.

Additional impacts of student attrition, according to studentretention.org, International Centre for Student Retention, (2007) include enrollment management and information systems, marketing, and student recruitment exercises. Likewise, the International Centre for Student Retention, (2007) research on student attrition revealed the following damaging financial and programmatic consequences for institutions: direct loss of revenue, recruitment and image costs, and undermining of the diversity of the curriculum. The research proposes policy areas that should be tackled by campuses facing enrollment problems to include: planning strategies, including cost studies, enrollment forecasts, and program review; shared decision-making between the faculty and the administration; staffing and personnel policies; and the revitalization of student life and the linkage of faculty and student affairs personnel. Dr. Joe Lee, president of Alabama State acknowledged that “institutions typically implement centralized corrective measures targeting retention, instead of more effective, decentralized approaches” (Powell, 2003, p. 34).
Institutional Departure Issues and Models

In discussing retention issues one must begin with Tinto’s, (1987, 1993), often cited breakthrough longitudinal model of institutional departure. His model, Leaving College Rethinking the Causes and Cures of Student Attrition, has been the foundation of departure research to date. Tinto’s historical theory delves into student’s initial commitment to the institution, student involvement in social and intellectual life of the college (integration), external and internal forces, and interestingly compares student departure to Van Gennep’s, (1960, 2004) and Durkheim’s, (1951, 1979), theories of suicide: of departure from society.

Van Gennep’s, (1960, 2004), The Rites of Passage, hypothesized three phases in the process of individuals and societies movements through time and with methods that encourage social stability through change. The three phases include separation, incorporation and transition. Durkheim’s, (1951, 1979), Suicide, studied sociology’s position in describing any suicide rate differences between and within countries over a specific time period. Despite their limits, Tinto carefully highlights Van Gennep and Durkheim’s theories to show the connection with phases of leaving postsecondary institutions.
According to Tinto, (1987, 1993), student departure from institutions occurs, as his longitudinal process of interactions model highlights, for many reasons. The interactions he studied were between individuals that have specific attributes, skills, prior educational experiences, financial resources, and the levels of their intentions and commitments toward their education with other contacts within the academic and social systems of institutions. Subsystems within this model, such as adjustment, difficulty, congruence, isolation, obligations and finances impact the route of student departure. Tinto explains “that one must distinguish between the formal and informal manifestations of each system and the manner in which experiences in either may impinge upon social and intellectual integration within the life of the college” (p.113).

**Longitudinal Model of Individual Departure**  
(Tinto 1975, 1987)

[Diagram of Longitudinal Model of Individual Departure]

Tinto also reports that male, female and adult postsecondary departure reasons are similar as their commitment to further their education is impacted by their commitments made to work and family. Research continues to imply that although the number of women enrolled in postsecondary universities and the number of degrees awarded to women have increased, their college experience continues to be different than that of their male peers. (Astin 1975, Gosman et al. 1983, Baxter-Magolda, 1990). As compared to males, female departure is focused more on social influences rather than by academic forces and consequently is pressured by forms of social integration. (Alexander and Eckland 1974, Pascarella and Terezini 1983). Departure takes a different form of leaving for females. Males are less likely to leave college; nevertheless they are more likely to leave due to academic reasons. Females are more likely to leave college voluntarily. Tinto concludes positing that women’s and men’s departure from postsecondary universities differ for various reasons, including reasons beyond the control of the university. This seems to somewhat epitomize the stereotypical expectations of women’s role in the community. Data would imply that this is changing, however corroboration is not found in male and female student persistence research. (Tinto, 1993).

Seidman, (2005), College Student Retention, a critic of Tinto’s departure model, contends that Tinto’s model is flawed in that the design accounts for the mainly white, traditional-age student that recently graduated from high school and is more likely to be recruited by college and universities.

Reworking the Student Departure Puzzle, (2000) edited by Braxton, Part 1: Revising Tinto’s Theory, Baird notes three arguments of the Tinto model: 1) that there are weaknesses in
the model itself, 2) operational metrics have limitations, 3) and/or ambiguity about the core of
the model’s operation. Researchers like Bean and Metzner (1985) and Cabrera, Stampen, and
Hansen (1990) proposed that the Tinto model failed to consider all aspects of student departure
behavior. Tierney (1992) has criticized the model based on Tinto’s misapplication of
anthropological views. Hurtado and Carter (1997) pointed out that some of the concepts were
too ambiguous. The second argument noted by Baird suggested that an astonishing breadth of
operational definitions were observed when examining the model. As Hurtado and Carter (1997)
point out academic and social considerations include “the effort or time spent in activities;
students’ perceptions, reported behaviors, and participation in specific activities; students’
satisfaction with aspects of the social or academic environments; students’ interpersonal
relations; objective performance criteria; or a combination of these measures” (p. 376). The
longitudinal model is often examined in undergraduate data sets developed for other purposes.
Persistence researchers often studied factors that could have been related to Tinto’s model rather
than considering university specific data and designing and measuring possible solutions for their
target data set. Therefore, the meaning of the variables within Tinto’s model is confusing,
empirically and theoretically. The third argument is supported by Hurtado and Carter’s (1997)
observation that Spady’s (1971) original definition of perceived social integration is largely a
psychological measure. This belief allows for personal interpretations and judgments of
students. According to Baird following this reasoning illustrates that several variables within
Tinto’s model can be viewed to function intrapsychically. Personal statements of intent include
goals and institutional commitments; psychological consequences of interaction include social
and academic integration within the universities’ culture. Baird expanded by noting that Tinto’s
more recent model modified the goal commitment portion of student’s perceptions to highlight
the importance of external commitments and the degree of assistance or obstruction these
commitments had on student’s educational advancement. Stage’s (1986b) psychological
orientation to college outcomes supports this view. Spotlighting the internal perceptions as the
focus of Tinto’s model causes the unit of measure, namely the individual student, to also be
reflected upon.

Harvey-Smith (2002) posited that Bean’s (1980) persistence model indicated that
undergraduate student departure issues are comparable to employee turnover issues. Bean’s
persistence model built upon Price’s (1977) work by integrating the following four variables:
drop out (dependent variable), satisfaction and institutional commitment (intervening variables),
organizational determinants, and background variables. Bean theorized that organizational
variables mirrored departure variables. His proposed variables that affect turnover for
employees include communications, monotony, commitment level, and organization excellence,
all, he believes, are similar to student departure variables. This model underlines the importance
of behavior as predictor of persistence. The presumption is that the process guides intent and
beliefs guide attitudes, which in turn persuades behavior. Furthermore, this model presumes that
beliefs affect a student’s value experience with the total campus, their courses, and their friends.
External variables have significant affect on student attitudes and choices while attending
college. The results of Bean’s model supports the supposition that variables such as personal,
environmental and organizational, play a role in shaping people’s intents and commitments; it
also implies that noncognitive variables, such as the approval of one’s family and university
environment, play a role in shaping a student’s desire to leave or graduate. Bean’s model differs from Tinto’s, in that, it is renowned for explaining persistence of nontraditional students.

McClanahan, (2004), proposed that Bean’s (1980) causal model hypothesized that students’ backgrounds needed to be accounted for when trying to understand their interactions with the environment of the IHE [institutions of higher education] …that interactions between the institution and the student are both objective and subjective. Objective measures include grades, and belonging to student organizations. Subjective measures include the actual value of their education and the quality of the university. The objective and subjective measures then influence how satisfied the student is with the institution. Satisfaction increases a student’s institutional commitment. A student’s level of commitment to an institution is considered to be a predicator of student attrition (Bean, 1980). Results from testing Bean’s causal model (Bean, 1980) indicated that the two most important variables influencing commitment for both men and women were institutional quality and opportunity. Outcomes demonstrated that if men were not satisfied with their college experiences they would leave the university while women were less likely to leave the university if they were committed to their college. McClanahan’s, (2004), report continues that in a subsequent study, Bean’s (1985) research for his revised model found that peers have more impact on students’ social experience than faculty interactions, that students are more actively engaged in their socialization than was once believed, and that grades are not a consequence of socialization but rather of selection.
Retention Strategies

Tinto, (1993), notes that the answer to the question “What works in retaining students?” does not contain intervention strategies used in explaining structural elements and treatment of attrition. In fact, many successful retention programs exist. Retention programs differ in many ways, including design, structure, cost, mode of operation and focus. Conversely, retention programs are similar in the way retention is thought about, the kind of focus retention efforts receive, and the aim of their energies. The “principles of effective retention” are (p. 145-147):

1) Effective retention programs are committed to the students they serve. They put student welfare ahead of other institutional goals.

2) Effective retention programs are first and foremost committed to the education of all, not just some, of their students.

3) Effective retention programs are committed to the development of supportive social and educational communities in which all students are integrated as competent members.

RIT’s Report of the Retention Task Force, 2000, reported that retention and graduation rates will increase once the institution is committed to the success of their students in all its numerous forms. The definition of a successful student is one who is benefits from integrating into the university community, yielding progress toward degree completion, and from positive faculty relationships within a supportive educational atmosphere. Some of the reported retention strategies include (pp. 16-20):
1) **Faculty advising:** a strong faculty advising system will ensure that a) all first-year and at risk students have the opportunity to develop a faculty connection and b) they will receive solid academic counsel around such key issues as course selection, course withdrawal, supplemental instruction, career direction, etc.

2) **Early Warning System:** “early warning”, electronic, systems track carefully the academic performance of freshmen and intervene at the first sign of trouble.

3) **Attracting High Quality First-Year Students:** A recent study by the U.S. Department of Education finds that the single most dependable high school indicator of college success is the “intensity and rigor” of the high school curriculum; students who performed well in AP classes are thus among the most promising college freshman. Kuh et al., 2005, notes the “greatest indicators for whether a student will graduate are academic preparation and motivation.” (Adelman, 2004; Pascarella & Terenzini, 1991, 2005).

4) **Learning Communities:** keys to success are keeping a small group of students together in a course or courses that last over an extended period of time.

The most prominent omission in this report is the exclusion of strategies for upperclassman. The Retention Task Force discovered a significant correlation at RIT for first year students between student persistence and advancement toward their degree. Retention programs need to begin when a student enters their institution in order to be effective.
Researching Education in the 21st Century, Kuh et. al, 2005, indicates that retention success lies in the following combined strategies: student engagement on two levels a) balancing studies and extracurricular activities and b) institutions role in providing opportunities and services that encourage student involvement; clear institutional purposes and goals along with a clear position on how things are done at the institute; student learning focus in policies and procedures; adapted environments that allow for improved educational enhancements due to institutional resources that can not be found at any other location. Further supporting this adaptation theory is research conducted by Myer & Davis, (2003), in which adaptive systems connect the role of diversity, use feedback for development, materialize as something new, and self-organizes and become unstable. Kuh continues the combined strategies to include: a culture of student success; an environment of constant reflection, improvement and change; responsibility and accountability for the quality of education offered and for student success whereby leadership is the foundation; institutional challenging academics that promote high standards along with support to achieve those standards; engaging students with multiple learning venues and providing opportunities to apply their new knowledge; faculty mentoring and interactions beyond the classroom; providing educational opportunities that complement academic programs and lastly, to have academic and social programs in place that create a supportive campus.

**Future of Innovation and Security Fears**

The United States’ economic and security welfare built solid over the last half a century will be considered at risk if there is in fact a science crisis. Science, Technology, Engineering & Mathematics (STEM) Coalition presented to the Honorable Rob Portman, Nov. 2006, their
intense view that this nation’s future economic wealth in the competitive global economy will largely depend on our ability to improve math, science and engineering education that will attract more of the best students into STEM disciplines. It is imperative that innovation programs are grown and supported to allow for this nation to face the global challenges of the 21st century with resolve. The coalition also pointed out the need for a stronger focus at the U. S. Department of Education on STEM education programs. Math and science education programs, including the Math and Science Partnership program, at the U. S. Department of Education will need increased funding to allow each state to continue research-based initiatives to augment teacher knowledge and improve student achievement in math and science.

The National Defense Education and Innovation Initiative (NDEII), Jan. 2006, Hart-Rudman noted that over the next twenty-five years the greatest threat to U.S. national security is the inadequacies of our research and educational systems as compared to any possible conventional war imagined. America faces additional security and prosperity challenges; dramatic and creative responses are needed for the increased pressure from growing global economies that create national security issues. These challenges threaten America’s economic innovative success and military strength at its’ very core. This nation’s innovative edge is eroding and creating grave problems for education with a deteriorating federal commitment to physical sciences and engineering research.

In addition, Hart-Rudman acknowledges this nations’ dominance as a world leader is not guaranteed into the future. America’s ability to conquer said challenges is dependent on the capabilities and foundation of past innovations. Nonetheless, the threats continue to be sobering with less incentives for students, male and female, to study science, engineering and languages,
and with inadequate funding for basic physical science and engineering research. America’s threatening deficiencies in light of other nations growing their innovative capabilities substantiates these fears. Hart-Rudman suggests that it is vital for this country to concentrate on increasing minorities and women in STEM fields. The report concludes by stressing that America needs to effectively attract both minorities and women to the physical sciences. This nation cannot afford to continue underutilizing this talent.

As we look to the future of science and innovation, it is important to remember the contributions of the past. Some of the female and male scientists who have lead great discovery and advancement in this country and have impacted the U.S. as we know it today include: Marie Curie, 1867-1934, chemist and physicist, Jane Goodall, 1934-, primatologist, Mae C. Jemison, 1956 -, physician and astronaut, Florence Nightengale, 1820-1910, founder of modern nursing, and Ellen Ochoa, 1958 -, astronaut and engineer, to name a few. Historical male scientists include: Thomas Edison, 1847-1931, inventor, Charles Darwin, 1809-1882, evolution theorist, Isaac Newton, 1643-1727, and Albert Einstein, 1879-1955, physicists, Louis Pasteur, 1822-1895, chemist, and René Descartes, 1596-1650, mathematician, to name a few.

**Retirement Concerns**

According to a report by the National Education Association, as of 1999 almost 18 percent of science and engineering faculty members at four-year universities were at least 60 years old. The majority of faculty was contemplating retirement within three years; however a quarter of them had no intention of retiring in the near future. Nevertheless, an article in The Chronicle of Higher Education, 2003, highlighted the dire predictions made in 1994 for research universities due the end of mandatory retirement. The predictions included that professors over
70 years of age would clog tenure tracks and tap too much of the salary pool with their higher salaries. Currently, that has yet to occur. Ronald Ehrenberg, a professor of economics and director of the Cornell Higher Education Research Institute stated that professors beyond the age of seventy at 44 percent of the universities that participated in a recent survey continue to teach and do research. This faculty-retirement policies survey was conducted at 608 institutions for the American Association of University Professors. Science and engineering professors are now facing unlimited career prospects with mandatory retirement history in academe. The article asserts that if professors continue to make money for the institute, they are able to continue doing the experiments they love to do. Professors that retire but would like to continue their experiments have smaller amounts of resources than their tenured peers; however they are not bound to administrative responsibilities that often bog down full-time faculty. The article describes an emeritus professor in his mid eighties, Bruce Stocker, who is satirized by his Stanford University graduate students as a ghost driving a noisy cart loaded with beakers and flasks through uninhabited halls. On the contrary, ghosts aren’t able to publish papers or receive licensing fees, as Professor Stocker and many others continue to do. In as much as this particular professor has yet to give up doing research, he was forced into retirement at the age of 70 because the mandatory-retirement law was in effect.

Reported scientist retirement data appears to highlight both theories, scientist retirements will create a great need for more scientists and there is a lack of retirements due to the end of mandatory retirement.
Summary

Higher education involves levels of expectations. Expectations from students, families and the world. The outcomes of education, whether successful or unsuccessful, have impacts that are far reaching. Postsecondary institutions have recently studied, implemented and supported systems that facilitate student success throughout their educational journey. However, attrition continues to be a concern for both males and females in sciences and literature regarding retention issues has yet to profess any empirical solutions. Retention literature from the students’ perspective is virtually nonexistent. Additionally, research has been inconclusive in the study of gender impacts on postsecondary education in the sciences and the economy. Therefore, additional research was necessary to study the association and impacts of gender in the educational arena as well as the industry arena.
Chapter 3: Methodology

Both female and male students enrolled in the sciences face challenges in obtaining postsecondary science degrees for a myriad of reasons. Research acknowledges the multitude of issues that exist not only in the sciences but for everyone attending postsecondary institutions. As a technological, career-oriented university, RIT has historically enrolled more males than females. The global need for scientists, engineers and technologically savvy people is increasing at a rapid pace.

As stated earlier, the challenge presented by having many science programs in existence at RIT and other institutions lies in studying the retention data of all the sciences in which male and female students enroll. For this thesis the retention data focused strictly on gender impacts, both male and female students enrolled in biology, biotechnology with bioinformatics option and biotechnology programs. Chapter 3 describes the participants, materials, research method and procedure, and data collection used in this research.

Participants:

The participants in this experiment are male and female students enrolled in three undergraduate biological science programs in RIT’s College of Science during the years 1995 – 2003. Total enrollment for all biological science programs was comprised of 340 males; of which 122 were designated biology majors, six bioinformatics, 28 biotechnology with bioinformatics option majors, 181 biotechnology majors, and three environmental science majors. The majority of male students were enrolled in the biotechnology program. Male student ethnicity consisted of six African Americans, 263 Caucasians, nine Internationals, one Native American, 24 Asians, 12 Latino/Hispanics, 11 Other, and 14 Unknown. The majority of
male students were Caucasians. Total enrollment was comprised of 423 females; of which 215 were designated biology majors, three bioinformatics, 13 biotechnology with bioinformatics option major, 190 biotechnology, and two environmental science majors. The majority of female students were enrolled in the biology program. Female student ethnicity consisted of 26 African Americans, 329 Caucasians, three Internationals, four Native Americans, 22 Asians, seven Latino/Hispanics, five Other, 27 Unknown. The majority of female students were Caucasians. Enrollment of females and males in the year’s 1996, 1999, 2000-2003 was approximately the same. Female enrollment was higher than male enrollment in 1995 (42 vs. 27), 1997 (59 vs. 23) and 1998 (54 vs. 30). Attrition (Tinto, 1993, pg. 8), the departure of persons from individual institutions, varied among the students in the biological sciences department from 1995-2003. In 1995, 1997, and 1998 more women in biological sciences departed from the institute. In 1996, 2000-2003 more men in biological sciences departed from the institute. In 1999 attrition numbers were nearly the same for both men and women.

The independent variables in this study are the three possible outcomes: if the students graduated, if they departed voluntarily, and if they departed involuntarily. The dependent variable for this study is gender. The examination of these characteristics was important to the study as it was hoped it would be possible to identify possible factors contributing to significant differences in retention by gender.

**Materials:**

Data was received from the Institutional Research Office in excel format. The data included retention and graduation information pertaining to females and males broken down by 1) the Institute as a whole and 2) specifically for all College of Science programs for the years
1995-2003. It also included information for each participant in the biological science program: their major, gender, cumulative grade point average, outcome (of voluntary, graduated, involuntary), if placed on suspensions, if they received any grades of D, F, or a W for withdrawal from a course, if they were placed on probation throughout their enrollment at RIT, if they were placed on probation their first year, if they received financial aid, their ethnicity, if they were enrolled in a First Year Enrichment course and the year they entered RIT.

**Experimental Procedure:**

This true experiment used Chi square distribution for this procedure as it focuses on the frequency and relationship between two different factors in a single population. According to Devore (2004):

“Chi square is the basis for a number of procedures in statistical inference. Chi-square is the sum of the squared difference between observed \((o)\) and expected \((e)\) data (or the deviation, \((d)\), divided by the expected data in all possible categories” (p. 658).

This nonparametric test of independence is intended to work with data that are conveyed as frequencies and is intended to ascertain whether two variables are autonomous or interrelated. The difference between the observed and the expected frequencies is the underlying principle of Chi-square testing. The computation of the expected frequencies is based on the hypothesis that differences do not exist between the observed and expected frequencies except from happenstance. (Lehmkuhl, 1996).

Two noteworthy limitations when using Chi-square distribution are: 1) an ideal association is not necessarily achieved with a 1.00 and 2) the size of both the sample and the
contingency table influence the results. Chi-square distribution is intended to perform with fairly diminutive samples and a restricted amount of rows and columns. Although the association between the frequencies may stay rather constant, the values of Chi-square increase as the number of rows and columns increase. In fact, if the sample size increases to twice as much, the value of Chi-square doubles, however all else stays the same. Degrees of freedom; separate data is used to make inferences of other data, are dependent of the number of rows and columns, and are not dependent on sample sizes. Consequently, results are exaggerated when drawing conclusions about the differences between observed and expected frequencies based on inflated Chi-square values. (Lehmkuhl, 1996).

“Understanding the dynamics underlying goodness-of-fit can help institutions sharpen their recruiting efforts, refine their marketing methods, and identify needed improvements in student services and in teaching/learning processes” (Heverly, 1999, p.3).

**Procedure:**

The data being studied were organized into the form of a 2 x 9 contingency table. The table consists of row and column totals and the total of participants included in the study. The single population is students enrolled in RIT undergraduate biological science programs with respect to two different categorical factors; if they retained or departed. It is a two character test of independence that will test the probability that a student’s graduation date is or is not affected by their gender if chosen randomly.

The expected frequencies are computed as follows: multiply the row total and the column total and divide by the overall total. Expected frequency = (row total)(column
total)/(overall total). For example: to compute the expected number of females to graduate from biological science program in 1995 the operation would be \((215*37)/337 = 23.6053\).

According to Lehmkuhl, (1996), when calculating multiple data responses and Chi-square values the variables need to be nominal as well as ordinal, ratio or interval. Also, discrete or continuous variables are effective with Chi-square distribution. If it is theorized that data occur in each category that is studied, then cells can not yield an observed frequency that would be equal to zero.

The formula for computing the degrees of freedom when computing Chi-square and contingency coefficient is: 

\[
df = (k-1)(r-9),
\]

letting \(k\) represent the number of columns and \(r\) represent the number of rows in the contingency table.

In addition, Lehmkuhl states that Chi-square (\(X^2\)) is calculated using the following equation:

\[
X^2 = \sum \frac{(O-E)^2}{E}
\]

letting \(O\) represent the number of instances in the \(n\)th row of the \(n\)th column, and \(E\) represents the expected frequency. Chi-square is achieved by subtracting the expected frequency from the observed frequency of each cell, squaring the difference and dividing the product by \(N\). The outcome of each cell is totaled to achieve the Chi-square value. “If the \(p\) value for the calculated \(X^2\) is \(p > 0.05\), the hypothesis will be accepted. The deviation is small enough that chance alone accounts for it” (Chi-Square Test, n.d., para. 21).
Each observation consisted of both the expected and actual impact of gender on graduation in the three biological sciences programs. In reporting the Chi Square distribution, statistical reliability is used as an indicator of whether the expected assumed model has the same results as the actual model. For the three groups of students that were studied; biology (SBIB), biotechnology with bioinformatics option (SBIF) and biotechnology (SBIT), the following expected and actual results are shown in Tables 1-6:
### Table 1: Biology expected results

<table>
<thead>
<tr>
<th></th>
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<tbody>
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<td>31</td>
<td>27</td>
<td>26</td>
<td>20</td>
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<td>15</td>
<td>19</td>
<td>125</td>
</tr>
<tr>
<td>Male</td>
<td>13</td>
<td>18</td>
<td>15</td>
<td>14</td>
<td>11</td>
<td>15</td>
<td>8</td>
<td>15</td>
<td>93</td>
</tr>
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<td>37</td>
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<td>41</td>
<td>32</td>
<td>44</td>
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<td>35</td>
<td>218</td>
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### Table 2: Biology actual results

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<th></th>
</tr>
</thead>
<tbody>
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<td>Female</td>
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<td>23</td>
<td>32</td>
<td>23</td>
<td>20</td>
<td>19</td>
<td>25</td>
<td>20</td>
<td>215</td>
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<tr>
<td>Male</td>
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<td>27</td>
<td>13</td>
<td>15</td>
<td>12</td>
<td>10</td>
<td>11</td>
<td>12</td>
<td>115</td>
</tr>
<tr>
<td>Total</td>
<td>37</td>
<td>50</td>
<td>45</td>
<td>41</td>
<td>32</td>
<td>44</td>
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<td>32</td>
<td>330</td>
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</tbody>
</table>

### Table 3: Biotechnology with bioinformatics option expected results

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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
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<td>2.71</td>
<td>6.82</td>
<td>14.84</td>
<td>12.22</td>
<td>15.22</td>
<td>11.58</td>
<td>11.22</td>
<td>52.22</td>
</tr>
<tr>
<td>Total</td>
<td>14.00</td>
<td>8.10</td>
<td>30.00</td>
<td>17.83</td>
<td>22.21</td>
<td>22.21</td>
<td>21.86</td>
<td>20.09</td>
<td>182.21</td>
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### Table 4: Biotechnology with bioinformatics option actual results

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<th></th>
<th></th>
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</tr>
</thead>
<tbody>
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<td>Female</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
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<td>25</td>
</tr>
<tr>
<td>Total</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>14</td>
<td>17</td>
<td>10</td>
<td>41</td>
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</table>
Summary

This chapter outlined and described the participants, materials, research method and procedure, and data collection used for this thesis. Biological science students selected in this study enrolled as freshman at RIT from the years 1995-2003. Quantitative measures were used to determine whether two variables are independent or related. The analysis and findings of the data are provided in the next chapter. Conclusions and recommendations are offered in chapter 5.
Chapter 4: Analysis and Findings

The original data received from Institutional Research included retention and graduation data for the 16,083 students attending RIT from 1995-2003. Subset data of enrollment, attrition and variables mentioned in Chapter 3 was also included for the 1,923 students enrolled in the College of Science across programs in biology, chemistry, medical sciences, imaging science, mathematics, physics and general science exploration. The data was summarized using standard descriptive statistics. The data are presented in Tables 7, 8, 9, 10, 11, 12, and 13.

Founded in 1829, RIT is an internationally recognized leader in professional and career-oriented education enrolling more than 15,000 students in eight colleges. RIT has placed a greater focus on retention issues in the past decade. According to RIT’s Report of the Retention Task Force dated June 2000, institutional retention rates ranged from a high of 64.7% to a low of 57.4% (p. 4). Secondary data of student retention was received by Dr. Robert Bowen of RIT’s Office of Institutional Research for the years 1995 - 2003. Tables 7-13 are essentially a summary of these data.
<table>
<thead>
<tr>
<th>Females</th>
<th>Attrition After:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enter Fall:</td>
<td>N 1 QTR 2 QTR 1 YR 2 YR 3 YR 4 YR 5 YR 6 YR 7 YR</td>
</tr>
<tr>
<td>1995</td>
<td>416 0.72 3.36 12.25 21.15 24.27 29.56 29.56 30.04 28.36</td>
</tr>
<tr>
<td>1996</td>
<td>448 2.9 5.35 7.81 16.07 21.87 28.79 27.67 26.56 26.11</td>
</tr>
<tr>
<td>1998</td>
<td>475 3.57 4.63 9.68 18.31 22.52 27.36 29.89 28.42</td>
</tr>
<tr>
<td>1999</td>
<td>494 3.64 4.85 13.15 19.63 23.27 28.94 31.37</td>
</tr>
<tr>
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<td>555 4.32 6.3 11.71 19.27 24.14 28.46</td>
</tr>
<tr>
<td>2001</td>
<td>481 4.15 5.4 11.01 17.46 20.37</td>
</tr>
<tr>
<td>2002</td>
<td>529 2.26 2.83 9.26 15.12</td>
</tr>
<tr>
<td>2003</td>
<td>489 2.04 4.7 8.38</td>
</tr>
</tbody>
</table>

1995-99 N=2326
2000-03 N=2054

<table>
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<tbody>
<tr>
<td>3 YR 4 YR 5 YR 6 YR 7 yr</td>
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<tr>
<td>5.76 47.11 63.94 69.47 71.15</td>
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<td>6.25 51.11 67.63 71.65 72.99</td>
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<tr>
<td>4.86 47.87 63.69 67.34 68.96</td>
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<td>4.04 48.58 63.56</td>
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<td>4.5 43.42</td>
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<td>2.91</td>
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Average Graduation Rate 1995-1997: 70.96

Table 7 – RIT’s Female enrollment and graduation data 1995-2003.
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<th>Males</th>
<th>Attrition After:</th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>1 QTR</td>
<td>2 QTR</td>
<td>1 YR</td>
<td>2 YR</td>
<td>3 YR</td>
<td>4 YR</td>
<td>5 YR</td>
<td>6 YR</td>
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<tr>
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<td>40.05</td>
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<td>41.44</td>
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<td>5.59</td>
<td>15.52</td>
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<td>30.38</td>
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<tr>
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<td>5.88</td>
<td>13.72</td>
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<td>28.95</td>
<td>33.92</td>
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<tr>
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<td>6.13</td>
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<td>2003</td>
<td>1479</td>
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<td>5.4</td>
<td>11.02</td>
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</table>

1995-99 N=5575
2000-03 N=6128

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<td>4 YR</td>
<td>5 YR</td>
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<td>7 YR</td>
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<td>22.86</td>
<td>46.56</td>
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<td>55.19</td>
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Average Graduation Rate 1995-1997: 57.1

Table 8 – RIT’s Male enrollment and graduation data 1995-2003.
### College of Science: Female enrollment and graduation data 1995-2003

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<tr>
<th>Females</th>
<th>Attrition After:</th>
<th>Graduation % After</th>
<th>3 YR</th>
<th>4 YR</th>
<th>5 YR</th>
<th>6 YR</th>
<th>7 YR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td>N 1 QTR 2 QTR 1 YR 2 YR 3 YR 4 YR 5 YR 6 YR 7 YR</td>
<td>3 YR</td>
<td>4 YR</td>
<td>5 YR</td>
<td>6 YR</td>
<td>7 YR</td>
<td></td>
</tr>
<tr>
<td>---------</td>
<td>-------------------------------------------------</td>
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<td>------</td>
<td>------</td>
<td>------</td>
<td></td>
</tr>
<tr>
<td>1995</td>
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<td>5.94</td>
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<td>75.24</td>
<td>76.23</td>
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<tr>
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<td>55.04</td>
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<td>67.88</td>
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<tr>
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<td>1.58</td>
<td>58.73</td>
<td>65.07</td>
<td>68.25</td>
<td>69.04</td>
<td></td>
</tr>
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<tr>
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<td>57.67</td>
<td>67.39</td>
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<tr>
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<td>64.15</td>
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Average Graduation Rate 1995-1997: 71.72

Table 9 – College of Science: Female enrollment and graduation data 1995-2003.
<table>
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<th>Attrition After</th>
<th>College of Science:</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Fall N 1 QTR 2 QTR 1 YR 2 YR 3 YR 4YR 5YR 6 YR 7 YR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1995</td>
<td>95</td>
<td>1.05 3.15 12.63 23.15 25.26 31.57 35.78 36.84 33.68</td>
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<tr>
<td>1996</td>
<td>104</td>
<td>2.88 3.84 12.5 20.19 25.96 26.92 32.69 31.73 31.73</td>
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<tr>
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<td>0.93 4.67 16.82 20.56 32.71 40.18 40.18 40.18 38.31</td>
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<td>1998</td>
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<td>5.37 5.37 16.12 33.33 34.4 40.86 41.93 43.01</td>
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<td>110</td>
<td>2.72 3.63 15.54 25.45 28.18 28.18</td>
<td></td>
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<tr>
<td>2001</td>
<td>119</td>
<td>3.36 5.04 15.96 25.21 29.41</td>
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<tr>
<td>2002</td>
<td>132</td>
<td>6.81 9.84 15.9 28.78</td>
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<tr>
<td>2003</td>
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<table>
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<th>Graduation % After</th>
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Average Graduation Rate 1995-1997: 62.09

Table 10 – College of science: Male enrollment and graduation data 1995-2003.
### COS Female Graduation Percentages

#### Table 11 – Female Graduation Percentage Rates for 1995-2003

<table>
<thead>
<tr>
<th>Year</th>
<th>3 YR</th>
<th>4 YR</th>
<th>5 YR</th>
<th>6 YR</th>
<th>7 YR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class of 1995</td>
<td>5.94</td>
<td>55.44</td>
<td>70.29</td>
<td>75.24</td>
<td>76.23</td>
</tr>
<tr>
<td>Class of 1996</td>
<td>4.58</td>
<td>55.04</td>
<td>67.88</td>
<td>67.88</td>
<td>70.64</td>
</tr>
<tr>
<td>Class of 1997</td>
<td>1.58</td>
<td>58.73</td>
<td>65.07</td>
<td>68.25</td>
<td>69.04</td>
</tr>
<tr>
<td>Class of 1998</td>
<td>3.77</td>
<td>61.32</td>
<td>73.58</td>
<td>74.52</td>
<td></td>
</tr>
<tr>
<td>Class of 1999</td>
<td>2.17</td>
<td>57.6</td>
<td>67.39</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class of 2000</td>
<td>5.66</td>
<td>64.15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class of 2001</td>
<td>1.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 12 – Male Graduation Percentage Rates for 1995-2003
For this study only one stratum, namely gender, was considered. This is a potential flaw of the study. For instance, could it be possible that a large number of Asian males enrolled in the programs skewed the retention and graduation rates relative to females enrolled in the programs? Variables such as students’ major, grade point average (gpa), outcome (of voluntary, graduated, involuntary), suspensions, grades of D, F, or a W, probations, financial aid, ethnicity, First Year Enrichment course enrollment, and the year entered RIT, warrant future consideration.

In addition, another retention and graduation impact variable to study could be if the student transferred from another college or university. Studying these ancillary variables will

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**Table 13 – Rochester Institute of Technology and the College of Science male and female enrollment for the years 1995-2003.**

<table>
<thead>
<tr>
<th>Year</th>
<th>Institute Females</th>
<th>COS Females</th>
<th>Institute Males</th>
<th>COS Males</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>416</td>
<td>101</td>
<td>962</td>
<td>95</td>
</tr>
<tr>
<td>1996</td>
<td>448</td>
<td>109</td>
<td>1006</td>
<td>104</td>
</tr>
<tr>
<td>1997</td>
<td>493</td>
<td>126</td>
<td>1081</td>
<td>107</td>
</tr>
<tr>
<td>1998</td>
<td>475</td>
<td>106</td>
<td>1198</td>
<td>93</td>
</tr>
<tr>
<td>1999</td>
<td>494</td>
<td>92</td>
<td>1328</td>
<td>106</td>
</tr>
<tr>
<td>2000</td>
<td>555</td>
<td>106</td>
<td>1530</td>
<td>110</td>
</tr>
<tr>
<td>2001</td>
<td>481</td>
<td>83</td>
<td>1538</td>
<td>119</td>
</tr>
<tr>
<td>2002</td>
<td>529</td>
<td>108</td>
<td>1581</td>
<td>132</td>
</tr>
<tr>
<td>2003</td>
<td>489</td>
<td>110</td>
<td>1479</td>
<td>116</td>
</tr>
</tbody>
</table>
assist in understanding more completely, retention and graduation data of the student body at the university level and within the college of science.

For the first group of participants, students in the biology program that were studied using Chi-square distribution and the frequencies that were determined are as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Biology - Females</th>
<th>Biology - Males</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>(215*37)/337 = 23.6053</td>
<td>(122*37)/337 = 13.3947</td>
</tr>
<tr>
<td>1996</td>
<td>(215*50)/337 = 31.8991</td>
<td>(122*50)/337 = 18.1009</td>
</tr>
<tr>
<td>1997</td>
<td>(215*43)/337 = 27.4332</td>
<td>(122*43)/337 = 15.5668</td>
</tr>
<tr>
<td>1998</td>
<td>(215*41)/337 = 26.1573</td>
<td>(122*41)/337 = 14.8427</td>
</tr>
<tr>
<td>1999</td>
<td>(215*32)/337 = 20.4154</td>
<td>(122*32)/337 = 11.5846</td>
</tr>
<tr>
<td>2000</td>
<td>(215*44)/337 = 28.0712</td>
<td>(122*44)/337 = 15.9288</td>
</tr>
<tr>
<td>2001</td>
<td>(215*24)/337 = 15.3116</td>
<td>(122*24)/337 = 8.6884</td>
</tr>
<tr>
<td>2002</td>
<td>(215*35)/337 = 22.3294</td>
<td>(122*35)/337 = 12.6706</td>
</tr>
<tr>
<td>2003</td>
<td>(215*31)/337 = 19.7774</td>
<td>(122*31)/337 = 11.2226</td>
</tr>
</tbody>
</table>

Chi-square was computed subtracting the expected frequency from the observed frequency of each cell, squaring the difference and dividing by the specified cell’s expected frequency. The outcome of each cell is totaled to achieve the Chi-square value (Lehmkuhl, 1996). For this group of students Chi-square = \( X^2 = 13.59763826 \).

Consulting the National Institute of Standards and Technology (NIST) ITL’s table of Chi-square values, using 8 degree of freedom and the 0.05 - level of significance, it is found that a minimum value of 17.535 deems the observed frequency to be considerably different from the expected frequency. In this example, the value of 13.59763826 does not exceed that minimum value; therefore the observed values and the expected values are not drastically different from each other.
For the second group of participants, students in the biotechnology with bioinformatics option program that were studied, frequencies were found to be:

<table>
<thead>
<tr>
<th>Biotechnology with bioinformatics option - Females:</th>
<th>Biotechnology with bioinformatics option - Males:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995: = Not computed</td>
<td>1995: = Not computed</td>
</tr>
<tr>
<td>1996: = Not computed</td>
<td>1996: = Not computed</td>
</tr>
<tr>
<td>1997: = Not computed</td>
<td>1997: = Not computed</td>
</tr>
<tr>
<td>1999: = Not computed</td>
<td>1999: = Not computed</td>
</tr>
<tr>
<td>2000: = Not computed</td>
<td>2000: = Not computed</td>
</tr>
<tr>
<td>2001: (13*14)/41 = 4.439</td>
<td>2001: (28*0)/41 = 9.561</td>
</tr>
<tr>
<td>2002: (13*17)/41 = 5.3902</td>
<td>2002: (28*0)/41 = 11.6098</td>
</tr>
<tr>
<td>2003: (13*10)/41 = 3.1707</td>
<td>2003: (28*0)/41 = 6.8293</td>
</tr>
</tbody>
</table>

The result for Chi-square = $X^2 = 2.133981533$. Consulting the table of Chi-square values again, using 2 degree of freedom and the 0.05 - level of significance, it is found that a minimum value of 7.378 deems the observed frequency to be considerably different from the expected frequency. In this example, the value of 2.133981533 does not exceed that minimum value; therefore the observed values and the expected values are not drastically different from each other.

For the third group of participants, students in the biotechnology program that were studied, the frequencies were:
Once more the Chi-square is calculated by obtaining the difference between the observed and expected frequencies in each cell for all of the participants, then squaring that difference and dividing by the expected frequency of that particular cell. Each cell outcome is added, and the total becomes the value of the Chi square. For this group of data Chi-square = $X^2 = 18.97949407$.

Consulting the table of Chi-square values again, using 8 degree of freedom and the 0.05 - level of significance, it is found that a minimum value of 17.535 deems the observed frequency to be considerably different from the expected frequency. In this example, the value of 18.97949407 does exceed that minimum value; therefore the observed values are drastically different from the expected values.

Participants that were not studied were students enrolled in the bioinformatics and environmental science programs as those programs were newer and there was not a sufficient amount of data available for the years 1995-2003.

This study examined the affect of gender on students’ graduation date to understand the affect of gender on student retention at RIT. The study of the biological science students in the biology and biotechnology with bioinformatics option showed that with the probability of
random selection it was highly *unlikely* that their graduation date was affected by their gender.

The study of biotechnology science students showed that with the probability of random selection it was highly *likely* that their graduation date was affected by their gender. As noted earlier more males were enrolled in biotechnology and more females were enrolled in biology for the years 1995-2003.
Chapter 5: Conclusion

The role of gender in education and careers in science will continue to have the same outcomes if “status quo” remains to be the paradigm. Gender bias not only harms both sexes it is detrimental to the future of the world. Inroads and investments have been made to pave the way for change. Literature regarding the future of science education, retention, a looming science crisis and the future of U.S. innovation and security, as highlighted in this thesis, gives credence to both the positive and negative sides of the argument.

Research on the impact of gender on education certainly deserves our attention. Retention programs have been researched, documented and implemented for decades and yet large portions of undergraduate students still do not persist in college. It appears to be even more challenging for the sciences. Continually achieving the same or similar results equates to the need for a shift in culture. Recognized organizational culture scholar, Peter Senge, asserts “most change initiatives fail” (p. 5). He explains that you cannot create a new culture. You can only immerse yourself in the culture to understand it. Immersing in the institutional culture will lead to the renewed insight that solutions will not be simple or linear. They will have many layers.

As acknowledged in the introduction, Tinto (1993) stated retention efforts that work in all cases is “having institutions assess the needs of each and every individual and treat those needs on a person-by-person basis… that the institution exists to serve the needs of the individual, not the group” (p. 191). As the world becomes more competitive, global, and more flat – according to Thomas L. Friedman - it’s more important than ever before for institutions to know the needs of their students, also known as customers. Current retention solutions appear to
focus on programs for retention of freshman and sophomores where it is believed to be the most critical time in students’ persistence rates.

The tactics RIT’s Retention Task Force recommended for improving retention for freshman include:

1) a strong faculty advising system that allows the opportunity to develop a faculty connection, 2) early warning system that tracks academic performance of freshmen, 3) attracting high quality first-year students, 4) creating learning communities that keep a small group of students together in courses that last over a period of time, 5) teaching excellence; putting the very best teachers in freshman classrooms, 6) research opportunities to ensure a positive faculty-student interaction, 7) departmental traditions like “board game night,” 8) gathering places that are comfortable and convenient, 9) stress reduction as realistically as possible, 10) first-year enrichment for credit course that include coping and time management skills, 11) on-campus employment, 12) summer orientation with active participation by faculty, 13) student interaction through housing plans, and activities, 14) social activities and spaces to form affinity with the university, and 15) minority student programs that focus on academic intervention and opportunity to work together. (pp. 16-30).

A quick perusal of these recommendations, one notices that most of these would be important to have in place for all students. Additional recommendations could have included fulfilling the needs of all students, male and female, and recommendations for their total educational experience.
Pine and Gilmore, authors of The Experience Economy, take the position that firms/institutions must recognize that goods and services are no longer enough; customers now want transformation experiences. These experiences assist individuals in realizing aspirations and sustain those objectives throughout time. They highlight Harvard Business School. Harvard transforms individuals with its immense resources that are readily available, such as professors, courses, the *Harvard Business Review* and Harvard Business School Press, newsletters, web sites among many other resources, and grooms individuals to face challenges. Institutions aiming to achieve this standard for their students/customers will need to stretch their view of their core business consisting of selling books, courses, and degrees to viewing their business as changing customers.

As the future of science is debated and retention concerns persist it will continue to be of the utmost importance for institutions to know their customers and to offer transformational experiences – that last beyond their educational journey, and to take a look at their institutional/organizational system for answers that provide solutions regarding gender equity retention challenges and scientific innovation that transcends goodness to greatness.

**Recommendations:**

The findings of this study have implications for administrators and educators in understanding the impact of gender on student persistence in the biotechnology program. A possible task RIT, as well as biology program administrators, could undertake is creating a balanced scorecard. The balanced scorecard examines four perspectives of an organization: financial, customer, internal-business-process and the learning and growth perspective. This
allows for a systems view of the organization/institution and the several processes that are involved in the daily operations. Processes impact all aspects of an organization.

Although more research needs to be done, additional recommendations for the biotechnology program include: forming a task force to study the issue of gender impact on graduation and identify those students that may have experienced gender bias and evaluate and recommend solutions, institute an exit interview policy whereby students discuss with administrator the issues that lead to their decision to depart and document those issues, create and administer a survey focused on gender issues for student feedback, coordinate focus groups of biotechnology students for more immediate feedback, develop supportive social and educational activities for students in the biotechnology program at all year levels, possibly implement a big sister/brother program, develop faculty workshops for training faculty on awareness of gender issues in the classroom, and the importance of their role in advising and mentoring, meet with male and female alumnae of the biotechnology program to gain their educational experience feedback. The department should facilitate these initiatives on a regular basis. Combining the study of both academic and non-academic factors will create a more complete picture of student issues impacting retention.
Definition of Terms

**Applied Research**: Applied research is aimed at gaining knowledge or understanding to determine the means by which a specific, recognized need may be met. In industry, applied research includes investigations oriented to discovering new scientific knowledge that has specific commercial objectives with respect to products, processes, or services.


**Anthropological concepts**: The scientific study of the origin, the behavior, and the physical, social, and cultural development of humans.


**Attrition**: The departure of persons from individual institutions. Tinto, V., Leaving College (1993), pg. 8.

**Bachelor’s degree**: An academic degree conferred by a college or university upon those who complete the undergraduate curriculum. Also called *baccalaureate*.  

**Chi-square distribution**: chi-square distribution (also chi-squared or $\chi^2$ distribution) is one of the most widely used theoretical probability distributions in inferential statistics, i.e. in statistical significance tests. It is useful because, under reasonable assumptions, easily calculated
quantities can be proven to have distributions that approximate to the chi-square distribution if the null hypothesis is true.  [http://en.wikipedia.org/wiki/Chi_square 1/3/08](http://en.wikipedia.org/wiki/Chi_square 1/3/08)

**Crisis:** a crucial stage or turning point in the course of something.  
[http://wordnet.princeton.edu/perl/webwn?s=crisis&o2=&o0=1&o7=&o5=&o1=1&o6=&o4=&o3=&h=000](http://wordnet.princeton.edu/perl/webwn?s=crisis&o2=&o0=1&o7=&o5=&o1=1&o6=&o4=&o3=&h=000) Jan. 21, 2008.

**Diversity:** recognizing, appreciating, valuing, and utilizing the unique talents and contributions of all individuals regardless of age, career experience, color, communication style, culture, disability, educational level or background, employee status, ethnicity, family status, function, gender, language, management style, marital status, national origin, organizational level, parental status, physical appearance, race, regional origin, religion, sexual orientation, thinking style, speed of learning and comprehension, etc.  

**Economic Prosperity:** state of growth with rising profits and full employment.  

**Ethnic Minority:** a group that has different national or cultural traditions from the majority of the population.  

**Gender Equity:** means fairness and justice in the distribution of benefits and responsibilities between women and men.  It often requires women-specific program and policies to end existing inequalities.  Source: Transforming health systems: gender and rights in reproductive health. WHO, 2001
Global: involving the entire earth; not limited or provincial in scope.

http://wordnet.princeton.edu/perl/webwn?s=global&sub=Search+WordNet&o2=&o0=1&o7=&o5=&o1=1&o6=&o4=&o3=&h=0  Jan. 24, 2008.

GPA: a measure of a student's academic achievement at a college or university; calculated by dividing the total number of grade points received by the total number attempted.

http://wordnet.princeton.edu/perl/webwn?s=gpa&o2=&o0=1&o7=&o5=&o1=1&o6=&o4=&o3=&h=00  Jan. 24, 2008


Intrapsychically: Existing or taking place within the mind or psyche.


Leadership: is less a role or set of strategies and more a point of view. It is a viewpoint that results from creating meaning, and learning from, the events and relationships of a leader’s lifetime.  http://www.netlibrary.com.ezproxy.rit.edu/Reader/  Jan. 21, 2008

Learning styles: the interaction between learning characteristics, the nature of the task and the learning environment. (Education Canada. 2003, Vol. 43, no 2, Spring, p. 1).

Longitudinal: pertaining to research design or survey in which the same subjects are observed repeatedly over a period of time. (http://dictionary.reference.com/browse/longitudinal)

Percentile: any of the 99 numbered points that divide an ordered set of scores into 100 parts each of which contains one-hundredth of the total.

http://wordnet.princeton.edu/perl/webwn?s=percentile&o2=&o0=1&o7=&o5=&o1=1&o6=&o4=&o3=&h=  Jan. 21, 2008
**Peer:** a person who is of equal standing with another in a group.


**Persistence:** continuing or recurring; prolonged.


**Precollege:** educational years K-12.

**Postsecondary:** Education beyond the secondary level, especially education at the college or university level. [http://www.answers.com/topic/higher-education](http://www.answers.com/topic/higher-education) Jan. 21, 2008

**Retention:** The rate at which a percentage of entering students complete their college degree programs within a seven-year period.

**Science:** derives from the Latin *scientia*, knowledge, the present participle of *scire*, to know. (Ambrose, S., et al, p. 2).

**Socialization:** the adoption of the behavior patterns of the surrounding culture.

[http://wordnet.princeton.edu/perl/webwn?s=socialization&o2=&o0=1&o7=&o5=&o1=1&o6=&o4=&o3=&h=0000](http://wordnet.princeton.edu/perl/webwn?s=socialization&o2=&o0=1&o7=&o5=&o1=1&o6=&o4=&o3=&h=0000) Jan. 21, 2008

**S.T.E.M.:** Science, Technology, Engineering and Mathematics.

**Tenure:** commonly refers to life tenure in a job and specifically to a senior academic's contractual right not to be fired without cause. [http://en.wikipedia.org/wiki/Tenure](http://en.wikipedia.org/wiki/Tenure) Jan. 21, 2008

**Undergraduate:** A student in a university who has not yet taken a degree, and thus is still below the academical standing of a graduate. (OED, http://dictionary.oed.com/cgi/entry/50204726?single=1&query_type=word&queryword=retention&first=1&max_to_show=10).
**Workforce:** is the labor pool in employment. It is generally used to describe those working for a single company or industry. The term generally excludes the employers or management and implies those involved in manual labor. It may also mean all those that are available for work.  [http://en.wikipedia.org/wiki/Workforce](http://en.wikipedia.org/wiki/Workforce) Jan. 21, 2008.
References


Chi Square Test (n.d.). Chi-square should not be calculated if the expected value in any category is less than 5 heading, section 5a. Retrieved Feb. 1, 2008 from Penn State Lehigh Valley web site: http://www2.lv.psu.edu/jxm57/irp/chisquar.html


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http://proquest.umi.com.ezproxy.rit.edu/pqdweb?index=4&did=609464591&SrchMode=3&sid=1&Fmt=10&VInst=PROD&VType=PQD&RQT=309&VName=PQD&TS=1203037114&clientId=3589&aid=1


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