Tracking Chemistry Self-Efficacy and Achievement in a Preparatory Chemistry Course

Carmen Alicia Garcia

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Tracking Chemistry Self-Efficacy and Achievement in a Preparatory Chemistry Course

by

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A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy
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Key words: Higher education, HLM, gender differences, ethnicities, SAT scores

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DEDICATION

I dedicate this work to my husband, Luis Humberto, my daughter Alicia, my son Rodrigo, my father Ignacio, and my mother Carmela (may she rest in peace) for all their love and support.
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Self-efficacy is a person’s own perception about performing a task with a certain level of proficiency (Bandura, 1986). An important affective aspect of learning chemistry is chemistry self-efficacy (CSE). Several researchers have found chemistry self-efficacy to be a fair predictor of achievement in chemistry. This study was done in a college preparatory chemistry class for science majors exploring chemistry self-efficacy and its change as it relates to achievement. A subscale of CAEQ, Chemistry Attitudes and Experiences Questionnaire (developed by Dalgety et al, 2003) as well as student interviews were used to determine student chemistry self-efficacy as it changed during the course. The questionnaire was given to the students five times during the semester: in the first class and the class before each the four tests taken through the semester. Twenty-six students, both men and women, of the four major races/ethnicities were interviewed three times during the semester and events that triggered changes in CSE were followed through the interviews. HLM (hierarchical linear modeling) was used to model the results of the CSE surveys. Among the findings, women who started at significantly lower CSE than men accomplished a significant gain by the end of the
semester. Blacks’ CSE trends through the semester were found to be significantly different from the rest of the ethnicities.
Chapter I Introduction

Chemistry is considered a difficult subject by most students (Cousins, 2007), even by those who say they like it. General chemistry is at the core of many science major’s curriculum, so success in it is desirable. A fair percentage of those students who attempt general chemistry either drop it, changing majors at times, or have to retake it. Women and minorities continue to be underrepresented in the STEM careers. This translates into a special interest in recruiting and encouraging these segments of the population toward pursuing scientific careers. Retaining students in chemistry goes beyond the importance of maintaining a competitive leadership in science.

In an effort to alleviate attrition as a chronic problem, educators and researchers have looked into different strategies to identify and improve factors that promote success of at-risk students (Grove, 2008; Lewis & Lewis, 2005, 2007, 2008; Mahalingam, 2008; Mills et al 2009; Wagner et al, 2002). Different pedagogical classroom reforms have been implemented across all levels of science education for the last couple of decades. Such reforms include inquiry and cooperative learning, as well as combinations of both (Geier, 2008; Linn, 2007; Lyman, 1992). Subsequent effectiveness studies of these reforms have been the focus of educational research for some years after implementation. (Lewis & Lewis, 2008; Schroeder, 2007). Affective aspects of learning chemistry have not been thoroughly investigated, aspects such as self-efficacy. It is likely that addressing
teaching pedagogies in the classroom and affective aspects of learning could improve attrition and reinforce student motivation for learning chemistry.

Self-Efficacy Theoretical Background

*Self-efficacy*, a concept that emerged from Albert Bandura’s Social Cognitive Theory (1986), is an aspect of learning that has recently stirred the interest of education researchers. Self-efficacy is defined as one’s perception of his/her own ability to perform a certain task with a certain level of proficiency. Self-efficacy is task-specific and context-specific. Self-efficacy is relevant because, if someone doesn’t feel able to do something like learning science, he/she won’t even try it. According to Bandura (1997), there are four sources of self-efficacy: mastery experience, vicarious experience, social persuasion and physiological states. Mastery experience refers to a person’s own experience performing a task. For example, when someone hits a baseball, the act of hitting a ball is the actual experience. Vicarious experience refers to the perception that one is capable of doing something because someone similar to oneself can do it, too. For example, I feel my sister and I are similar and, if my sister can hit a baseball, I feel that I can as well. Social persuasion occurs when an individual is encouraged by someone else to perform a certain task. For example, if my sister tells me that I can do it, I feel I can hit a ball. Physiological states refer to the anxiety that one must endure when one performs the task, for example, the anxiety experienced when one has to hit the ball in a situation where the team needs a hit to complete a run.

Self-efficacy is cyclical in its nature: it increases with positive experiences and decreases with negative experiences. There are all sorts of positive outcomes for those
with high self-efficacy such as longer perseverance in the face of adversity when pursuing a task, higher achievement, deeper interest. Complementary, someone with low self-efficacy will not only delay his/her attempts to accomplish the desired task but after weak trials very likely give up all together.

Self-Efficacy and Achievement in the Literature

Several studies on self-efficacy have investigated its predictive power of academic performance (Multon, Bown & Lent, 1991; Chemers et al., 2001; Pajares, 2002; Kan, 2006; Lawrenz et al 2009). Lalich et al. (2006) found a correlation (r=.35) between self-efficacy and final achievement in a general chemistry course and Kan (2006) found a correlation (r=.29) between self-efficacy and achievement in chemistry. Some researchers have a valid concern with students’ ability to assess their own capabilities (Lawson, 2007; Hansen, 2008).

Self-efficacy is task-specific and science self-efficacy implies a certain confidence to learn science. However, science is a wide field of expertise: Learning earth sciences is different from life sciences (Lawson et al, 2007) and physical sciences (Britner, 2008). Recently research in science and mathematics self-efficacy became a relevant topic for education research (Pajares, 2002). Currently, there is an ever-increasing body of literature about self-efficacy for biology, engineering, physics and chemistry. In terms of the instructional level there are studies done in elementary school (Lloyd et al, 2005), middle school (Pajares, 1996; Britner, 2006), high school (Kan, 2006; Cousins, 2007; Britner 2008) and college (Cavallo, 2006; Chemers, 2001; Dalgety, 2006; Fencl, 2005; Lawson et al, 2007; Marra, 2009). Some of the studies were qualitative in nature
(Huchinson-Green, 2008; Zeldin & Pajares, 2000; Zeldin et al, 2006) others were quantitative (Britner & Pajares, 2006; Chemers, et al, 2001; Garcia & Coppola, 1992; Hutchison, 2006) or mixed methods (Dalgety & Coll 2006). Several instruments have been developed to evaluate self-efficacy in the classroom (Baldwin, 1999; Dalgety, Coll & Jones, 2003; Silver et al, 2001; Esen & Ye_im, 2008; Fencl, 2005).

Almost every study done on self-efficacy has found differences between genders; in general, men tend to have higher self-efficacy than women although women may be just as capable as men (Lloyd et al, 2005; Michaelides, 2008; Pajares, 1996, 2002). Test anxiety has been found to be another gender related difference with women typically experiencing higher level of anxiety during tests (Garcia & Coppola 1993; Britner, 2008; Lynch, 2008; McCarthy & Widanski, 2009). Fencl & Scheel (2005) did a study on self-efficacy in the physics classroom; they investigated the effect of different teaching strategies on physics self-efficacy. They found that self-efficacy is a predictor of achievement and that teaching strategies affect self-efficacy. Cooperative learning was found to have the highest correlation to all sources of self-efficacy.

Dalgety & Coll developed the Chemistry Attitudes and Experiences Questionnaire, CAEQ (2003), an instrument specific for chemistry. Later on these authors conducted a one-year, mixed-methods, longitudinal study on first-year college chemistry (2006) students; they administered the instrument three times. The results of the questionnaire were triangulated via interviews. The researchers were unable to track student identities through the year, and they analyzed the data one question at a time. Among their findings, the authors claimed that students seemed to have increased their chemistry self-efficacy; however, as exposed by the researchers, the increase might be
associated with students with low self-efficacy leaving the course. The gender differences in self-efficacy were also part of their findings; men had higher self-efficacy than women. The qualitative aspect of the study revealed that students were less confident about tutoring peers, about their own study skills for chemistry specifically and about their mathematical ability, gender differences were found in the interviews as well, men had higher self-efficacy than women.

Zeldin and Pajares (2000) studied self-efficacy beliefs of women in STEM careers and found that vicarious experiences and verbal persuasions were extremely important sources of self-efficacy for women even though mastery experiences are thought to be the main and most important sources of self-efficacy in general. Zeldin, Britner and Pajares (2006) performed a comparative study of the self-efficacy beliefs of successful men and women in STEM careers. They suggested that self-efficacy beliefs sustain women in their quest to persevere and succeed in a male dominated environment. Women described their sense of self-efficacy as being supported by vicarious experiences and social persuasion from the significant people in their lives. Men’s main sources of confidence were mastery experiences and in general demonstrated a strong and stable sense of self-efficacy.

Hutchison et al. (2006) developed a survey to identify the factors that influence student’s self-efficacy beliefs that specifically drive them to obtain desired outcomes. Nine categories emerged in the factors that influence self-efficacy: understanding of the material, motivation towards success, teaming issues, computing abilities, availability of help, and availability to access help, issues about doing assignments, problem solving abilities, enjoyment, interest and satisfaction. Some gender differences in the importance
of these factors were found as well. Also Hutchison (2007) found that second year college students have higher self-efficacy than first year students.

Hutchison-Green et al (2008) performed a qualitative investigation of the impact of first-year engineering experience on students’ efficacy beliefs and found gender differences in the way men and women are influenced by these experiences. Three months into the semester participants had changed their sources of self-efficacy beliefs from their high school experiences (mastery) to vicarious; although they were experiencing mastery. This was in agreement with the Self-Efficacy Theory (Bandura 1997) that asserts that vicarious experiences gain relevance when mastery experiences are scarce or non-existent. Meaning that students were having new experiences as freshman, their high school experiences did apply in this new context. Other findings included that men were more likely to focus on the positive experiences while women focused on the negative ones. Men also had higher computer self-efficacy while women tended to underestimate their abilities in general.

Marra et al (2009) in their longitudinal and across institutions study of women engineering students’ self-efficacy found that, although women have made progress in gaining self-efficacy in some aspects a feeling of exclusion is still pervasive, particularly for African-American women. The authors claimed that sources of self-efficacy impact women regardless of their ethnicity.

Our Study

According to Self-Efficacy Theory, positive experiences reinforce self-efficacy (Bandura, 1986, 1997). Based on this premise going over chemistry basic concepts in
general chemistry after a preparatory course might have this kind of re-enforcing effect: a second time might have just that effect for those who take preparatory chemistry.] Seery (2009) examined the effect of prior knowledge on performance in undergraduate chemistry and found a strong correlation suggesting that a semester of preparatory chemistry is very likely to increase prior knowledge as well as chemistry self-efficacy. Eddy (2000) found that chemistry anxiety was higher for students with two or fewer chemistry courses. This finding supports the idea that a preparatory chemistry course improves self-efficacy. There are few studies about self-efficacy stability (Smist, 1993; Dalgety & Coll 2006) in the literature and, to the best of our knowledge there is none about the effect of reinforcing chemistry basics in minority students. Small sample numbers of minorities are probably a problem.

White men who still dominate the STEM fields have long perceived minority students such as Blacks, Hispanics and women as lacking abilities in these fields. Steele (1992) and Steele & Aaronson (1995) defined this as stereotype threat and its effect is felt as diminished achievement in many contexts due to stress, anxiety, and, decreased enjoyment. Social and educational psychologists have developed a body of literature since, on stereotype threat. Since self-efficacy and achievement influence each other it would be natural to investigate the possible connection with stereotype threat in today’s educational environments where diversity pervades.

The purpose of the present study is to track the variation of student chemistry self-efficacy (CSE) throughout a one-semester experience in a preparatory college chemistry course and its connections to achievement in relation to gender and ethnicity.
Research Questions

The research questions that guide this study are:

1- How does students’ CSE change during a semester of college preparatory chemistry? Does it vary the same by gender or by ethnicity?

2- Is the relationship between students’ CSE and achievement the same for men and for women? Are there ethnicity related differences?

3- What are the sources of CSE described by students through the semester? Are the sources of student CSE different for different kinds of students in terms of chemistry self-efficacy?

The following chapter is a description of an assessment done for the preparatory course in which the data for our study was collected. This assessment was done post Preparatory Chemistry in General Chemistry I and used some achievement measures as well as drop out rate.
Chapter II Assessment of a College Chemistry Preparatory Chemistry Course

Introduction

Chapter II introduces a study developed to assess the effectiveness of the Preparatory Chemistry Course utilized in the main study of this dissertation. This work was preliminary to set the foundations for further research on student chemistry self-efficacy. The University of South Florida Department of Chemistry offered a Preparatory Chemistry course for the first time in Fall 2006. The purpose of this Preparatory Chemistry course was to serve potential science majors who had not taken high school chemistry and or those who had previously taken high school chemistry but had low SAT Math scores or had taken chemistry several years prior to enrolling in General Chemistry. The premise for implementing this course lied on research evidence showing that the more courses or hours of chemistry taken by students the better their confidence and achievement would be (Boujaoude & Giuliano, 1991; Harrison, 2003; Youl et al, 2005; Seery, 2009). The Department of Chemistry also developed a survey tool (First Day Survey) to better understand the student population served by this course (Appendix B). It became a pressing interest to determine the effectiveness of this Preparatory Course and its impact on achievement in subsequent chemistry courses.

The purpose of the study here introduced was to assess the performance of students who took Preparatory Chemistry and followed into General Chemistry I in comparison to students that did not. The data for this study was taken in the fall of 2006.
and the spring of 2007. This is a cohort previous to the one in which the rest if this dissertation was done.

Research Questions

1- Is the performance of students who took Preparatory Chemistry different from those who did not on the first General Chemistry I Exam?

2 - Is the achievement for students who took Preparatory Chemistry at a different level on the General Chemistry I Final Exam as those who did not?

3 – Considering the dropout rate in General Chemistry I was there a difference between those students who took Preparatory Chemistry and those who did not?

Method

Course Description and Setting

Preparatory Chemistry as a course for science majors was taught for the first time in the fall 2006. The course had two teaching components: a lecture, which met in a large lecture hall either two times a week for 75 minutes or three times a week for 50 minutes, and a weekly fifty-minute inquiry-guided chemistry activity session. Chemistry faculty taught lectures but study sessions were led by teaching assistants (TAs). Each TA facilitated the inquiry-based activities to up to 40 students working in groups of four students. TAs did not answer student questions directly but rather guided students to think and arrive to their own answers. The final exam for the Preparatory Chemistry course was the 2006 version of the California Chemistry Diagnostic High School Exam (California Final Exam) obtained from American Chemical Society, ACS.
Performance was assessed for students who took the Preparatory Chemistry course in Fall 2006 and then took General Chemistry I in Spring 2007 and compared to students who did not take the Preparatory Chemistry course. Hereafter, “Prep+Chem students” refers to participants who took the sequence of courses (N=161); “noPrep+Chem” refers to students who enrolled directly in General Chemistry I (N=322); students retaking General Chemistry were grouped under “repeat-Chem” (N=178), all-Chem students refers to the cohort of previous groups combined. First, a correlation study of the following measures was conducted for the Prep+Chem students: the Standard Achievement Test (SAT) math, the California Final Exam, and the first exam for General Chemistry I (Exam1). Second, a correlation study for scores from Exam 1 and the Final Exam for General Chemistry I (Final Exam) for all-Chem students was conducted. Third, the Exam 1 and Final Exam scores were compared for the three groups Pre+Chem and noPrep+Chem and repeat-Chem. Finally, the dropout rate for General Chemistry I was compared for these three groups. Correlations and analysis of variance (ANOVA) were done using SPSS OS X. Association studies using Chi-square were performed using SAS 9.0.

Description of the Population

One hundred and fifty of the 418 students that took Preparatory Chemistry in Fall 2006, went on to take General Chemistry I in Spring 2007. According to the results of the First Day Survey, students were mainly in their first year of college (90%) and the majority (69%) had taken one year of high school chemistry. Only a small percent did not have any chemistry in high school (6%). Out of this student population 15% were
not taking math, 11% were taking calculus, 37% were taking algebra and/or trigonometry and 37% were taking pre-calculus. The demographic distribution was as follows: 9% Asians, 15% Blacks, 22% Hispanics, and 66% Whites. Seventy one percent were women and the majority were US citizens (87%). Most students were going to pre-med or health-related fields (73%) and were expecting to get either an A (81%) or a B (19%) in the course.

Results

Correlations between SAT Math, California Final Exam and Exam 1 Scores for Prep+Chem students

Correlations between the SAT math, California Final Exam, and Exam 1 scores are presented in Table 2.1. Pearson's correlation coefficient $r$ measures the strength of the linear association between the California Final Exam and Exam 1, California Final and SAT Math, and Exam 1 and SAT Math scores. These correlations were all statistically significant. The strongest correlation $r = .440$ was between the California Final Exam and Exam 1 scores, and is a medium/large effect size (Cohen, 1988). This means that student performance on the California Final taken at the end of Preparatory Chemistry was moderately predictive of their performance the following semester on Exam 1 in General Chemistry I. The correlation $r = 0.282$ between California Final and SAT Math scores is a medium effect size, while the correlation $r = 0.184$ between SAT Math and Exam 1 scores is a small effect size correlation.
Correlation Between Exam 1 and Final Exam Scores

For all students that took General Chemistry I in Spring 2007, Exam I and Final Exam scores were correlated. A Pearson correlation of $r = 0.595$ was statistically significant and indicated a high effect level. This means that the student performance in the Exam 1 was predictive of their performance on the Final Exam. Exam score statistics are summarized in Table 2.2.

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Mean Score</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam 1</td>
<td>662</td>
<td>58.7%</td>
<td>16.0%</td>
</tr>
<tr>
<td>Final Exam</td>
<td>523</td>
<td>57.0%</td>
<td>14.5%</td>
</tr>
</tbody>
</table>

ANOVA for Exam 1

Table 2.3 shows the Exam 1 descriptive statistics for all students.

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean Score</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prep+Chem</td>
<td>161</td>
<td>61.0%</td>
<td>14.8%</td>
</tr>
<tr>
<td>noPrep+Chem</td>
<td>322</td>
<td>58.3%</td>
<td>16.7%</td>
</tr>
<tr>
<td>repeat-Chem</td>
<td>178</td>
<td>57.0%</td>
<td>15.4%</td>
</tr>
</tbody>
</table>

ANOVA results are presented in Table 2.4.

The calculated effect $f = 0.093$ was very small and indicates that Exam 1 mean scores were not statistically significant between groups. Post hoc power analysis showed that in
order to detect a small size effect \( (f=0.10) \) a sample of 300 students in each group was needed (Cohen, 1988).

### Table 2.4 ANOVA of Exam 1 Scores by Group

<table>
<thead>
<tr>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>Significance</th>
<th>( f )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between groups</td>
<td>2</td>
<td>58.72</td>
<td>29.41</td>
<td>2.91</td>
<td>0.55</td>
</tr>
<tr>
<td>Within groups</td>
<td>658</td>
<td>6,657</td>
<td>10.12</td>
<td></td>
<td>0.093</td>
</tr>
<tr>
<td>Total</td>
<td>660</td>
<td>6,715</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ANOVA for Final Exam

Table 2.5 shows the score distribution and statistics for the Final Exam.

### Table 2.5 Descriptive Statistics for Final Exam by Group

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>Std Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prep+Chem</td>
<td>144</td>
<td>56.6%</td>
<td>13.5%</td>
</tr>
<tr>
<td>noPrep-Chem</td>
<td>236</td>
<td>58.3%</td>
<td>15.3%</td>
</tr>
<tr>
<td>repeat-Chem</td>
<td>133</td>
<td>55.0%</td>
<td>13.9%</td>
</tr>
<tr>
<td>Total</td>
<td>523</td>
<td>57.0%</td>
<td>14.5%</td>
</tr>
</tbody>
</table>

ANOVA results for the Final Exam are presented in Table 2.6. The results show that Exam 1 mean scores were not statistically significant between groups.

### Table 2.6 ANOVA of Final Exam Scores by Group

<table>
<thead>
<tr>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>2</td>
<td>976.8</td>
<td>487.9</td>
<td>2.331</td>
</tr>
<tr>
<td>Within Groups</td>
<td>520</td>
<td>108,866.</td>
<td>209.4</td>
<td>0.098</td>
</tr>
<tr>
<td></td>
<td>522</td>
<td>109,842.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
ANOVA for Dropout Rate

By the end of the semester, 139 out of 662 students (21%) had dropped out of General Chemistry. The distribution by groups was: 2.6% for Prep+Chem, 11.6% for noPrep-Chem, and 6.8% for repeat-Chem as seen in Table 2.7. Percentages were calculated on the basis of total students that started General Chemistry I at the beginning of the semester (662).

<table>
<thead>
<tr>
<th>Group</th>
<th>Total</th>
<th>Dropped</th>
<th>Remained</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prep+Chem</td>
<td>162</td>
<td>17</td>
<td>145</td>
</tr>
<tr>
<td>noPrep-Chem</td>
<td>322</td>
<td>77</td>
<td>245</td>
</tr>
<tr>
<td>repeat-Chem</td>
<td>178</td>
<td>45</td>
<td>133</td>
</tr>
<tr>
<td>Total</td>
<td>662</td>
<td>139</td>
<td>523</td>
</tr>
</tbody>
</table>

Chi-Square test was run in SAS 9.0 to compare dropout rates. A Chi-square test was utilized to investigate the association between groups and dropout rate. The Chi-Square statistic was statistically significant (Chi-square <0.0001) as seen in Table 2.8. So there was a significant difference in dropout rates among the groups.

<table>
<thead>
<tr>
<th>Statistic</th>
<th>DF</th>
<th>Value</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi-Square</td>
<td>2</td>
<td>9.99</td>
<td>.0067*</td>
</tr>
</tbody>
</table>

* significant

When looking at the percentages of students that dropped out, the closest numbers are between the group of repeaters (repeat-Chem) and the group of students who had the Preparatory Chemistry experience (Prep+Chem), so another Chi–Square test was run to see if there was a statistically significant difference between these two groups. As can be seen in Table 2.9, there was a significant difference between the dropout rates of students in Groups Prep+Chem (10.5%) and no-Prep-Chem (23.9%). The effect size between
Groups Prep+Chem and no-Prep-Chem was calculated as \( w = (x^2/n)^{1/2} = 2.95 \), which is considered a large effect size.

Table 2.9 Chi-Square Test for Groups Prep+Chem and noPrep-Chem

<table>
<thead>
<tr>
<th>Statistic</th>
<th>DF</th>
<th>Value</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi-Square</td>
<td>1</td>
<td>8.71</td>
<td>0.0032*</td>
</tr>
</tbody>
</table>

*significant

Discussion and Implications

SAT Math scores have been used in the past as predictors of chemistry performance (Bunce & Hutchinson, 1993; Lewis & Lewis, 2005). We found evidence that supports SAT Math as an appropriate predictor for chemistry performance since we found that there was a positive and significant medium correlation (0.44) between SAT Math and student performance in high school chemistry (California Final) and a positive small correlation \( r=0.18 \) between SAT Math scores and the first General Chemistry I exam.

Students who took Preparatory Chemistry scored slightly higher than the rest of the students in Exam 1 in General Chemistry. Although there was a non-significant difference in the Exam 1 and California Final scores between the students who took Preparatory Chemistry and those who did not, it is possible that there will be other long-term benefits to having taken another chemistry course (Boujaoude & Giuliano, 1991; Harrison, 2003; Seering, 2009; Youl et al, 2005). Chemistry knowledge has hopefully been increased after a semester long course, adding to what is prior knowledge. For scientists, prior knowledge is of crucial importance, chemistry students in our case, as Harrison (2003) puts it "science is a successive building of prior knowledge and experience", in other words learning chemistry is a constructivist process: students build
their chemistry knowledge upon basic concepts and that is exactly why prior knowledge is important.

It is possible that the significantly lower dropout rate of those who took Preparatory Chemistry was due to increased confidence or self-efficacy in learning chemistry along with feeling better prepared for General Chemistry. Self-Efficacy Theory (Bandura 1987, 1997) establishes that individuals who have high self-efficacy tend to persevere longer when trying to perform a task such as learning chemistry successfully. The next step was to perform chemistry self-efficacy research in a Preparatory Chemistry course.

Conclusions

1- Student performance on the California Final Exam was moderately predictive of performance on General Chemistry I Exam 1, and performance on Exam 1 was predictive of performance on General Chemistry I Final Exam. SAT Math scores were somewhat predictive of exam scores.

2- Exam 1 and Final Exam scores of General Chemistry I students that took Preparatory Chemistry were not different from those students who did not.

3- Dropout rates of students in General Chemistry I were significantly lower for students that took Preparatory Chemistry than for those students who did not.

Students who took Preparatory Chemistry performed at the same level of achievement as those who did not in General Chemistry I for Exam 1 and for the Final Exam. Among students who took Preparatory Chemistry there was a significantly lower dropout rate for General Chemistry I than those who did not.
The following chapter contains the method used to collect and analyze the data in the fall of 2007 for our study tracking self-efficacy and achievement done after this evaluation. Quantitative and qualitative data were collected. The qualitative data includes a chemistry self-efficacy (CSE) questionnaire as well and achievement measures for which exam scores were used. The qualitative data includes interview data.
Chapter III Method

This chapter describes the methods utilized to perform the collection of quantitative and qualitative data for this study; a description of the population of participants is also included. Initially, all the common aspects to both methodological components will be presented, then the specifics for the quantitative and qualitative inquiry approaches will be described.

Setting, Instructor, and Participants

This study took place in a public southeastern research university of the United States in the fall of 2007. Preparatory Chemistry was taught in two sections, one at 9 am and the other at 1 pm, both by the same instructor. The class met for 50-minute lectures Monday, Wednesday and Friday in a big lecture hall. Once a week either on Fridays or Mondays students had to attend a 50-minute session of inquiry learning-activities during which three to five students worked in teams. There were up to 40 students in a classroom with a TA as a facilitator for the activities. The role of the facilitator was to guide students’ understanding and answer their own questions. Student questions were not answered directly by facilitators to make students think and reach their own conclusions. The participants could be all those students that were enrolled in the Preparatory Chemistry course and were willing to participate, there were 276 women and 116 men. In the course of the semester some students stopped turning in the
questionnaires although they did not leave the course. The instructor is an enthusiastic male whom the great majority of students seemed to like based on my observations. The instructor was very encouraging constantly during the lectures and in the exams expressing great confidence in the students’ capabilities also based on my observations.

A 16 question-survey addressing demographic aspects was given on the first day of classes. There were 449 students originally enrolled in preparatory chemistry for science majors in the fall of 2007 and 409 students finished the course. Of those who finished the course 404 were included in our study. Our cohort had 7.3% Asians, 18.7% Black, 18.7% Hispanic, 50.9% White, 0.8% American Indian, 3.6% reported other ethnicities or no ethnicity at all. There were 79% women and 29% men.

Most of the students were in their first year attending university (74.4%), 11.4% were attending their second year, 8.6% their third year, 1.4% in their fourth year, and 4.2% had already attended more than four years of university. Fourteen percent were transfers from another college. In terms of their majors, 3.6% were chemistry majors, 68.9% were pre-med or health related, 1.9% engineering, 22.8% were other sciences, and 2.8% were non-science majors. Most of the student population had taken chemistry in high school only a 12.2% had no previous chemistry. A 25.6% had high school chemistry for only one semester, 54.2% for two semesters, 6.4% had three or four semester and 1.7% had previously five semesters of chemistry or more.
Quantitative Methods

Measures of Achievement

There were four exams prepared by the instructor that were given throughout the semester at the time lecture was scheduled. The final exam (fifth exam) was given during final exam week. The final exam was the California High School Chemistry Diagnostic Exam version 2006 obtained through ACS. These five exams were used as student achievement measure for our study.

ANOVA was run on SAT math by ethnicity and MANOVA was run on the five exams by ethnicity as well to find possible significant differences in achievement among the four ethnic groups that make up our cohort.

Chemistry self-efficacy instrument

Nine self-efficacy questions specific to chemistry were appended to the first day survey I (Appendix B). These questions were chosen based on their pertinence to our study from the 17 self-efficacy questions in the self-efficacy scale of the CAEQ (Chemistry Attitudes and Experiences Questionnaire) by Coll, Dalgety & Salter (2003). The CSE (chemistry self-efficacy) questions not used from the CAEQ referred to a lab setting and do not apply to the course in the present study since it does not include a lab component. Among the CSE questions used there are five about student understanding of the properties of elements according to the periodic table, usage of formulas and units and four questions about chemistry applied to day to day life situations. Students entered responses to the demographic questions and the CSE questionnaire on a scantron sheet.
The CSE questions were answered on a five-point Likert scale ranging from not very confident (1) to very confident (5).

Other psychometric measures

A set of two instruments were employed to characterize participant students. These instruments were:

(a) The Test of Logical Thinking, TOLT (Tobin, 1981)
(b) The Group Assessment of Logical Thinking (Roadrangka et. al., 1983)

Both, TOLT and GALT are used to determine if students have reached the stage of formal thinking. The developmental stage of formal thinking has been strongly associated with the learning chemistry. Either of these tests were randomly given to students at the beginning of the course.

Study Design

This study followed a mixed methods design. The quantitative component was done using the CAEQ questionnaire for measures of CSE and exams for measures of achievement. The qualitative portion used interviews as main source of data. This design is sequential in which the qualitative component follows the quantitative part and provides explanations using the interview data.

In total students were given five CSE surveys through the semester: the first day of class and then on the class before each one of the first four exams. Exams were administered at the end of each Instructional Unit. CSE questionnaires marked the end of an Instructional unit and they were labeled accordingly. Instructional Unit 0 corresponds to the first administration of the CSE questionnaire the first day of classes. Instructional
Unit 1 corresponds to the administration of CSE questionnaire 2 prior to the Exam 1 and so on. So basically the Instructional Units mark administration the CSE questionnaire and/or Exams were administered along the semester after a period of instruction.

Scores were saved on a hard disk as electronic files. The last CSE survey was given before the fourth exam. Each time a new batch of data was read and recorded and reviewed to ensure there were no mistakes in recording of names and/or scores. Once the data collection was finished descriptive statistics were calculated and records were cleaned for further use.

Not all students completed the five questionnaires given through the semester. There were 162 students with complete sets of questionnaires and there were students with 1, 2, 3, or 4 questionnaires missing. A total of 21% of the questionnaires were not turned in or missing. I wanted to include all students in the study and I also wanted to investigate what was the story with those students that did not complete all the CSE questionnaires.

CSE data was divided into two categories: one consisted of those students who had complete sets of CSE questionnaires (five total) and the other, those students who had incomplete sets of CSE questionnaires (less than five total). I will refer to Complete and/or Incomplete Sets from now on and in some cases all data collected will be referred to as entire data.

The dates for CSE questionnaires and exams were administered are as seen in Table 3.1:
Table 3.1 Data Collection Dates

<table>
<thead>
<tr>
<th>CSE 0</th>
<th>CSE 1</th>
<th>Exam 1</th>
<th>CSE 2</th>
<th>Exam 2</th>
<th>CSE 3</th>
<th>Exam 3</th>
<th>CSE 4</th>
<th>Exam 4</th>
<th>Exam 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aug 27</td>
<td>Sep 26</td>
<td>Sep 28</td>
<td>Oct 24</td>
<td>Oct 26</td>
<td>Nov 16</td>
<td>Nov 19</td>
<td>Dec 5</td>
<td>Dec 7</td>
<td>Dec 11</td>
</tr>
</tbody>
</table>

Because I did many comparisons between different groups and many times it is not practical to run significance test for each comparison. To summarize differences between groups, I calculated effect size as Cohen’s d (that expresses the difference in means between two groups in standard deviations)

\[ d = \frac{(X_1 - X_2)}{S_{pooled}} \quad \text{where} \quad S_{pooled} = \sqrt{\frac{\left(\frac{n_1}{n_1 - 1}\right)S_1^2 + \left(\frac{n_2}{n_2 - 1}\right)S_2^2}{n_1 + n_2 - 2}} \]

\( \bar{x}_1 \) is the mean of group 1, \( \bar{x}_2 \) the mean of group 2, \( n_1 \) is the sample size for group 1, \( n_2 \) is the sample size for group 2, \( S_1^2 \) is the variance for group 1, and \( S_2^2 \) is the variance for group 2. According to Cohen, \( d = 0.2 \) small, \( d = 0.5 \) medium, \( d = 0.8 \) large.

As a measure of internal consistency, Cronbach alpha was run for each time the questionnaire was administered and the results were: .88, .85, .90, .91, .91. These are good results since a minimum of .7 is required for a minimum coefficient of internal consistency, otherwise the results of a questionnaire are unreliable. To investigate the structure of the instrument, exploratory factor analysis (EFA) was performed on the data using SAS 9.2 and one factor was found confirming the results reported by the authors of the instrument. Cronbach alpha and CFA were run in both SPSS11 and SAS 9.2 with same results.

Repeated measures ANOVA done in SAS 9.2 was used to analyze the longitudinal data but only complete sets of data can be used for that analysis. HLM
Hierarchical Linear Modeling (HLM) has proven to be better for studying and understanding individual and or group change across time (Russell, 2004) more effectively than repeated measures ANOVA. The one big advantage of HLM is that all data collected, including incomplete sets of questionnaires can be used in the analysis. Incomplete sets of questionnaires were of particular interest in this study because those students with missing questionnaires had lower CSE than those with complete sets.

By using HLM to analyze the longitudinal data one can summarize and provide a more precise characterization of individual and group growth resulting in more insightful conclusions. Longitudinal data can be viewed as multilevel data with repeated measures nested within individuals as the first level of analysis. The second level includes the individual participants nested by gender and/or ethnicity. In the first level, the CSE changes over time (or Instructional Unit) are explored, and, in the second level, the differences in change by gender and ethnicity are examined.

The data was nested within individuals’ CSE over time (or Instructional Unit). Then individuals were nested within groups: gender & ethnicity and SAT math was added to the model to control for achievement. To account for the way CSE changed through time (Instructional Units) the growth curve model used was quadratic based on the way the data looked. HLM was run in SAS 9.0.

Qualitative Method

The main source of data employed for the qualitative inquiry was semi-structured interviews. Interviews also served the purpose of validating the CSE questionnaire in that they were used to verify students’ appropriate interpretation of the CSE questionnaire
as well as to identify what students consider helpful for learning chemistry, in other words, their sources of self-efficacy (Creswell, 2009; Patton, 2002).

Recruitment of Interviewees

Students were invited to participate in the study via an announcement, with the instructor’s permission, inviting all students to participate in the interviews for this study. Two weeks into the semester, each section was addressed, extending the invitation to all students to participate in the interviews. They had two weeks to contact me if they were willing to participate. There were very few students who were willing, only about four and all of them women. After the two weeks had passed and no new recruits were in sight I decided to individually contact some of my own students. I did my best to make sure they did not feel pressured to participate because I was their TA. I targeted students with ethnicity and gender in mind and also those whom I knew by then were not particularly strong students. Most students that I approached agreed readily, others were not interested so I used sample of convenience. After the first interview some students commented they were relieved at how easy it went. A few of these students talked to their friends and those friends came to be added to the list of interviewees.

In the end, there were 27 interviewees: 14 women and 13 men. Of the women there were one Asian, four Black, five Hispanic and three White. Of the men there were one Asian, three Black, five Hispanic and four White. One Black female dropped the course after the first exam and first interview resulting in 26 interviewees at the end of the study. I tried to contact her to get input about why she decided to drop the course but she did not answer my emails.
Interviewees

This description of the interviewees was obtained through the day 1 survey that is given to students every semester. A copy of this specific cohort’s survey results is attached as Appendix C. Of the 27 students that volunteered for the interviews, 16 participants were in their first year of college, four were in their second, two were on their third, one in the fourth and two have had more than four years in college. The cohort of interviewees pursued a wide variety of majors; some of them were combined majors. A total of 12 students declared their major as Pre-med, starting with Biomedical Science most of them, one was a Business major and was taking the course in preparation for a possible medical career in the future. Our group also included three Biology Majors one two Physical Therapy major, one Athletic Training major, three Psychology majors, one Mechanical Engineering major, and two or maybe three Chemistry majors (one undecided). Most of the students had taken some chemistry before except for four students (two White women, one Hispanic man and one Black man). Most students had one year of chemistry in high school. Only one student had one semester, two had three years and one had two years. All of them had taken their chemistry at least one year before. When it came to math, three students had not taken algebra before. Thirteen students had completed Algebra/Trigonometry, three participants had taken Pre-Calculus and two had completed Calculus. During the ongoing semester 18 students were taking Algebra/Trigonometry. Two students were taking Pre-Calculus, two were taking Calculus I, one was taking an unspecified math class and another was not taking a math classes. Only one student had taken a chemistry course similar or equivalent to Preparatory Chemistry before.
Twenty of the twenty-six remaining participants planned to take General Chemistry I the semester following this course. A couple of students changed majors and although they still needed General Chemistry I for their majors, they were going to wait a semester or two. A couple of students were not sure about remaining as Science Majors. One student had scheduling problems and was going to wait a semester before taking General Chemistry I.

With respect to the time elapsed since finishing high school 14 students had finished high school within the last year, six finished within the last two years, one within the last three years and three more than five years ago. All participants were planning on taking General Chemistry I Lab. All students expected to pass the course with a good grade; nineteen expected an A and six a B. (Probably because they were already Science Majors and most of them had taken chemistry before they expected a good grade). With respect to obligations outside school most participants did not have any: nineteen of them were not employed at all, one worked 10 hours per week, five worked 20 hours per week and one worked thirty hours per week.

Twenty-two of the participants were US citizens and four Non-US citizens. Eighteen participants considered English their first language while eight did not. Sixteen spoke another language but thirteen considered themselves to be bilingual. Other than English the languages spoken were Spanish, spoken by 10 participants; French spoken by the one person who dropped the class and Hindi spoken by one person, and one more person did not specify the language spoken. After looking at the wide variety of responses we can conclude that the cohort of participants that agreed to be interviewed is indeed quite diverse in terms of ethnicity, the majors they want to pursue and also the
results of Test of Logical Thinking (TOLT) and Group Assessment of Logical Thinking (GALT). The mean for TOLT in fall 2007 was 5.7 ± 2.4 out of possible 10 total points and for GALT mean was 7.1 ± 2.4 out of possible 12 total points. Either of these tests were randomly given to students at the beginning of the course.

Interviews served the purpose of validating the CSE questionnaire in that they were used to verify students’ appropriate interpretation of the CSE questionnaire. Also interviews were used to identify sources as described by Bandura’s (1986, 1997) sources of self-efficacy and as part of what students found helpful to learn chemistry. The sources are: mastery experiences, vicarious experiences, social persuasion and emotional states previously discussed.

Interviews Protocol and Process

Participants were interviewed three times during the semester. Students signed IRB approved informed consent forms immediately before their first interview, which was conducted between the administration of the first and second exams. The second interview took place between the second and third exam and the final interview between the third and fourth exams. The interviews were semi-structured and lasted approximately 30 minutes; the questions used are shown in Appendix D. During the first interview students were asked reworded questions from the CSE questionnaire to ensure they understood them properly and to detect any discrepancies between what they answered in the paper and pencil questionnaire and what they expressed verbally during the interview.
Evaluation of the data

The researcher transcribed each interview after being digitally recorded. Interviews were coded using HiperResearch™ at a later date and several evaluative passes were done using Bandura’s (1986, 1997) sources of self-efficacy as a frame. According to this theoretical framework the following considerations were made when evaluating the four different sources of self-efficacy:

Mastery experiences – were considered such sources as online homework (OWL), clicker questions during lecture, inquiry activities.

Vicarious experiences – were considered when attending the lecture, studying with someone else, at times listening to their peers during the inquiry activities.

Social persuasion – were considered when the instructor repeatedly encouraged them and assured them they were able to succeed in the course. Sometimes when students study with one or more peers social persuasion happens as well as when significant others and other influential people encourage students.

Emotional states – Are present when students are anxious about performing well for an exam or when the same student is happy and satisfied about doing well in an exam. Frustration is also part of this state of mind.

Several evaluation passes were done comparing individual students to find common trends. Initially only the interviews were explored but after a few passes, student CSE results from questionnaires and their scores reported at the interviews were considered and classification of high or low CSE was established. For this classification the following criteria were used: those students who obtained A or B in the course were
considered high achievers, those who obtained C or D were low achievers. In terms of CSE, those who had an average of 3 of higher were considered to have high CSE and those who had an average of less than 3 were considered to have low CSE.

After the all evaluation was done based on the information from the interviews, some of the quantitative results were considered such as the CSE scores as well as achievement scores. Using all the information available four categories were created: low CSE – low achievement, low CSE - high achievement, high CSE - low achievement and high CSE - high achievement. After these categories were created, the characteristics that helped define each of them were elucidated. Results for the qualitative part of the study are in Chapter VII, A summary of the interviews are in Appendix E.

The following figure shows the timeline data collection for our study:
Figure 3.1 Data Collection Timeline
The following chapter contains the results and analysis for the quantitative data collected for our study. The results contain several descriptive statistics and comparisons of CSE (chemistry self-efficacy) and achievement by gender and ethnicity as well as statistical tests such as Repeated Measures ANOVA and Hierarchical Linear Modeling (HLM) by ethnicity and gender as well. Results for all students that took part in the study are also referred to as entire cohort.
Chapter IV Results

General Descriptive Statistics

Entire Cohort

The quantitative data collected for the study consisted of achievement and CSE. There were a total of 404 participants in the study. Table 4.1 shows the descriptive statistics. There were 162 with complete sets of CSE questionnaires and 242 that had at least one questionnaire missing at some point in time.

The data or entire cohort was divided in Complete and Incomplete sets depending on whether or not the CSE questionnaires were all present or not. The data was also divided by gender and ethnicity. Other sub-sets were derived from combinations of the above groups such as women or men with Complete and Incomplete sets; Asians, Blacks, Hispanics or Whites with Complete or Incomplete sets. CSE and achievement mean scores were presented as well as comparisons of these parameters between groups. Links between CSE and achievement were explored for each group as well.

Table 4.1 Descriptive Statistics for CSE Questionnaires and SAT Math for all Students

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSE0</td>
<td>359</td>
<td>3.18</td>
<td>0.77</td>
<td>-0.24</td>
<td>0.31</td>
</tr>
<tr>
<td>CSE1</td>
<td>359</td>
<td>3.54</td>
<td>0.63</td>
<td>-0.51</td>
<td>0.94</td>
</tr>
<tr>
<td>CSE2</td>
<td>307</td>
<td>3.51</td>
<td>0.75</td>
<td>-0.54</td>
<td>0.64</td>
</tr>
<tr>
<td>CSE3</td>
<td>290</td>
<td>3.45</td>
<td>0.78</td>
<td>-0.51</td>
<td>0.32</td>
</tr>
<tr>
<td>CSE4</td>
<td>284</td>
<td>3.55</td>
<td>0.75</td>
<td>-0.44</td>
<td>0.43</td>
</tr>
<tr>
<td>SATMath</td>
<td>335</td>
<td>511</td>
<td>57.5</td>
<td>0.41</td>
<td>1.71</td>
</tr>
</tbody>
</table>

SAT Math scores were not available for all students.
CSE for Complete and Incomplete Sets

Table 4.2 Effect Size Differences between CSE for Complete and Incomplete Sets

<table>
<thead>
<tr>
<th>Instructional Unit</th>
<th>CSE0</th>
<th>CSE1</th>
<th>CSE2</th>
<th>CSE3</th>
<th>CSE4</th>
</tr>
</thead>
<tbody>
<tr>
<td>*Cohen’s d</td>
<td>0.158</td>
<td>0.095</td>
<td>0.187</td>
<td>0.213</td>
<td>0.094</td>
</tr>
</tbody>
</table>

*Cohen’s d:    d= 0.2 small,  d=0.5 medium,  d=0.8 large

As seen in Table 4.1, the number of students that took the CSE questionnaire decreased consistently as the semester progressed. The differences are summarized in Table 4.3. The trends of both groups Complete and Incomplete were similar as shown in Figure 4.2. The calculated Cohen’s d is small in each case, as seen in Table 4.2. Therefore, between students with Complete and Incomplete sets of questionnaires there was a small difference in terms of CSE. Those with Complete sets have higher CSE than those with Incomplete sets for the duration of the semester.
To help establish equivalence in terms of ability between those students who had Complete and Incomplete sets, a t-test and an equivalence test were run on SAT total scores.

Note: SAT scores were not available for all students.

The result of the t-test was $t(333, .801)$, not statistically significant. Then the equivalence was established by using the Lewis & Lewis (2005) method summarized in Table 4.3:

<table>
<thead>
<tr>
<th></th>
<th>$\bar{X}_{complete}$</th>
<th>$\bar{X}_{incomplete}$</th>
<th>Interval</th>
<th>$t_1$</th>
<th>$t_2$</th>
<th>$t_{\alpha=.10}$</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAT Total</td>
<td>1034</td>
<td>1028</td>
<td>-20.88, +20.88</td>
<td>3.96</td>
<td>5.00</td>
<td>1.29</td>
<td>Equiv</td>
</tr>
</tbody>
</table>

After failing to reject the Null Hypothesis (that the two populations are equivalent) by doing the t-test, we established that the two populations (with Complete and Incomplete sets) are equivalent. From table 4.3 we see that $t_1$ and $t_2$ were equal to or above $t_{\alpha=.10}$ as it is required by this method and the effect size within this equivalence is $d = 0.5$.

Achievement Through the Semester for Entire Cohort

The percent achievement for the entire cohort obtained in the exams through the semester looked as shown in Figure 4.2:
The achievement for exams 1, 2 and 4 was very similar (69, 68, 70), for exam 3 and 5 it dropped and the percentages are similar (56, 58) for this two exams as well as can be perceived in Figure 4.2.

Final Achievement in Letter Grades

The letter grades shows the total effort students put into the course so I decided to investigate this aspect as well. For achievement in letter grades for the course, the same two groups defined as Complete or Incomplete sets of CSE questionnaires were considered. At the end of the semester the distribution of final letter grades for students in the Complete set of questionnaires was as shown in Table 4.4:
Table 4.4 Distribution of Final Letter Grade for the Complete Sets

<table>
<thead>
<tr>
<th>Grade Obtained</th>
<th>No of Students</th>
<th>Student %</th>
</tr>
</thead>
<tbody>
<tr>
<td>*A</td>
<td>47</td>
<td>29</td>
</tr>
<tr>
<td>*B</td>
<td>98</td>
<td>60</td>
</tr>
<tr>
<td>*C</td>
<td>15</td>
<td>9</td>
</tr>
<tr>
<td>**D</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>162</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

*Passing grades: A, B, or C  
**Failing grades: D or F

The most salient feature of the table is that 89% of the students who had complete sets of questionnaires obtained either an A or a B in the course. There were very few Cs and even fewer Ds (1 man and 1 woman) and no Fs at all. In general the achievement of this set of students was high.

CSE Missing Data

Among those students who had CSE questionnaires missing, there were four categories according to how many questionnaires they missed: 1, 2, 3, and, 4; the results are summarized in Table 4.5:

Table 4.5 Distribution of Final Letter Grades for Students with Missing Questionnaires

<table>
<thead>
<tr>
<th>Grade Obtained</th>
<th>Complete sets</th>
<th>Missing 1</th>
<th>Missing 2</th>
<th>Missing 3</th>
<th>Missing 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>*A</td>
<td>47</td>
<td>21</td>
<td>4</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>*B</td>
<td>98</td>
<td>62</td>
<td>33</td>
<td>7</td>
<td>-</td>
</tr>
<tr>
<td>*C</td>
<td>15</td>
<td>25</td>
<td>33</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>**D</td>
<td>2</td>
<td>4</td>
<td>11</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>**F</td>
<td>-</td>
<td>3</td>
<td>4</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>162</strong></td>
<td><strong>115</strong></td>
<td><strong>87</strong></td>
<td><strong>33</strong></td>
<td><strong>7</strong></td>
</tr>
</tbody>
</table>

*Passing grades: A, B, or C  
**Failing grades: D or F

Those students who missed only one questionnaire obtained mainly As and Bs, a few Cs and very few Ds and Fs. Those students who missed 2 questionnaires obtained As, Bs and Cs, some Ds and few Fs. Those who missed 3 questionnaires obtained no As.
but did obtain Bs, Cs, and some Ds and Fs. And those who missed 4 questionnaires obtained no As or Bs but obtained Cs, Ds and Fs. These results show a link between the grades obtained and number of missing questionnaires.

Passing and Failing Students

CSE

![CSE for Passing and Failing Students](image)

Figure 4.3 CSE through the Semester for Students that Passed or Failed the Course

<table>
<thead>
<tr>
<th>Instructional Unit</th>
<th>CSE0</th>
<th>CSE1</th>
<th>CSE2</th>
<th>CSE3</th>
<th>CSE4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohen’s d</td>
<td>0.091</td>
<td>-</td>
<td>0.127</td>
<td>0.137</td>
<td>0.590</td>
</tr>
</tbody>
</table>

Table 4.6 Effect Size Differences between CSE for Passing and Failing Students

Figure 4.3 shows trends of CSE through the semester for passing and failing students. As seen in table 4.6 there was a small effect size difference in CSE between those who passed and those who failed at times 0, 1, 2, and 3 but the effect size increased
at time 4 to medium towards large ($d = 0.59$) difference. It makes sense that those who passed the course increased their CSE as seen in table 4.6 by an effect size $d = 0.521$ (calculated for CSE between time 0 and time 4), which is considered medium size. Those students who did not pass the course ended with the same CSE they started with as seen in Figure 4.3.

Achievement

![Achievement as Percent Score on Exams for Passing and Failing Students](image)

Figure 4.4 Achievement as Percent Score on Exams through the Semester for Students that Passed or Failed the Course

<table>
<thead>
<tr>
<th>Instructional Unit</th>
<th>Exam 1</th>
<th>Exam 2</th>
<th>Exam 3</th>
<th>Exam 4</th>
<th>Exam 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohen’s $d$</td>
<td>0.97</td>
<td>1.36</td>
<td>1.35</td>
<td>1.77</td>
<td>1.24</td>
</tr>
</tbody>
</table>

Table 4.7 Effect Size Differences for Achievement between Passing and Failing Students
Figure 4.4 shows achievement for passing and failing students. For achievement, there was a large and consistent gap (effect size $d = 1$ on average) as seen in table 4.7 between passing and failing students through the semester. This gap in achievement appears to take effect in CSE toward the second half of the semester. Their low CSE was a reflection of their negative mastery experience in the course. The difference in achievement through the semester between passing and failing students can be easily detected in figure 4.4.

Descriptive Statistics: Gender Differences

Entire Cohort

CSE

Gender differences were found in the CSE as previously reported in the literature. The following results correspond to all CSE questionnaires collected through the semester for the entire cohort.
CSE trends for men and women are very similar in shape except that women started at a lower level of CSE as seen in Figure 4.5. The gap between men and women decreased during the semester until it practically disappeared. The increase of CSE was calculated for each gender from the beginning of the semester (time 0) to the end (Instructional Unit 4) as summarized in Table 4.8. The effect size of the gain in CSE for men was $d = 0.25$ (small) and for women $d = 0.6$ (medium). Women ended the semester practically at the same CSE level as men. Women’s CSE increased was higher than men.

Table 4.8 Effect Size Differences between CSE for Men and Women

<table>
<thead>
<tr>
<th>Instructional Unit</th>
<th>CSE0</th>
<th>CSE1</th>
<th>CSE2</th>
<th>CSE3</th>
<th>CSE4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohen’s d</td>
<td>0.36</td>
<td>0.29</td>
<td>0.19</td>
<td>0.06</td>
<td>0.04</td>
</tr>
</tbody>
</table>
Achievement

Achievement as Percent Score on Exams by Gender for Entire Cohort

Table 4.9 Effect Size Differences for Achievement by Gender

<table>
<thead>
<tr>
<th>Instructional Unit</th>
<th>Exam 1</th>
<th>Exam 2</th>
<th>Exam 3</th>
<th>Exam 4</th>
<th>Exam 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohen’s d</td>
<td>0.137</td>
<td>0.059</td>
<td>0.03</td>
<td>0.074</td>
<td>0.197</td>
</tr>
</tbody>
</table>

Achievement for men and women was pretty close during the semester, it was expressed by the effect size Cohen’s d and it was summarized in Table 4.9. When $d = 0.2$ the effect size of the difference is considered small. The biggest differences between genders were for exam 1 and exam 5 and in both cases there is a small effect size difference. Men had slightly higher achievement than women at the end of the semester as seen in Figure 4.6.
Gender Differences for Complete Sets

CSE

The results for Complete and Incomplete sets are presented separately:

Figure 4.7 CSE for Complete Sets through the Semester by Gender

Table 4.10 Effect Size Differences through the Semester by Gender

<table>
<thead>
<tr>
<th>Instructional Unit</th>
<th>CSE0</th>
<th>CSE1</th>
<th>CSE2</th>
<th>CSE3</th>
<th>CSE4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohen’s d</td>
<td>0.29</td>
<td>0.43</td>
<td>0.23</td>
<td>0.06</td>
<td>0.001</td>
</tr>
</tbody>
</table>

In the Complete sets, men were found to have higher CSE than women in the first 3 times the survey was administered. As seen in Figure 4.7, the difference in CSE between men and women decreased as time elapsed. After the first half of the semester (after Instructional Unit 2), women’s CSE started to catch up with men and at the end the gender gap closed between genders; the differences practically disappeared as shown in Table 4.10.
Achievement

Figure 4.8 Achievement as Percent Score on Exam by Gender for Complete Sets through the Semester

<table>
<thead>
<tr>
<th>Instructional Unit</th>
<th>Exam 1</th>
<th>Exam 2</th>
<th>Exam 3</th>
<th>Exam 4</th>
<th>Exam 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohen’s d</td>
<td>0.06</td>
<td>0.24</td>
<td>0.05</td>
<td>-0.15</td>
<td>0.004</td>
</tr>
</tbody>
</table>

As seen in Figure 4.8 men and women in the Complete set had the same achievement for exams 1, 3 and 5. Men had higher achievement for exam 2 (77%, 73%) and women had higher achievement for exam 4 (75%, 73%). As Table 4.11 shows, the effect size of the gender differences in achievement was small in each case. Achievement was pretty close for men and for women in the Complete set; the effect size differences were very small, except for exam 2 that is small.
Observing at CSE and achievement for women in Figure 4.9 a link between CSE and achievement is apparent through time. In other words as CSE increased for women so did achievement, this was true for exams 1, 2, 3 and 4. Achievement for exam 5 was lower and there was no further measure of CSE taken after exam 4. We observed an overall positive increase of CSE for women in this cohort through the semester. Women started with a CSE for time 0 = 3.2 and ended at a CSE for Instructional Unit 4 = 3.6. That represented an increase of 0.39 standard deviations or an effect size $d = .526$ considered medium size.
Link between CSE and Achievement as Percent Score on Exams for Men with Complete Sets

The link between CSE and achievement is also apparent for men, although it is not identical to the one for women as seen in Figure 4.10. Achievement and CSE variation for men had a different pattern than for women; men’s CSE tended to drop slightly after Instructional Unit 1 and it leveled after Instructional Unit 3. Men and women ended the semester at the same level of CSE but men’s CSE tended to decrease while women’s tended to increase.
Gender Differences for Incomplete Sets

CSE

![CSE by Gender for Students with Incomplete Sets](image)

Figure 4.11 CSE by Gender for Incomplete Sets

<table>
<thead>
<tr>
<th>Instructional Unit</th>
<th>CSE0</th>
<th>CSE1</th>
<th>CSE2</th>
<th>CSE3</th>
<th>CSE4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohen’s d</td>
<td>0.45</td>
<td>0.22</td>
<td>0.24</td>
<td>0.16</td>
<td>0.10</td>
</tr>
</tbody>
</table>

The CSE trends were similar for students with Complete and Incomplete sets of CSE questionnaires in terms of gender differences as seen in Figure 4.11. The mean CSE was higher for men than for women (as it was for the Complete set) but at the end of the semester, a very small almost imperceptible gap remained between genders with an effect size $d = 0.1$ (considered small) remained between men and women in the Incomplete set as seen in Table 4.12. Those students in the Incomplete set had somewhat lower CSE.
Achievement

![Achievement as Percent Score on Exams by Gender for Incomplete Sets](image)

Figure 4.12 Achievement for Incomplete Sets by Gender

<table>
<thead>
<tr>
<th>Instructional Unit</th>
<th>Exam 1</th>
<th>Exam 2</th>
<th>Exam 3</th>
<th>Exam 4</th>
<th>Exam 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohen’s d</td>
<td>0.22</td>
<td>0.11</td>
<td>0.11</td>
<td>0.05</td>
<td>0.36</td>
</tr>
</tbody>
</table>

Trends for achievement in the Incomplete set by gender are seen in Figure 4.12; men had higher achievement in exams 1 and 2 and 5. Both, men and women had same mean scores for exams 2 and 3. At the end of the semester, there was a difference in achievement between men and women with an effect size of $d = 0.35$ considered halfway between small and medium (Cohen); men achievement was higher as seen in Table 4.13.
The link between CSE and achievement is evident through the semester for men in the Incomplete set. As seen in Figure 4.13, achievement dropped with achievement for Instructional Units 1, 2 and 3, and by time 4, CSE increased and so did achievement.
Link between CSE and Achievement for Women with Incomplete Sets

The link between CSE and achievement is evident through the semester for women with Incomplete sets as seen in Figure 4.14. The same case as with men, achievement dropped as CSE dropped and by Instructional Unit 4, CSE increased achievement increased. The difference between men and women in the Incomplete set are the levels of CSE and achievement where women are slightly lower in both measures.
Comparisons Between Complete and Incomplete Sets

CSE for Men

Figure 4.15  CSE for Men with Complete and Incomplete Sets

Table 4.14 Effect Size Differences for CSE for Men between Complete and Incomplete Sets

<table>
<thead>
<tr>
<th>Instructional Unit</th>
<th>CSE0</th>
<th>CSE1</th>
<th>CSE2</th>
<th>CSE3</th>
<th>CSE4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohen’s d</td>
<td>0.09</td>
<td>0.23</td>
<td>0.18</td>
<td>0.16</td>
<td>0.01</td>
</tr>
</tbody>
</table>

CSE varied during the semester in similar patterns for both Complete and Incomplete sets of men as seen in Figure 4.15. There was an imperceptible difference between the final CSE between the two cohorts of men at the end of the semester. In other words, there was practically no difference between the two cohorts at the end of the semester as can be seen in Table 4.14.
Achievement for Men

Table 4.15 Effect Size Differences for Achievement through the Semester for Men with Complete and Incomplete Sets

<table>
<thead>
<tr>
<th>Instructional Unit</th>
<th>Exam 1</th>
<th>Exam 2</th>
<th>Exam 3</th>
<th>Exam 4</th>
<th>Exam 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohen’s d</td>
<td>0.16</td>
<td>0.73</td>
<td>0.52</td>
<td>0.34</td>
<td>0.07</td>
</tr>
</tbody>
</table>

In terms of achievement the trends for both, men with Complete and Incomplete sets are similar as seen in Figure 4.16. Men in both sets start very close to each other on the first exam as seen in Table 4.15, then, their achievement departs from each other for exams 2, 3 and 4, the incomplete set had lower achievement for most of the semester but, at the end, both groups obtained the same achievement for the final.
CSE for Women

![Graph showing the CSE through the Semester for Women with Complete and Incomplete sets.](image)

**Figure 4.17 CSE for Women with Complete and Incomplete Sets**

<table>
<thead>
<tr>
<th>Instructional Unit</th>
<th>CSE0</th>
<th>CSE1</th>
<th>CSE2</th>
<th>CSE3</th>
<th>CSE4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohen’s d</td>
<td>0.23</td>
<td>0.08</td>
<td>0.25</td>
<td>0.27</td>
<td>0.13</td>
</tr>
</tbody>
</table>

There were small CSE effect size differences between the women in the Complete and Incomplete sets as seen in Table 4.16. These CSE differences were more pronounced in Instructional Units 0, 2 and 3 as seen in Figure 4.17. At the end, the gap between sets did not disappear completely but it was small. The final effect size between women in the Complete and Incomplete sets was \( d = 0.13 \) considered small (Cohen). This effect size is very similar to the effect size between genders \( (d = 0.103) \) for Incomplete sets.
Achievement for Women

There was a noticeable and constant difference in achievement between women in the Complete and Incomplete sets during the semester as seen in Figure 4.18, and that difference never disappeared. Women in Incomplete sets had lower achievement than those in Complete sets by an effect size that can be described as close to medium (0.37 - 0.63) as can be seen in Table 4.17.

Table 4.17 Effect Size Difference between Women with Complete and Incomplete Sets

<table>
<thead>
<tr>
<th>Instructional Unit</th>
<th>Exam 1</th>
<th>Exam 2</th>
<th>Exam 3</th>
<th>Exam 4</th>
<th>Exam 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohen's d</td>
<td>0.37</td>
<td>0.63</td>
<td>0.44</td>
<td>0.54</td>
<td>0.47</td>
</tr>
</tbody>
</table>
Descriptive Statistics: Ethnicity

CSE for Entire Cohort by Ethnicity

The trends of CSE and achievement for the four main ethnic groups that make up our population were different for each ethnic group. The following results show CSE for the four major ethnic groups collected during the semester.

![CSE through the Semester by Ethnicity](image)

**Figure 4.19 CSE Trends by Ethnicity through the Semester for the Entire Cohort**

As seen in Figure 4.19, CSE trend for Asians was to increase through the semester. Trend for Hispanics and Whites were similar in shape, they had an initial gain from Instructional Unit 0 to 1 that held for Instructional Unit 2, then it dropped slightly for Instructional Unit 3 and recovered for Instructional Unit 4 showing an overall CSE increase through the semester. The difference between these two groups was that Hispanics had somewhat higher CSE through the semester. Blacks on the other hand had
an initial CSE increase from Instructional Unit 0 to 1 and after that point their CSE decreased consecutively through the semester ending at the same CSE where they started.

Achievement for Entire Cohort by Ethnicity

![Graph of Achievement as Percent Score on Exams by Ethnicity]

Figure 4.20 Achievement as Percent Score on Exams by Ethnicity

The patterns for achievement through the semester are somewhat similar in shape for the different ethnic groups as seen in Figure 4.20. Asians achievement came close to Hispanics but they were higher on exam 3 and ended with higher mean score for exam 5. Hispanics had slightly higher achievement than Asians during the semester except for exam 3 and exam 5. Hispanics ended at the same level as Whites (achievement = 59%) and below the Asians (achievement = 66%). Whites achievement went down consecutively from exam 1 (achievement = 72%) to exam 2 (achievement=67%) and to exam 3 (achievement = 56.%), then, they increased their achievement for exam 4.
(achievement = 70%) and dropped some (achievement = 59%) for exam 5. Blacks had the lowest achievement of all ethnicities through the semester for exam 2 (achievement = 66%) where they were very close to Whites (achievement = 67%).

Relationship between CSE and Achievement by Ethnicity for Entire Cohort

Asians

Asians were the smallest number in our cohort. As seen in figure 4.21, their CSE increased through the semester, first sharply from Instructional Unit 0 to Instructional Unit 1 and after that, it remained unchanged for Instructional Units 1 and 2, and so did achievement. CSE increased more gently even if achievement dropped. CSE continued

Figure 4.21 CSE and Achievement as Percent Score on Exams for Asians

Asians were the smallest number in our cohort. As seen in figure 4.21, their CSE increased through the semester, first sharply from Instructional Unit 0 to Instructional Unit 1 and after that, it remained unchanged for Instructional Units 1 and 2, and so did achievement. CSE increased more gently even if achievement dropped. CSE continued
to increase until the end of the semester. In the graph the overall trend for CSE looks almost inverse to the overall trend for achievement.

Blacks

![CSE and Achievement as Percent Score on Exams for Blacks](image)

Figure 4.22 CSE and Achievement as Percent Score on Exams for Blacks

There were only 29 Black students that had complete sets of questionnaires so a little less than half of the total Black student population had missing questionnaires. Blacks showed a similar variation pattern to other ethnicities in achievement but at a lower level than the rest of the ethnicities. The link between CSE and achievement is not evident in Figure 4.22: Blacks’ CSE tended to decrease while their achievement increased and decreased a couple of times during the semester.
Blacks never recovered in terms of CSE and ended at the same level as they started. The course experiences did no help them to increase their CSE. Blacks did not gain CSE regardless how we look at the data.

Hispanics

Figure 4.23 CSE and Achievement as Percent Score on Exams for Hispanics

Achievement for Hispanics appears to have varied according to CSE as seen in Figure 4.23. The link in the pattern between these CSE and achievement is more evident for Hispanics than Asians or Blacks. The link seems more apparent for Hispanics than for Asians or Blacks. Blacks’ CSE trend seemed inverse to Asians’ since they tend to decrease in CSE while Asians’ tend to increase.
For Whites, achievement and CSE patterns appear to be linked through the semester as seen in Figure 4.24. This link appears to be similar for Whites and for Hispanics. This was not the case for Asians whose CSE increased regardless of their achievement or Blacks whose CSE decreased regardless of their achievement as well.
CSE for Complete Sets by Ethnicity

![Graph showing CSE through the Semester by Ethnicity for Complete Sets]

Figure 4.25 CSE through the Semester by Ethnicity for Complete Sets

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>Asians</th>
<th>Blacks</th>
<th>Hispanics</th>
<th>Whites</th>
</tr>
</thead>
<tbody>
<tr>
<td>*Cohen’s d</td>
<td>0.59</td>
<td>0.12</td>
<td>0.48</td>
<td>0.45</td>
</tr>
</tbody>
</table>

*This effect size refers the change of CSE between beginning CSE0 and end CSE4

As seen in Figure 4.25, Asians, Blacks and Hispanics who have complete sets started CSE at the same level at the beginning of the semester and they increased their CSE equally and proportionately from Instructional Unit 0 to Instructional Unit 1. Asians increased their CSE steadily until the end of the semester followed by the Hispanics who dropped slightly for Instructional Unit 2 but continued to increase with a softer slope than Asians till the end. Blacks had similar CSE to Asians from Instructional Unit 1 through 3 but their CSE dropped consistently for Instructional Unit 3 and 4. Whites started somewhat lower CSE than the other ethnic groups, increased similarly and remained at
the same mean value for Instructional Unit 2. They dropped a bit for Instructional Unit 3 but regained their confidence for 4.

Table 4.18 summarizes the difference in CSE calculated as Cohen’s d from beginning to end of the semester (Instructional Unit 0 to 4) for those in the Complete set by ethnicity and we observe that Blacks gained the least amount of CSE, Whites and Hispanics had similar gains and Asians had the highest CSE gain.

Achievement by Ethnicity for Complete Sets

![Achievement as Percent Score on Exams by Ethnicity for Complete Sets](image)

**Figure 4.26 Achievement as Percent Score on Exams by Ethnicity for Complete Sets**

As can be seen in Figure 4.26, of all those students who had complete sets of CSE questionnaires Asians had the highest achievement consistently through the semester, especially for exam 3. Whites and Hispanics follow Asians very closely and slightly
lower were Blacks. For exam 5, the final exam Asians obtained the highest mean 63% followed by Whites 61%, then Hispanics 60% and lastly Blacks 59%. The effect size of achievement between ethnic groups is summarized in Table 4.19:

Table 4.19 Effect Sizes between Ethnicities for Complete Sets at the End of the Semester

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Effect Size d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whites vs. Asians</td>
<td>0.17</td>
</tr>
<tr>
<td>Whites vs. Blacks</td>
<td>-0.18</td>
</tr>
<tr>
<td>Whites vs. Hispanics</td>
<td>-0.09</td>
</tr>
</tbody>
</table>

In terms of achievement Asians ended 0.173 (in standard deviation) higher than Whites as seen in Table 4.19; Whites. Blacks ended 0.178 below Whites and Hispanics ended 0.09 below Whites. All of these differences are considered small.
Link between CSE and Achievement for Complete Sets by Ethnicity

Asians

![Graph showing CSE and Achievement as Percent Score on Exams for Asians with Complete Sets](image)

Asians N=15 Complete sets

Figure 4.27 CSE and Achievement as Percent Score on Exams for Asians with Complete Sets

For Asians who had complete sets the trend of CSE increased through the semester while achievement decreased slightly as seen in Figure 4.27. This shows inverse pattern of CSE and achievement, similar to the trend in the entire group of Asians. The increase of CSE looks more pronounced than the decrease of achievement although the scales are different.
For Blacks with complete sets CSE and achievement appears to be linked for exams 1, 2, and, 3, as seen in figure 4.28. Although their achievement increased (similarly to Hispanics and Whites), Blacks’ CSE dropped after Instructional Unit 3 further, ending slightly above their starting point at the very beginning of the semester. The link between CSE and achievement was did not exist for Instructional Unit 4 CSE dropped and achievement increased.
For Hispanics with Complete sets the link between achievement and CSE is not evident as seen in Figure 4.29. Achievement pattern resembles Blacks’ and Whites’ (figures 4.28 and 4.30) but their CSE resembles Asians’ (Figure 4.27) since it increased steadily from Instructional Unit 2 to 4 with no relation to achievement. Their achievement was steady for exams 1 and 2, and 4 but it dropped for exams 3 and 5.
Whites were the largest ethnic group as expected. The pattern of trends for achievement was very similar to Blacks and Hispanics (Figures 4.28 and 4.29). The link between CSE and achievement was apparent all through the semester as seen in figure 4.20; this means one can follow the increase or decrease of CSE corresponded to that of achievement for Times 1, 2, 3, and 4. This differs from the other ethnicities where the variation of CSE does not always correspond to that of achievement.
CSE and Achievement Differences between Complete and Incomplete Sets by Ethnicity

Asians

The data was analyzed for Complete and Incomplete sets by ethnicity although the number of Asians was small to begin and splitting into the two sets decreased power. Some differences between sets were found.

![CSE through the Semester for Asians with Complete and Incomplete Sets](image)

Figure 4.31 CSE through the Semester for Asians with Complete and Incomplete Sets

<table>
<thead>
<tr>
<th>Time</th>
<th>CSE0</th>
<th>CSE1</th>
<th>CSE2</th>
<th>CSE3</th>
<th>CSE4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohen’s d</td>
<td>0.29</td>
<td>0.08</td>
<td>-0.34</td>
<td>0.31</td>
<td>0.13</td>
</tr>
</tbody>
</table>

Table 4.20 Effect Size Difference for CSE between Asians with Complete and Incomplete Sets

As seem in Figure 4.31, CSE for those Asians with complete sets of questionnaires increased steadily over the course of the semester. CSE for those Asians with incomplete sets showed a different pattern increasing their CSE consecutively from
Instructional Unit 0 to 2, dropped for Instructional Unit 3 and recovered for Instructional Unit 4 ending slightly below those with complete sets. The effect size of the differences between Complete and Incomplete sets were all small and they appear in table 4.20 and there was a $d = 0.13$ at the end of the semester which is defined as small in size. These results are probably due to the small sample sizes.

![Achievement as Percent Score on Exams by for Asians with Complete and Incomplete Sets](image)

Figure 4.32 Achievement Through as Percent Score on Exams for Asians with Complete and Incomplete Sets

<table>
<thead>
<tr>
<th>Instructional Unit</th>
<th>Exam 1</th>
<th>Exam 2</th>
<th>Exam 3</th>
<th>Exam 4</th>
<th>Exam 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohen’s d</td>
<td>1.31</td>
<td>0.88</td>
<td>2.10</td>
<td>0.53</td>
<td>0.93</td>
</tr>
</tbody>
</table>

Achievement for Asians with complete sets decreased very slightly through the semester as seen in Figure 4.32. Achievement for Asians in Incomplete sets was lower for those with complete sets; exam 3 was particularly lower ($d = 2.1$). The effect sizes

70
between Complete and Incomplete sets are the largest differences we have detected in the study as can be seen in table 4.21. There is a consistent difference between groups between Complete and Incomplete sets. Achievement for Asians with Complete sets decreased very slightly through the semester, even for exam 3 for which almost everyone’s achievement dropped.

Blacks

![CSE through the Semester for Blacks with Complete and Incomplete Sets](image)

Figure 4.33 CSE through the Semester for Blacks with Complete and Incomplete Sets

<table>
<thead>
<tr>
<th>Instructional Unit</th>
<th>CSE0</th>
<th>CSE1</th>
<th>CSE2</th>
<th>CSE3</th>
<th>CSE4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohen’s d</td>
<td>0.08</td>
<td>0.04</td>
<td>0.55</td>
<td>0.40</td>
<td>0.40</td>
</tr>
</tbody>
</table>

Table 4.22 Effect Size Difference for CSE Between Blacks with Complete and Incomplete Sets

As seen in figure 4.33, Black students with complete sets increased their CSE after Instructional Unit 0 and remained steady until 2 then, their CSE dropped for
Instructional Unit 3 and dropped even further for 4. Those Black students with incomplete sets of questionnaires their CSE increased only for Instructional Unit 1 and then, there was a considerable drop for Instructional Unit 2 and smaller consecutive drops for Instructional Unit 3 and 4. Black students with complete sets barely gained CSE at the end of the semester. Those with incomplete sets of questionnaires ended at even lower CSE than when they started. The difference between students in Complete and Incomplete sets was that those with the complete sets had a small CSE increase at the end of the semester and those with incomplete sets decreased their CSE. The effect sizes between the two groups were calculated and are summarized in Table 4.22; at the end of the semester the difference between Complete and Incomplete sets was $d = 0.40$ considered towards medium size. Those with complete sets had the higher CSE as has been the case in each and every comparison.

Achievement was lower for those Black students with incomplete sets as seen in Figure 4.34; the same trend as seen all through the study. There was a constant gap between groups through the semester. As seen in Table 4.23, the effect size between Black students with complete and incomplete sets was medium size through the semester ending with a $d = 0.73$ closer to a large size effect.
Figure 4.34 Achievement as Percent Score on exams for Blacks with Complete and Incomplete Sets

Table 4.23 Effect Size Difference for Achievement between Blacks with Complete and Incomplete Sets

<table>
<thead>
<tr>
<th>Instructional Unit</th>
<th>Exam 1</th>
<th>Exam 2</th>
<th>Exam 3</th>
<th>Exam 4</th>
<th>Exam 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohen’s d</td>
<td>0.59</td>
<td>0.56</td>
<td>0.49</td>
<td>0.71</td>
<td>0.73</td>
</tr>
</tbody>
</table>

Hispanics

Hispanics with complete sets increased slightly and consecutively their CSE through the semester as seen in Figure 4.35. For those Hispanics with incomplete sets, there was similar trend but at a lower level of CSE. There were variations in the effect size differences between the two groups through the semester as seen in Table 4.24, the largest one being at Instructional Unit 3 with and effect size $d = 0.82$ that is considered large. At the end of the semester there was a difference $d = 0.43$ medium size effect between the two groups.
As seen in Figure 4.36, in terms of achievement there were slight variations between Hispanics in the Complete and Incomplete sets through the semester. The largest difference was for exam 2 (d = 0.35) as seen in table 4.25 and after that the effect size decreased consistently. At the end of the semester there was practically no difference between the two cohorts, d = 0.08
Figure 4.36 Achievement as Percent Score on Exams for Hispanics with Complete and Incomplete Sets

Table 4.25 Effect Size Difference for Achievement Between Hispanics with Complete and Incomplete Sets

<table>
<thead>
<tr>
<th>Instructional Unit</th>
<th>Exam 1</th>
<th>Exam 2</th>
<th>Exam 3</th>
<th>Exam 4</th>
<th>Exam 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohen’s d</td>
<td>0.04</td>
<td>0.35</td>
<td>0.23</td>
<td>0.10</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Whites

As seen in Figure 4.37, CSE scores for Whites were similar for Complete and Incomplete sets for Instructional Units 1 and 2. However, there was an unexpected outcome for Instructional Units 3 and 4 where those with incomplete sets had higher CSE scores than those with complete sets. This result is different from the rest of the results in the study. In Table 4.26 that summarizes the effect size differences between Complete and Incomplete sets for Whites, the negative numbers show that those in the Complete set...
had a lower score than those in the Incomplete set. At the end of the semester the effect between the two sets was size $d = 0.16$ (small), those with incomplete set as seem below.

![CSE through the Semester for Whites with Complete and Incomplete Sets](image)

**Figure 4.37 CSE through the Semester for Whites with Complete and Incomplete Sets**

<table>
<thead>
<tr>
<th>Instructional Unit</th>
<th>CSE0</th>
<th>CSE1</th>
<th>CSE2</th>
<th>CSE3</th>
<th>CSE4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohen’s d</td>
<td>0.001</td>
<td>0.07</td>
<td>0</td>
<td>-0.12</td>
<td>-0.16</td>
</tr>
</tbody>
</table>

The difference in achievement for Whites fluctuated between Complete and Incomplete sets as seen in Figure 4.38 Those with complete sets had higher achievement than those with incomplete sets as in previous cases. As seen in Table 4.27 the differences in achievement between the two sets in terms of effect size started very small ($d = 0.07$) to medium towards large at mid semester and ended as small to medium ($d = 0.32$). These trends in achievement were similar for all ethnicities.
Figure 4.38 Achievement as Percent Score on Exams for Whites with Complete and Incomplete Sets

Table 4.27 Effect Size Difference for Achievement Between Whites with Complete and Incomplete Sets

<table>
<thead>
<tr>
<th>Instructional Unit</th>
<th>Exam 1</th>
<th>Exam 2</th>
<th>Exam 3</th>
<th>Exam 4</th>
<th>Exam 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohen's d</td>
<td>0.07</td>
<td>0.74</td>
<td>0.42</td>
<td>0.62</td>
<td>0.32</td>
</tr>
</tbody>
</table>
The CSE trends for Incomplete sets were somewhat similar to the Complete sets in that Asians’ trend was at the top of CSE scores as seen in Figure 4.39. Blacks started the highest of all ethnicities and had an increase for Instructional Unit 1 but after that, their CSE dropped below their initial point (Instructional Unit 0) ending lower than where they started. This trend for Blacks was similar to that in the Complete set. In this case, the difference was that the CSE level for Whites follows Asians’ and then Hispanics’ trend comes next, at a lower level than Whites. These three ethnicities increased CSE at the end of the semester but the Blacks’ CSE decreased.
Achievement for Incomplete Sets by Ethnicity

The achievement trends for those in the Incomplete set were similar for all ethnicities as seen in Figure 4.40. Asians had the lowest achievement for exam 3. Hispanics’ achievement trend was the highest followed by Whites and Asians and Blacks were the lowest in the Incomplete sets.
Link between CSE and Achievement for Incomplete Sets by Ethnicity

Asians

Asians in the Incomplete set show a link between CSE and achievement for Instructional Unit 2, 3 and 4 although the changes in CSE are not exactly proportional to the changes in achievement as seen in Figure 4.41. This could be due to difference in scales for CSE and achievement.
Blacks

![Chart Image]

Figure 4.42 CSE and Achievement as Percent Score on Exams for Blacks with Incomplete Sets

There are no links observed between CSE and achievement for this cohort of Black students as seen in Figure 4.42. The general trend in CSE was down after its highest point just before the first exam. Achievement was steady for the first two exams, dropped for the third exam, recovered a little for the fourth and dropped again for the fifth exam (final). This pattern is similar to the one for Blacks with complete sets except the levels of CSE and achievement were higher for those with complete sets.
As seen in Figure 4.43, Hispanics with incomplete sets showed a link between CSE and achievement through the semester. CSE for Hispanics with complete sets also tended to increase through the semester while achievement had a pattern similar to the pattern for Hispanics with incomplete sets shown in the graph above.
White students with incomplete sets show a clear link between CSE and achievement for Instructional Units 1, 2, 3, and 4 as seen in Figure 4.44. CSE dropped slightly and consecutively from Instructional Unit 1 to 3 and so did achievement, then CSE increased for time 4 and so did achievement. White students with complete sets of questionnaires also showed a link between CSE and achievement through the semester.
Repeated Measures ANOVA

Repeated measures ANOVA was used to analyze the longitudinal data but only complete sets of data can be used for that analysis. The data was coded by gender. The values for CSE obtained at instructional units 0, 1, 2, 3, and 4 were coded as time since they were sequential along the semester. A total of 162 sets of data were used since those were the complete sets. The rest of the sets (242) had at least one score missing at a given time during the semester.

The results for repeated measures ANOVA are summarized in Table 4.28. The contrast variable time corresponds to instructional units. There was a significant difference between for CSE for time 0 (before instructional unit 1) and times 1, 2, 3, and, 4. The rest of the comparisons were not significant. The interaction by gender was not significant either.

<table>
<thead>
<tr>
<th>Contrast variable</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>time 0 vs. time 1</td>
<td>1</td>
<td>13.2822</td>
<td>13.2822</td>
<td>33.05</td>
<td>&lt;.0001*</td>
</tr>
<tr>
<td>time 0 vs. time 2</td>
<td>1</td>
<td>11.8292</td>
<td>11.8292</td>
<td>22.06</td>
<td>&lt;.0001*</td>
</tr>
<tr>
<td>time 0 vs. time 3</td>
<td>1</td>
<td>5.4710</td>
<td>5.4710</td>
<td>7.67</td>
<td>.0063*</td>
</tr>
<tr>
<td>time 0 vs. time 4</td>
<td>1</td>
<td>8.7165</td>
<td>8.7165</td>
<td>11.74</td>
<td>.0008*</td>
</tr>
</tbody>
</table>

HLM

HLM (Hierarchical Linear Modeling) has proven to be an excellent way for studying and understanding individual and or group change across time (Russell, 2004, Lewis & Lewis 2008) more effectively than repeated measures ANOVA. The one big advantage of HLM is that all data collected, including incomplete sets of questionnaires could be used in the analysis. Incomplete sets of questionnaires were of particular
interest in this study because those students with missing questionnaires had lower CSE than those with complete sets.

Longitudinal data could be viewed as multilevel data with repeated measures. For the first level, the data was nested within individuals: CSE over time. Then for the second level, individuals were nested within groups according to gender & ethnicity and SAT math was added to the model to control for achievement. To account for the way CSE changed through time the growth curve model used was quadratic based on the way the data looked. Instructional units were coded as time.

Model

Level-1 Model specification

\[ Y_{\text{CSE}} = \pi_{0i} + \pi_{1i} \times \text{Time}_{it} + \pi_{2i} \times \text{Time}^2 + e_{it} \]

Quadratic growth terms (Time \(^2\)) have been used with HLM to describe growth models similar to ours (Crowe, 2009; Silberglipt et al, 2006; Walden et al, 2007; Whitbourne et al, 2009) to better fit the appearance of our data, as seen in Figure 4.1.

\( \pi_{0i} \) - intercept, \( \pi_{1i} \) - slope, \( e_{it} \) - random effect

Level-2 model specification

\[ \pi_{0i} = \beta_{00} + \beta_{01} \times \text{Gender}_i + _{02} \times \text{Ethnicity}_i + _{03} \times \text{SATmath} + r_{0i} \]

\[ \pi_{1i} = \beta_{10} + \beta_{11} \times \text{Gender}_i + _{12} \times \text{Ethnicity}_i + _{13} \times \text{SATmath} + r_{1i} \]

\[ \pi_{2i} = \beta_{20} + \beta_{21} \times \text{Gender}_i + _{22} \times \text{Ethnicity}_i \]

where \( \beta_{00}, \beta_{10} \) and \( \beta_{20} \) are intercepts, \( \beta_{01},_{02}, \beta_{11},_{12}, \beta_{21} \) and \( _{22} \) are slopes and \( r_{0i} \) and \( r_{1i} \) are random effects
Combined Model

\[ Y_{CSE} = \beta_{00} + \beta_{01} \times Gender + \beta_{02} \times Ethnicity_{i} + \beta_{03} \times SATmath + \beta_{10} \times Time + \beta_{11} \times Gender_{i} \times Time + \beta_{12} \times Ethnicity_{i} \times Time + \beta_{13} \times SATmath \times Time + \beta_{20} \times Time^2 + \beta_{21} \times Gender_{i} \times Time^2 + \beta_{22} \times Ethnicity_{i} \times Time^2 + e_{ti} \]

HLM was run in SAS 9.2 using Proc Mixed following the approach described by Singer (1998). Analysis of residuals was conducted. A few outliers were identified (outliers were considered those values with residuals of 2 or greater), they were removed and the program was run again with barely noticeable effect in the coefficients and none in the results. So there would be no changes in the results and interpretation of the model with or without the outliers present. SAT math was added to our model after gender and ethnicity were found statistically significant to control for achievement and SAT math was centered around the mean (511) of the cohort.

HLM Coefficient Estimations

Initially the unconditional model (no predictors) was run to obtain the ICC or interclass correlation. The ICC describes the proportion of the variability in the total outcome (CSE) that lies between students as opposed to within a particular student. Proc mixed is run without predictors.

The results were:

\[ ICC = \rho = 0.3123 / (0.3123 + 0.2528) = 0.5545 \]

This means that a little more than half (55.5%) of the total variation in CSE is attributed to difference among students, and 45% variability is within students. The results for the HLM are summarized in table 4.29:
Table 4.29 HLM Coefficients

<table>
<thead>
<tr>
<th>Estimate</th>
<th>Std Error</th>
<th>DF</th>
<th>t-value</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>3.09</td>
<td>0.11</td>
<td>302</td>
<td>27.91</td>
</tr>
<tr>
<td>Time</td>
<td>0.34</td>
<td>0.06</td>
<td>294</td>
<td>5.92</td>
</tr>
<tr>
<td>Ethnicity a</td>
<td>0.16</td>
<td>0.16</td>
<td>329</td>
<td>1.00</td>
</tr>
<tr>
<td>Ethnicity b</td>
<td>0.44</td>
<td>0.12</td>
<td>329</td>
<td>3.79</td>
</tr>
<tr>
<td>Ethnicity c</td>
<td>0.13</td>
<td>0.11</td>
<td>329</td>
<td>1.23</td>
</tr>
<tr>
<td>Ethnicity d</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender 1</td>
<td>-0.37</td>
<td>0.97</td>
<td>329</td>
<td>-3.83</td>
</tr>
<tr>
<td>Gender 0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time*Ethn a</td>
<td>0.05</td>
<td>0.043</td>
<td>329</td>
<td>1.09</td>
</tr>
<tr>
<td>Time*Ethn b</td>
<td>-0.09</td>
<td>0.031</td>
<td>329</td>
<td>-2.99</td>
</tr>
<tr>
<td>Time*Ethn c</td>
<td>-0.01</td>
<td>0.03</td>
<td>6329</td>
<td>-0.22</td>
</tr>
<tr>
<td>Time*Ethn d</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time*Gen 1</td>
<td>0.06</td>
<td>0.03</td>
<td>329</td>
<td>2.29</td>
</tr>
<tr>
<td>Time*Gen 0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time²</td>
<td>-0.051</td>
<td>0.01</td>
<td>270</td>
<td>-6.23</td>
</tr>
<tr>
<td>SAT MATH</td>
<td>0.002</td>
<td>0.0006</td>
<td>329</td>
<td>3.05</td>
</tr>
</tbody>
</table>

Gender 1 – Women, Gender 0 – Men
Ethnicity a – Asians, Ethnicity b – Blacks, Ethnicity c – Hispanics, Ethnicity d – Whites

* Statistically significant

Table 4.29A Covariance Parameter Estimates

<table>
<thead>
<tr>
<th>Covariance Parameter</th>
<th>Estimate</th>
<th>Standard Error</th>
<th>Z value</th>
<th>Pr Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>UN(1,1)</td>
<td>0.77</td>
<td>0.15</td>
<td>5.04</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>UN(2,1)</td>
<td>-0.35</td>
<td>0.10</td>
<td>-3.4</td>
<td>0.0005</td>
</tr>
<tr>
<td>UN(2,2)</td>
<td>0.22</td>
<td>0.08</td>
<td>2.87</td>
<td>0.0021</td>
</tr>
<tr>
<td>UN(3,1)</td>
<td>0.04</td>
<td>0.02</td>
<td>2.81</td>
<td>0.0049</td>
</tr>
<tr>
<td>UN(3,2)</td>
<td>-0.03</td>
<td>0.12</td>
<td>-2.24</td>
<td>0.025</td>
</tr>
<tr>
<td>UN(3,3)</td>
<td>0.003</td>
<td>0.001</td>
<td>1.72</td>
<td>0.04</td>
</tr>
<tr>
<td>Residual</td>
<td>0.17</td>
<td>0.012</td>
<td>13.99</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

Where UN(1,1) is the variance for the intercept, UN(2,1) is the covariance between intercept and ethnicity, UN(2,2) is the variance for ethnicity, UN(3,1) is the covariance between gender and intercept, UN(3,2) is the covariance between gender and ethnicity and UN(3,3) is the variance for gender. Although these parameters were not used to answer any of our research questions they are usually reported.
Estimated CSE for the Different Ethnicities and Genders through after Applying HLM Coefficient

Figure 4.45 shows the trends by gender and ethnicity after applying the coefficients obtained by the HLM model:

![Figure 4.45. CSE Trends by Gender and Ethnicity as Modeled by HLM](image)

<table>
<thead>
<tr>
<th>Gender</th>
<th>Ethnicity</th>
<th>N</th>
<th>CSE@ Time 0</th>
<th>CSE@ Time1</th>
<th>CSE@ Time2</th>
<th>CSE@ Time 3</th>
<th>CSE@ Time 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Women</td>
<td>Black</td>
<td>57</td>
<td>3.15</td>
<td>3.41</td>
<td>3.56</td>
<td>3.61</td>
<td>3.56</td>
</tr>
<tr>
<td>Women</td>
<td>Asian</td>
<td>20</td>
<td>2.87</td>
<td>3.27</td>
<td>3.56</td>
<td>3.75</td>
<td>3.84</td>
</tr>
<tr>
<td>Women</td>
<td>Hispanic</td>
<td>53</td>
<td>2.85</td>
<td>3.19</td>
<td>3.43</td>
<td>3.56</td>
<td>3.60</td>
</tr>
<tr>
<td>Women</td>
<td>White</td>
<td>134</td>
<td>2.72</td>
<td>3.06</td>
<td>3.31</td>
<td>3.45</td>
<td>3.49</td>
</tr>
<tr>
<td>Men</td>
<td>Black</td>
<td>15</td>
<td>3.53</td>
<td>3.72</td>
<td>3.81</td>
<td>3.80</td>
<td>3.68</td>
</tr>
<tr>
<td>Men</td>
<td>Asian</td>
<td>7</td>
<td>3.25</td>
<td>3.58</td>
<td>3.81</td>
<td>3.94</td>
<td>3.96</td>
</tr>
<tr>
<td>Men</td>
<td>Hispanic</td>
<td>19</td>
<td>3.22</td>
<td>3.50</td>
<td>3.68</td>
<td>3.75</td>
<td>3.72</td>
</tr>
<tr>
<td>Men</td>
<td>White</td>
<td>61</td>
<td>3.09</td>
<td>3.37</td>
<td>3.56</td>
<td>3.64</td>
<td>3.62</td>
</tr>
</tbody>
</table>

As seen on Table 4.30 the calculated CSE at the different times after applying the coefficients obtained by HLM and also the total sample numbers by ethnicity and gender.
The information was organized in decreasing order of CSE at time 0, and shown graphically in figure 4.45.

The model was based in a comparison using White men’s CSE performance as the reference. The trend lines were calculated by adding all the estimates for the coefficients in the model equation and multiplying by the time accordingly for each of the points. For example:

For Asian Women at time 2

\[ Y_{\text{CSE}} = \beta_{00} (3.0886) + \beta_{01} \times \text{Gender} (-0.3733) + \beta_{02} \times \text{Ethnicity} \times (0.1596) + \beta_{03} \times \text{SATmath} \]

\[ (0 \times 0.0018) + \beta_{10} \times \text{Time} (0.3356 \times 2) + \beta_{11} \times \text{Gender} \times \text{Time} (0.062 \times 2) + \beta_{12} \times \text{Ethnicity} \times \text{Time} (0.047 \times 2) + \beta_{20} \times \text{Time}^2 (0 \times -0.051) + \]

\[ \beta_{21} \times \text{Gender} \times \text{Time}^2 (ns) + \beta_{22} \times \text{Ethnicity} \times \text{Time}^2 (ns) = 3.56 \]

Note: The term SATmath is the only continuous variable and we centered it around the mean (that was 511) so for a person (an Asian women in this case) who had a score of 511, the SAT value would be zero. However, for someone who had a SAT math score of 520, \((511 - 520 = -9)\) then the score used would be -9 since the score is subtracted from the mean. Those terms that were non significant so they were eliminated from the model.

**Interpretation of Coefficients**

The model was based in a comparison using White men’s CSE performance as the reference. The average mean CSE for the population of White men was CSE = 3.1 at the beginning of the course (Time 0). The population of women in general started at a lower CSE average, 0.37 \((\beta_{01} = - 0.037, p = .0002)\) lower than the men of the same ethnicity. There was a statistically significant gender by time interaction for women \((\beta_{11} = 0.062, p = .0225)\). This interaction shows that women in general demonstrated a positive
CSE gain over time compared to men ($\beta_{11} = 0.062$, $p = .0225$). At the end of the semester women’s CSE was very close to that of men of the same ethnicity. In general, women’s CSE increase through the semester was significant but men’s was not although they also experienced some increase depending on their ethnicity.

The negative coefficient for time$^2$ or time*time ($= -0.051$) captures the trend in the data that increases and then levels off. After the quadratic term (Time$^2$) was added to the model it resulted statistically significant; this meant that a quadratic curve model fits our data.

Black students started the semester with ($\beta_{02b} = 0.44$, $p = .0005$) significantly higher CSE (3.2 for women and 3.5 for men from Table 4.30) than the other ethnicities. Black students showed an interaction with time ($\beta_{12b} = -0.094$, $p = 0.003$) that was negative and significant. The negative sign denotes that their increase in CSE was lower than for White men.

Considering where they started and where they ended, Blacks gained very little CSE: men increased 0.11 and women 0.39 CSE units. Black and White men and women ended very close in CSE values but Whites increased their CSE by 0.49 for men and 0.79 for women. Although there are no previous studies by ethnicity, it was surprising to find that White students started with the lowest CSE of all ethnicities Hispanics increased their CSE by 0.75 for women and 0.5 for men and Asians increased 0.97 for women and 0.71 for men. The time interaction was not significant for Asians, Hispanics or Whites.
CSE and Achievement

ANOVA for SAT Math by Ethnicity

The relevance of CSE is its connection to achievement so we examined achievement by ethnicity through the semester. Students took four exams and the final. Patterns for achievement through the semester look very similar for all ethnicities and it is evident that Black students had the lowest achievement as seen in table 6A. At the end of the semester Asians had the highest achievement followed by Whites and Hispanic at the same level and Blacks had the lowest achievement consistently for exams 1, 3, 4, and 5.

Table 4.31. Achievement as Percent Score and SAT Math by Ethnicity for Preparatory Chemistry

<table>
<thead>
<tr>
<th></th>
<th>Exam 1</th>
<th>Exam 2</th>
<th>Exam 3</th>
<th>Exam 4</th>
<th>Exam 5</th>
<th>SAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asians</td>
<td>71 (N=27)</td>
<td>71 (N=26)</td>
<td>60 (N=26)</td>
<td>70 (N=24)</td>
<td>66 (N=26)</td>
<td>516 (N=26)</td>
</tr>
<tr>
<td>Hispanics</td>
<td>73 (N=71)</td>
<td>72 (N=70)</td>
<td>57 (N=68)</td>
<td>73 (N=70)</td>
<td>59 (N=71)</td>
<td>520 (N=66)</td>
</tr>
<tr>
<td>Whites</td>
<td>72 (N=193)</td>
<td>67 (N=194)</td>
<td>56 (N=187)</td>
<td>70 (N=178)</td>
<td>70 (N=178)</td>
<td>519 (165)</td>
</tr>
<tr>
<td>Blacks</td>
<td>64 (N=71)</td>
<td>66 (N=65)</td>
<td>50 (N=71)</td>
<td>64 (N=71)</td>
<td>53 (N=71)</td>
<td>411 (63)</td>
</tr>
</tbody>
</table>

Also in table 4.31 SAT math scores are listed according to ethnicity that show Blacks had the lowest scores. In table 4.32 are the results for the ANOVA for SAT math that resulted significant and the follow up Tukey tests are on table 4.33.

The results for ANOVA were: $F = 9.55, p = .000$ and the Tukey test revealed that Blacks were significantly lower than the rest of the ethnicities. These results are relevant because in past studies SAT math have been used to predict performance in college chemistry.
Table 4.32 Results for SAT Math ANOVA

<table>
<thead>
<tr>
<th></th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>3</td>
<td>87419.42</td>
<td>29139.806</td>
<td></td>
<td>.000</td>
</tr>
<tr>
<td>Within Groups</td>
<td>316</td>
<td>964255.58</td>
<td>3051.442</td>
<td>9.550</td>
<td>.000</td>
</tr>
<tr>
<td>Total</td>
<td>319</td>
<td>1051675.0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4.33 Results for Tukey for SAT Math

<table>
<thead>
<tr>
<th>Comparisons</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blacks vs. Asians</td>
<td>.016</td>
</tr>
<tr>
<td>Blacks vs. Hispanics</td>
<td>.000</td>
</tr>
<tr>
<td>Blacks vs. Whites</td>
<td>.000</td>
</tr>
</tbody>
</table>

MANOVA for Exams By Ethnicity

A MANOVA was run to find if the grades for Blacks in each of the five exams were significantly different from the other ethnicities and the results were as follow in table 4.34 for the MANOVA and in table 4.35 for the follow up Tukey tests:

Table 4.34 MANOVA Results for the 5 Exams by Ethnicity

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>Exam 1</th>
<th>Exam 2</th>
<th>Exam 3</th>
<th>Exam 4</th>
<th>Exam 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>MANOVA (15, 867)</td>
<td>2.90*</td>
<td>7.40*</td>
<td>3.41*</td>
<td>5.95*</td>
<td>2.13</td>
</tr>
<tr>
<td>(3, 318)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.52</td>
</tr>
</tbody>
</table>

*p<.05

Table 4.35 Results for the Tukey Tests

<table>
<thead>
<tr>
<th>Comparisons</th>
<th>Exam 1</th>
<th>Exam 2</th>
<th>Exam 3</th>
<th>Exam 4</th>
<th>Exam 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asians vs. Blacks</td>
<td>ns</td>
<td>ns</td>
<td>*</td>
<td>Ns</td>
<td>ns</td>
</tr>
<tr>
<td>Asians vs. Hispanics</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>Ns</td>
<td>ns</td>
</tr>
<tr>
<td>Asians vs. Whites</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>Ns</td>
<td>ns</td>
</tr>
<tr>
<td>Black vs. Hispanics</td>
<td>*</td>
<td>ns</td>
<td>ns</td>
<td>Ns</td>
<td>ns</td>
</tr>
<tr>
<td>Blacks vs. Whites</td>
<td>*</td>
<td>ns</td>
<td>ns</td>
<td>Ns</td>
<td>ns</td>
</tr>
<tr>
<td>Hispanics vs. Whites</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>Ns</td>
<td>ns</td>
</tr>
</tbody>
</table>

*p<.0025, ns - not significant

For the Tukey tests as seen in table 4.35, a Bonferroni adjustment was done for the p = .0025 since there were 4 groups and 5 exam each, a total of 20 comparisons. The results were that there was a significant difference between Blacks and Hispanics and Blacks and Whites only for exam 1 and, for exam 3 there was a significant difference...
between Blacks and Asians. For exams 2, 4 and 5 there were no significant differences between any of the ethnicities.

HLM in Complete Set of Data

The same HLM model was run using only the complete set of data. The complete set is that set of 162 students with each and every one of the five CSE questionnaires given through the semester and the results look as seen in figure 4.46.

![CSE Trends for Complete Set of Data as Modeled by HLM](image)

Figure 4.46 CSE Trends for Complete sets of Questionnaires as Modeled by HLM
Table 4.36 CSE Trends for Complete Sets of Questionnaires as Modeled by HLM

<table>
<thead>
<tr>
<th></th>
<th>CSE@ Time 0</th>
<th>CSE@ Time1</th>
<th>CSE@ Time2</th>
<th>CSE@ Time 3</th>
<th>CSE@ Time4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Women Asian</td>
<td>2.89</td>
<td>3.27</td>
<td>3.55</td>
<td>3.74</td>
<td>3.83</td>
</tr>
<tr>
<td>Women Black</td>
<td>3.26</td>
<td>3.52</td>
<td>3.69</td>
<td>3.76</td>
<td>3.74</td>
</tr>
<tr>
<td>Women Hispanic</td>
<td>2.98</td>
<td>3.29</td>
<td>3.51</td>
<td>3.64</td>
<td>3.67</td>
</tr>
<tr>
<td>Women White</td>
<td>2.70</td>
<td>3.02</td>
<td>3.25</td>
<td>3.38</td>
<td>3.42</td>
</tr>
<tr>
<td>Men Asian</td>
<td>3.29</td>
<td>3.61</td>
<td>3.83</td>
<td>3.96</td>
<td>3.99</td>
</tr>
<tr>
<td>Men Black</td>
<td>3.67</td>
<td>3.86</td>
<td>3.97</td>
<td>3.98</td>
<td>3.89</td>
</tr>
<tr>
<td>Men Hispanic</td>
<td>3.38</td>
<td>3.63</td>
<td>3.79</td>
<td>3.85</td>
<td>3.82</td>
</tr>
<tr>
<td>Men White</td>
<td>3.10</td>
<td>3.36</td>
<td>3.53</td>
<td>3.60</td>
<td>3.58</td>
</tr>
</tbody>
</table>

Figure 4.46 shows the trends from the HLM model after it was applied to the complete sets of data (Set B). Table 4.36 shows the modeled values at the different times for set B that includes only those with complete sets of questionnaires. The trends are similar between the complete set of data and those of the entire data. These trends for complete sets of data are at a higher level of CSE for all ethnicities and genders than for the trends of entire data set. This is evidence that those students with the complete sets had higher CSE than those who had incomplete sets and the HLM model captured this. The trend for Black males showed a very small increase in CSE compared to men in the other ethnicities.

HLM Coefficients in Complete Set of data

Table 4.37 shows the HLM estimates (coefficients) and p values obtained for the entire data and for the complete set. The intercept for the complete set was the same value, meaning that White men started at the same level of CSE of 3.1. The significance of the estimates obtained is the same in both cases except for (._03) SAT math, (._11)
time*gender0 (women) interaction, and (_12b) time*ethnicity b interaction in the complete set, which was not significant in this case. The reason for the lack of significance in the case of SAT mathematics could be to the fact that there was less variability in the SAT mathematics and for those with complete sets of questionnaires. In the case of the time*gender interaction it is possible that either the interactions were no longer there or the power to detect them was not enough since the sample size decreased. The values of the estimates are not identical but they are not that different in each case. Where estimates varied the most were for _02a, _02b, _02c, and _03. Overall the complete set results have higher CSE as is the case in all of the descriptive statistics.

<table>
<thead>
<tr>
<th></th>
<th>Entire Data</th>
<th></th>
<th>Complete Set</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate</td>
<td>p</td>
<td>Estimate</td>
<td>p</td>
</tr>
<tr>
<td>_00</td>
<td>Intercept</td>
<td>3.0886</td>
<td>&lt;.0001*</td>
<td>3.0995</td>
</tr>
<tr>
<td>_10</td>
<td>Time</td>
<td>0.3356</td>
<td>&lt;.0001*</td>
<td>0.3037</td>
</tr>
<tr>
<td>_02a</td>
<td>Ethnicity a</td>
<td>0.1596</td>
<td>0.3174</td>
<td>0.1925</td>
</tr>
<tr>
<td>_02b</td>
<td>Ethnicity b</td>
<td>0.4372</td>
<td>0.0002*</td>
<td>0.5669</td>
</tr>
<tr>
<td>_02c</td>
<td>Ethnicity c</td>
<td>0.1340</td>
<td>0.2204</td>
<td>0.2813</td>
</tr>
<tr>
<td></td>
<td>Ethnicity d</td>
<td>0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>_01</td>
<td>Gender 0</td>
<td>-0.3733</td>
<td>.0002*</td>
<td>-0.4044</td>
</tr>
<tr>
<td></td>
<td>Gender 1</td>
<td>0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>_12a</td>
<td>Time*Ethn a</td>
<td>0.04707</td>
<td>0.2775</td>
<td>0.055</td>
</tr>
<tr>
<td>_12b</td>
<td>Time*Ethn b</td>
<td>-0.09352</td>
<td>0.003*</td>
<td>-0.063</td>
</tr>
<tr>
<td>_12c</td>
<td>Time*Ethn c</td>
<td>-0.00650</td>
<td>0.8265</td>
<td>0.0085</td>
</tr>
<tr>
<td></td>
<td>Time*Ethn d</td>
<td>0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>_11</td>
<td>Time*Gen 0</td>
<td>0.06183</td>
<td>0.0225*</td>
<td>0.0621</td>
</tr>
<tr>
<td></td>
<td>Time*Gen 1</td>
<td>0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>_20</td>
<td>Time 2</td>
<td>-0.05107</td>
<td>&lt;.0001*</td>
<td>-0.04711</td>
</tr>
<tr>
<td>_30</td>
<td>SAT_MATH</td>
<td>0.00186</td>
<td>0.0025*</td>
<td>0.0009</td>
</tr>
</tbody>
</table>

* Statistically significant

Gender 0 – Women, Gender 1 – Men
Ethnicity a – Asians, Ethnicity b – Blacks, Ethnicity c – Hispanics, Ethnicity d – Whites
Comparison of CSE between Raw Data and HLM

There was good agreement between the HLM modeled trends and the raw data trends except for the Asian men; the model underestimated their CSE. After reviewing both the model and the raw data, no errors were found. It is possible that this was an effect of the Asian men small sample size (N = 7). In any case Asians tend to have high CSE and high achievement in general (Kao, 1995; Peng & Wright 1994; Stanley & Okazaki, 2009), so it is less of a concern than with minorities that tend to have lower confidence such as women, or possibly Hispanics or Blacks.

What was common in the raw data, all except for Black men, increased CSE at the end of the semester. Black women achieved a very small gain but Black men ended the semester with a lower CSE than they started. Both, raw and modeled trends indicate that CSE gains for Black women were smaller than for the rest of the women.

Although White men ended at lower CSE than Blacks, they still showed a gain from the starting to the ending points. All trends, raw or modeled, showed a tendency to increase CSE through the semester. All groups ended with higher CSE than they started with but Blacks gain was very small compared to the rest of the ethnicities, this is what makes their trends different, especially for Black men. It was interesting and unexpected to note that White men and women had the lowest CSE at the beginning of the semester. Asians had the highest CSE gains followed by Hispanics, which was unexpected and then Whites.

There was good agreement between the HLM modeled trends and the raw data trends except for the Asian men; the model underestimated their CSE. After reviewing both the model and the raw data, no errors were found. It is possible that this was an
effect of the Asian men small sample size. In any case Asians tend to have high CSE and high achievement in general, so it is less of a concern than with minorities that tend to have lower confidence such as women or under achieve such as Hispanics or Blacks.

Link Between CSE and Achievement in General Chemistry I

A correlation between the last CSE and total final points in General Chemistry I was run to find out if there was still a link by the end of the following semester (spring 08) and a value $r = 0.46$ was obtained for the 191 who finished the course.
Chapter V Discussion of Quantitative Analysis

This chapter contains the discussion of the results from quantitative analysis in the study. The quantitative analysis encompasses the descriptive statistics for CSE and achievement, comparisons by gender and ethnicity of complete and incomplete sets, repeated measures ANOVA and HLM (Hierarchical Linear Model) done on CSE as well as MANOVA done on achievement by ethnicity as it related to CSE results.

Descriptive Statistics for CSE

There descriptive statistics show a normal distribution for the CSE for the entire cohort, as seen in table 4.1, however one can notice that as the semester advanced, the number of students turning in the CSE questionnaire decreased consistently. There was an increase of CSE from Instructional Unit 0 to Instructional Unit 1 and after that CSE varied only slightly and at the end CSE was higher than the beginning.

Those students with Complete Sets of questionnaires invariably obtained higher mean CSE and achievement scores as seen in Figure 4.1. CSE difference between complete and incomplete sets was calculated as Cohen’s d for each point in time. As seen in Table 4.2, each d resulted in a small difference between these two groups. A t-test using SAT math established equivalence between the complete and incomplete groups in terms of mathematics capability that has been proven crucial for learning chemistry in the past (Bunce & Hutchinson 1993, Lewis & Lewis 2005).
Those students who did not have complete sets most likely were absent for the lectures before the exams. According to previous literature there is a direct link between attending lectures and achievement (Chan, 2009; Chen, 2008; Gatherer & Manning, 1998; El Tantawi, 2009; Hove, 2008; Stanca, 2006; Thatcher, 2007). However, there is a caveat about this, attending the lecture indicates student commitment to the course(s), it doesn’t mean that, solely by attending lectures high achievement or even passing the course is ensured. This is why one can associate not attending lecture regularly with being less likely to do well in the course.

CSE and Achievement in Letter Grades

Most students (94%) came into the preparatory chemistry course having taken chemistry in high school. Their CSE was established according to their positive or negative experiences in the course according to Bandura (1986, 1997). About 12% of the students did not take chemistry in high school but some chemistry was part of their curriculum so they had an idea what to expect. This means that there was a CSE established, students had experience learning chemistry.

Students with complete sets had higher CSE and through the semester as seen in Figure 4.1. And looking into SAT scores to see if there was a difference between those students with complete and incomplete sets none was found in terms of ability. Still there was a link between achievement and the tendency to miss CSE questionnaires as seen on Tables 4.4 and 4.5. This suggests that those who were committed to taking the questionnaires were also committed to exerting the necessary effort in the course and obtained higher grades.
As seen in Figure 4.3, CSE for failing and passing students showed very similar, almost identical trends for the first three times (Instructional Units 0, 1, and 2) CSE questionnaires were given. Both cohorts dropped in CSE for Instructional Unit 3, but passing students increased their CSE by Instructional Unit 4. Having succeeded in the course was a positive mastery experience (Bandura, 1986, 1997) that reinforced their CSE and increased it overall at the end of the semester. By the same token, CSE for those who failed the course decreased consistently from Instructional Units 2, 3 and 4, dropped to a lower level. The low CSE was a reflection of their negative mastery experience in the course. Those who failed the course ended with the same CSE they started at the beginning of the semester (at Instructional Unit 0). So at the end of the semester, between passing and failing students there was a CSE effect size difference $d = 0.59$, considered medium to large.

Achievement for those who passed and those who failed as shown in Figure 4.4 revealed a higher-level trend for those who passed and a lower for those who failed. Table 4.7 shows an effect size difference that is very large ($d = 0.97-1.77$) between passing and failing cohorts.

CSE and Achievement by Gender

Women started with lower CSE than men for the entire cohort, as seen in Figure 4.5. This result is in agreement with previous literature where women’s CSE is lower than men’s (DeBacker & Nelson, 1999, 2000; Lloyd et al, 2005; Michaelides, 2008; Miller et al, 1996; Pajares, 1996, 2002; Pintrich & De Groot, 1990; Smist et al, 1997). But as the semester advanced, the gender gap closed until it practically disappeared as
revealed by the calculated effect sizes in table 4.8. It could be argued that those women who had low CSE were the ones not turning in the questionnaires as the semester progressed and that was why the CSE gender gap disappeared; this is possible to a small degree. After looking at CSE for those women who had complete sets it was observed that the gender gap disappeared at the end of the semester. The closing of the gender gap in CSE was a positive outcome of the course. A small effect size difference remained for women in the incomplete sets. The gender gap disappearance was a positive outcome of the course.

Achievement by gender was similar for the entire cohort as seen in Figure 4.6. Trends by gender were very close and at the end of the semester there was a small effect size difference ($d = 0.2$) with men having slightly higher achievement. In the complete sets there were small differences between genders but both cohorts ended with the same achievement as seen in Figure 4.8. Differences between genders for the incomplete sets were small but at the end of the semester the difference in achievement was small towards medium ($d = 0.36$) as seen in table 4.12, which corresponds to the final exam. This difference in achievement between genders is something to be noted. When taking into consideration that the whole cohort had a small size difference in achievement between genders, it is likely that this was due to women in the incomplete set, since women in the complete set had equal achievement to men in the complete set at the end of the semester.
Link between CSE and Achievement by Gender

The link between CSE and achievement for women with the complete sets might not be perfect but still, one can discern in Figure 4.9 that CSE and achievement varied with each other through the semester. Overall, the CSE trend appears to increase. For men with complete sets, the link between CSE and achievement can be discerned as seen in Figure 4.10. In this case the overall CSE trend decreased over time, which is the exact opposite of women’s CSE. The trends for achievement were very similar for both genders.

The link between CSE and achievement for men with incomplete sets is very apparent as can be seen in Figure 4.13 and the same can be said about women’s in Figure 4.14. It is easy to perceive that in both cases as CSE increased, so did achievement for Instructional Units 1, 2, 3, and 4.

Comparison between Men with Complete and Incomplete Sets

When comparing CSE for men with complete and incomplete sets, the trends were similar although men with incomplete sets started at a lower level of CSE as seen in Figure 4.15, and at the end of the semester both cohorts ended at the same level. As seen in Table 4.14 the difference in CSE between men in the complete and incomplete sets disappeared by the end of the semester. The same thing happened for achievement as seen in Figure 4.16 where even if there were differences during the semester, both cohorts ended at the same level of achievement as seen in Table 4.15.
Men in the incomplete set gained CSE from Instructional Unit 0 to Instructional Unit 4 and that increase had an effect size $d = 0.29$ which was a little larger than that of men with complete set $d = 0.18$.

Comparison between Women with Complete and Incomplete Sets

Women with complete sets had higher CSE than those with incomplete sets differences varying in effect sizes as seen in Figure 4.17 and Table 4.16. In terms of achievement, women with complete sets had higher achievement with medium effect sizes differences than those women in the incomplete set and this was constant through the semester as seen in Figure 4.18 and Table 4.17.

In terms of CSE for those students in the complete sets, women caught up with the men who had higher CSE through the semester. Men in the incomplete sets, who also started at lower CSE than those with complete sets also caught up with men in the complete set. The same thing happened with achievement, at the end of the semester men in complete and incomplete sets and women in the complete sets ended with the same achievement. Women in the incomplete set had lower CSE and achievement through the semester. So, it is very likely that women with incomplete sets were responsible for having lower achievement than men in the entire cohort since women with complete sets achievement was practically the same as men’s.

It was easier for men in the incomplete set to catch up in terms of CSE and achievement than it was for women in the incomplete set. Bouncing back more readily is a sign of resilience and therefore higher self-efficacy. The results were in agreement with what is found in the literature since men have shown to have higher self-efficacy than
women in general. Women in the Complete set had an overall CSE increase during the semester (from Instructional Unit 0 to 4), the effect size of the increase was $d = 0.54$ considered medium size. Women in the Incomplete set had an increase $d = 0.66$ also considered medium size which was a larger increase than that of women in the complete set, the same as men. These results suggest that women in general were somewhat weaker in CSE and achievement with the exception of the cohort of women with complete sets who were able to close the gender gap for CSE and achievement by the end of the semester and this was excellent.

CSE and Achievement by Ethnicity

Entire Cohort

In terms of ethnicity, Black students started the semester with the highest CSE followed by Asians, Hispanics and then Whites as seen in Figure 4.19. The trends for Blacks appeared different than for all the other ethnicities because their CSE tended to increase while Blacks’ CSE decreased through the semester. It was encouraging to observe an increase in CSE for all ethnicities but intriguing to see that Blacks did not improve and ended the semester very close to the CSE level where they started. Black’s CSE had a spike from Instructional Unit 0 to 1 but it trickled down through the semester to their starting level (Instructional Unit 0). In terms of achievement Blacks also had the lowest achievement through the semester as seen in Figure 4.20. The other ethnicities were close to each other through the semester in terms of achievement; Asians ended slightly above Hispanics and Whites. Blacks’ achievement and CSE surely need to improve if their retention and the increase of their numbers in the sciences is to be
accomplished. Clearly Blacks were not where they need to be and something needs to be done. Considering CSE from beginning to end of the semester Blacks had a gain with an effect size $d = 0.12$, Asians $d = 0.59$, Hispanics $d = 0.48$, and Whites $d = 0.45$.

Complete Sets by Ethnicity

CSE trends by ethnicity for those with complete sets were that not different from the entire set as can be seen in Figure 4.25. In this case Hispanics started with the highest CSE, followed closely by Blacks, Asians and then, slightly below, Whites. The CSE increased for all ethnicities except for Blacks who dropped all the way almost to their starting point by the end of the semester. If one ignored the CSE measured at Instructional Units 1, 2, and 3, and only focused on where CSE started and where it ended for each ethnic group, we would find that Blacks had a very small increase with an effect size $d = 0.12$; Whites had an medium size increase $d = 0.45$ followed by Hispanics $d = 0.48$ and Asians who had a higher increase of $d = 0.59$, all these as seen in table 4.18. These results also show how CSE for Blacks did not develop as for the rest of the ethnicities.

In terms of achievement, there is only a small effect size between the four ethnicities in the complete sets as seen in Table 4.19 and in Figure 4.26, where the differences at the end of the semester are shown and although Blacks were below the other ethnicities, the difference is small: $d = 0.18$ between Blacks and Whites, Blacks having the lower score. These results are still positive, having the Black students’ achievement in the complete set only slightly below the rest of the ethnicities.
Incomplete Sets by Ethnicity

The CSE trends for those students in the incomplete sets by ethnicity look similar to those students in the complete sets as seen in Figure 4.39. Blacks started with the highest CSE and ended with the lowest. Asians and Hispanics started at the same level and Asians ended with the highest CSE followed by the Hispanics. Whites started with the lowest CSE and ended below Hispanics but above the Blacks. CSE for Asians, Blacks, Hispanics and Whites varied differently through the semester but in the end, all except for the Blacks increased their CSE. Black’s CSE increased for Instructional Unit 1 and dropped immediately for Instructional Unit 2 and they did not recover at all. This result is intriguing and it needs to be investigated.

The results for achievement of these cohort of students were similar in terms of the way the trends look as seen in Figure 4.40 and somewhat unexpected because Hispanics and Whites had the highest trends, ending practically with the same scores for the final exam, Asians and Blacks had the lowest trends also ending with the same score for the final exam. These results were definitely unexpected for Asians especially for exam 3 where they had the lowest score of all ethnicities.

Link between CSE and Achievement for the Entire Cohort

There were differences in the link between CSE and achievement for the different ethnicities: Asians CSE tended to increase through the semester regardless of achievement as seen in Figure 4.22. Blacks’ trend as seen in Figure 4.21 shows that CSE decreased regardless of how achievement varied through the semester. For Hispanics and Whites there is an evident link between CSE and achievement through the semester, the
two measures change with each other as seen in Figures 4.22 and 4.23 respectively. According to these results, Blacks and Asians had opposite CSE trends through the semester. For Hispanics and Whites (Figure 4.24) CSE and achievement had a discernible link through the semester.

Link between CSE and Achievement for Complete Sets

For Asians in the complete sets CSE and achievement appears inverse except that the slope for achievement has a softer slope than that of the entire set as seen in Figure 4.27. Blacks with complete sets showed a link between CSE and achievement through the semester except for Instructional Unit 4 where CSE decreased further but achievement increased as can be seen in Figure 4.28. This is somewhat different to the CSE for Blacks in the entire cohort (Figure 4.22), whose CSE dropped right after Instructional Unit 1. Blacks in the complete set had a closer link to their achievement until the very end, their CSE was more stable for Instructional Units 1 and 2 as seen in Figure 4.28, but in the end, even those Blacks with complete sets CSE dropped almost to their initial level, that of Instructional Unit 0. In the end, Blacks’ CSE increased only slightly. Blacks CSE and achievement should show a positive outlook where achievement should be higher and their CSE should have a higher increase through the semester to match the trends of the other ethnicities.

For Hispanics in the complete set, the link between CSE and achievement is not easily detected through the semester, as seen in Figure 4.29, CSE trend is similar to Asians’ trend: it increased through the semester regardless of achievement. As seen in Figure 4.30, Whites show a link between CSE and achievement very similar that of the
entire set as seen in Figure 4.24, there is barely a difference between these two sets in terms of appearance of trends.

Link between CSE and Achievement for Incomplete Sets

The link between CSE and Achievement for Asians in the incomplete sets is evident as seen in Figure 4.41. From Instructional Unit 1, CSE and achievement change with each other through the semester. For Blacks there is no visible link between CSE and achievement as seen in Figure 4.42; CSE decreased independently from achievement. For Hispanics, CSE and achievement are closely linked as seen in Figure 4.43 and for Whites we can also see a close link between CSE and achievement as seen in Figure 4.44.

CSE and Achievement Differences between Complete and Incomplete Sets

As seen in Figure 4.31 Asians with complete sets had a steady increase of CSE through the semester while those with incomplete sets had a different pattern; there was a sharp increase for Instructional Unit 3 that went above those with the complete set. The differences between the complete and incomplete cohorts are reported in Table 4.20. The effect size differences were inconsistent through the semester and it is very likely that the reason for these unusual patterns may be due to the small and changing number of Asians in the incomplete cohort. Achievement for these two cohorts was as expected, that is, those in the complete set had higher achievement than those in the incomplete set as seen in Figure 4.32 and the effect size of the differences reported in Table 4.21 were large except for exam 4 that had a medium effect size.
The CSE difference between Blacks in the complete and incomplete sets can be seen in Figure 4.33 that shows those Blacks in the complete set had higher CSE than those in the incomplete set, as expected. Both cohorts had very similar CSE for Instructional Units 1 and 2 but those in the incomplete set dropped dramatically for Instructional Unit 3 and continued until the end of the semester. Those students in the complete set dropped less dramatically and kept their CSE steadier until the end of the semester ending with a small CSE gain. Those in the incomplete set dropped below their initial CSE, which is very intriguing. The effect size differences between these two cohorts in terms of CSE are reported in Table 4.22 and they go from very small at the beginning of the semester, and they increase to medium towards the end of the semester. Black students in the incomplete set lost their confidence as the semester advanced. This is not a good outlook for this cohort of Black students. In terms of achievement, those Blacks in the incomplete set had lower scores than those in the complete set as expected according to Figure 4.34 and the effect sizes of the differences as seen in Table 4.23 were medium for Instructional Units 1, 2 and 3, towards large for Instructional Units 3 and 4. This means that the difference between complete and incomplete cohorts increased towards the end of the semester.

As seen in Figure 4.35, Hispanics in the complete set CSE increased with a gentle slope through the semester. Those in the incomplete set had a sharper increase from Instructional Unit 0 to s 1 and 2, then a drop for Instructional Unit 3 and recovered for time 4. As expected, those in the complete set had higher CSE. The effect size differences are reported in Table 4.24 and the values are inconsistent through the semester, the largest was reported for Instructional Unit 3 (d = 0.8) and the smallest for Instructional
Unit 2 (d = 0.16). Both cohorts of Hispanics gained CSE at the end of the semester. In terms of achievement, the two cohorts were very close but the complete set had higher scores than the incomplete set as seen in Figure 4.36. The effect size of the differences appears in Table 4.25 where the d values were small especially first and last values were almost imperceptible. These were the smallest differences in achievement so far between complete and incomplete cohorts.

CSE for Whites in the complete and incomplete sets was very similar for Instructional Units 0, 1, and 2 and slightly different for Instructional Units 3 and 4 as seen in Figure 4.37. The effect size of the differences between these two cohorts was very small through the semester as seen in Table 4.26 and they ended with a d= -0.16 meaning that the incomplete sets had higher CSE. It was unusual that for Instructional Units 1, 3, and 4, CSE scores were higher for those students in the incomplete set than for those in the complete set, which is the opposite of what was previously observed. Looking at how the number of participants who missed questionnaires increased as the semester advanced, it is very likely that those with low CSE were the ones who missed the questionnaires leaving those with higher CSE continuing to complete the surveys until the end. This was especially evident for White students since there were 109 students in the incomplete set at Instructional Unit 0, the participants dropping to 95, 76, 72, and, by the end, at Instructional Unit 4, there were only 56 White students. In terms of achievement, those in the complete set had higher scores than those in the incomplete set as expected and as seen in Figure 4.38. Both cohorts started at the same point, the effect sizes of the differences are reported in Table 4.27. At the end of the semester there was a
small to medium difference \( d = 0.32 \) with those in the complete set at the higher end as expected.

Repeated Measures ANOVA

The Repeated Measures ANOVA was performed on CSE measured by the self-efficacy questionnaire given five times during the semester for the whole cohort. Since ANOVA requires complete sets of data and there were 162 students with the complete sets of questionnaires, the results were based on only these students who had complete sets. Instructional Unit was coded as time for this analysis. We found that there was a significant CSE increase from time 0 to times 1, 2, 3, and 4 as seen in Table 4.28. This means that students gained chemistry self-efficacy at the very beginning of the semester; from the first time the took the CSE questionnaire (time 0) to time 1 which was when they took the first exam and after that, even if their CSE changed, each time they had an exam, it was not a significant change. The interaction between gender and time was not found to be significant which means that the repeated measures ANOVA did not detect an effect of time by gender for this study.

Hierarchical Linear Model

To get a more detailed idea about the way CSE changed through the semester the data was divided by gender and by ethnicity and HLM was used to model the changes of CSE. The results were based in a comparison of White men to the rest. Women were found to have started at lower CSE than men of their same ethnicity but during the semester they increased it until they reached the same CSE as men at the end of the
semester. This is a very good outcome. Women in general tend to have lower CSE than men as found in several other studies (DeBacker & Nelson, 1999, 2000; Lloyd et al, 2005; Michaelides, 2008; Miller et al, 1996; Pajares, 1996, 2002; Pintrich & De Groot, 1990; Smist et al, 1997) so having found that through the course of one semester the gender gap had disappeared was desirable and encouraging.

CSE trends by ethnicity were found to be different for Blacks than for the rest of the ethnicities as seen in Figure 4.45. This difference lies in the fact that the Asians, Hispanics and Whites had an increase in CSE, which was a desirable and a positive outcome, but results for Blacks did not show the same increase. Blacks barely increased their CSE at the end of the semester; results especially for Black men are definitely intriguing and should be looked into.

CSE link to achievement is very important because of its association as a predictor of performance so it was necessary to explore the achievement by ethnicity especially after the CSE results by ethnicity. Results for the four exams, the final (exam 5) and SAT Math scores are summarized in Table 4.31. Blacks achievement was the lowest consistently for the exams and the SAT Math scores indicating that their CSE is in agreement with their achievement.

Multivariate analysis of variance or MANOVA was run by ethnicity for achievement using the four exams and the final; the results are found in Tables 4.34 and 4.35. Black students had significantly lower grades than Whites and Hispanics in the first exam. Also, for the third exam, Blacks had significantly lower scores than Asians. Blacks were not significantly lower than the rest of the ethnicities for exams 2, 4, and 5, which was good news. Blacks having significantly lower scores for the first exam is reasonable
since they also had significantly lower SAT in math than the other ethnicities as seen in Table 4.32 and 4.33 and SAT math had been used in the past (Bunce & Hutchinson, 1993; Lewis & Lewis, 2005) to predict success in chemistry. The rest of the results, that Blacks’ achievement is not significantly lower than the rest of the ethnicities for 3 exams, including the final, is definitely good news. It is still desirable that Blacks achievement would be at the same level as the rest of the ethnicities and definitely not consistently below even if it is not statistically lower.

Because Blacks started with significantly higher CSE than the rest of the ethnicities so it might not be unusual to find that they had the least gain, although they hardly seemed they to have gained at all. In the raw data they ended the semester with lower CSE than they started and that was unexpected and that is why Black’s CSE trends were significantly different from the rest of the ethnicities. Never the less, Black women CSE increased, even if moderate, was a positive outcome.

But Blacks started the semester with the significantly higher CSE score and yet, they had significantly lower SAT math and exam 1 scores than the rest of the ethnicities. This contradiction in Blacks had been found in the past, only the context is different and the fact that confidence (CSE) was measured several times during a semester. Hare and Costenell (1985) found that, in desegregated schools in Champaign Illinois, although Black students had lower achievement than Whites, they still had higher self-esteem with respect to home-life, school and peer relations than Whites. Also Osborne (1994) using the National Educational Survey, found that from grades 8 to 10, Black students had lower achievement but somewhat higher self-esteem than White students. According to social psychologists, this tendency they call *disidentification*, is an adaptation or
withdrawal by stigmatized individuals to protect their self-esteem and has its roots on stereotype threat (Steele & Aaronson, 1995). Blacks, Hispanics, and women, have long suffered from stereotype threat, which implies that they have less ability in math and the sciences than White men (Steele, 1992).

Steele’s stereotype threat and disidentification mechanism have been widely incorporated to the social and educational psychology fields. Although Hansford and Hattie (1982) were not specifically researching disidentification mechanism, they found that correlation between various measures of self and academic performance suggested disidentification for Blacks and Hispanics. Osborne (1997) examined correlations among measures of self-esteem and academic performance across a variety of content areas. Blacks showed a trend of disidentification over time (8th to 12th grade), the same as with his first study, but this time disidentification was especially pronounced for boys. Griffin (2002) collected data from 132,903 students in 75 high schools in Florida found evidence of disidentification in Blacks and Hispanics. Morgan & Mehta (2004) investigating possible paths for this mechanism using NELS 1988-1994 data found that Black students relationship between academic achievement and academic self-concept was 30-40% weaker than for White students.

It is possible that when Black students came into the course their CSE was inflated somewhat due to disidentification and during the course of the semester and they did gain some CSE although it is not ideal that their CSE gain was so small, especially compared to the other ethnicities. These unresolved issues among Black students need attention. These are indications that stereotype threat is present and its eradication is complex, hard and lengthy. Other issues need to be conquered before Blacks’ CSE can
improve for example; Ellis & Ryan (2003) found that Blacks used ineffective test-taking strategies although they had high test-taking self-efficacy and good test preparation. Effective test-taking skills are crucial.

Contrary to our findings, Saunders et al (2004) found significantly higher self-efficacy for Black women compared to men in high school. These researchers found that self-efficacy was a better predictor of achievement for Black women than for Black men so she suggested that more research is needed to find what factors influence Black men’s achievement. This finding suggests that the link between achievement and self-efficacy is different for Black men and women the same way it is different between men and women in general. Another possibility is that Black men are more susceptible to stereotype threat than Black women or that men need to further compensate for it.

The following chapter has the conclusions and implications for the quantitative analysis of our study.
Chapter VI Conclusions and Implications

The conclusions presented in this chapter were drawn from the quantitative aspects of our study. The quantitative aspect includes descriptive statistics by gender and ethnicity for the entire cohort including complete and incomplete sets of CSE questionnaires. The gender differences found at the beginning of our study for CSE disappeared by the end of the semester almost completely. Women tended to increase their CSE through the semester. Those students with incomplete sets of questionnaires had consistently lower CSE and at times, achievement. Men in the incomplete sets were able to catch up with the CSE and achievement of men with the complete sets but the same was not true for women in the incomplete set who had a small effect size difference for CSE and almost a medium effect size for achievement than women in the complete set and men.

The link between CSE and achievement ranged from being very evident to not evident at all for the different cohorts. By gender, the link was more evident for those men and women in the Incomplete set than for those in the complete set. CSE for Women in the Complete set showed an evident tendency to increase while CSE for men showed a marked tendency to decrease their CSE. Asians and Blacks showed no apparent link because Asians’ CSE tended to increase regardless of achievement, the total opposite of Blacks whose CSE tended to decrease regardless of achievement. Hispanics and
Whites tended to show an easily discernible link between CSE and achievement through the semester.

There was a positive correlation \( r = 0.46 \) between the last CSE observed in Preparatory Chemistry and the final grade in General Chemistry I the following semester for those students who finished that course. This correlation is higher than what has been reported in the literature (Lalich et. al., 2006; Kan, 2006).

With respect to ethnicity Asians, Hispanics and Whites increased their CSE through the semester regardless of where they started, and the same can be said for achievement; no significant differences were found between these three ethnicities. Blacks started with the significantly higher CSE than the rest of the ethnicities but ended the semester with the lowest CSE and achievement. Black’s achievement was significantly lower than the rest of the ethnicities for the first exam, probably as a reflection of having significantly lower SAT math than the rest of the ethnicities. For the rest of the exams they were not significantly lower for most of the semester, they still were consistently lower than the other ethnicities.

Treisman (1983) investigated the poor performance of minority students in freshman calculus at Berkley and found that an important obstacle for Blacks and Hispanics success was a pattern of social and intellectual isolation that led students to disillusion, demoralization and ultimately attrition from the sciences. After observing how Chinese students, created an academic environment that extended to their social lives, he proposed that could be the answer to this problem. He decided to create a natural environment for Hispanics and Blacks that would be conducive to an academic and social support for mathematic and the sciences.
A workshop was created that is still in place with such excellent results that it has been the model for several other interventions. This workshop is known as the Professional Development Program where freshman students are immersed in a highly structured and intensive set of activities. Groups are formed even before classes start so students can get acquainted and start working together before they are pressured once the semester has started. These students are taught a variety of skills that go from how to use the system to some of the concepts they need to understand in their courses.

Students are interviewed and their background is screened through a mathematics placement test. Each student is helped to design an academic plan for their freshman year with an understanding of where they are in reference to their classmates and the expectation that they will do well. Also each student has a sophomore buddy. Student progress is monitored through the semester and supplementary instruction is provided. An important aspect of this workshop is that it is non-remedial. In case someone needs remedial instruction arrangements are made through the regular campus units that are provided.

Steele (1997) who has researched stereotype threat intensively implemented an intervention very much on the same lines as Treisman’s workshop for college students to help Black and White students maximize the advantages of university life and alleviate stereotype threat. Part of the strategies of this program insured that students grasped the idea that the university acknowledged their intellectual potential and had high expectations for them. Among the most important messages that students took in was the fact that White as much as Black students were undergoing adjustments to university life. This program was explicitly non-remedial; it was open to those who wanted to participate
on voluntary basis so Blacks did not signaled as in need of it alleviating the feeling of stereotype threat.

Other recommendations from past studies are ample but in the end they seem to be derived from Treisman’s extensive intervention. They include training in study skills and support from instructors (Jonson-Reid, 2004) as well as mentoring and emphasis in Black role models (Dumas-Hines et al, 2001; Jonson-Reid et al, 2004). Fuertes & Sedlack (1995) suggested collecting feedback from students at the end of the semester to alleviate negative experiences and enhance positive ones in the mentoring programs as well as in general.

Johnson (2007) recommended that interventions to retain minorities focus such issues as stereotype threat, lack of knowledge on what to expect from college and the science culture, lack of personal support, racial prejudice, and feeling of isolation when there is an absence of minorities in their college environment.

For future studies it is important to analyze what is working instead of reinventing the wheel (Dumas-Hines et al, 2001; Kerlepman et al, 2008) so longitudinal studies are necessary to see if the issues are prevalent or they are alleviated. Also important is to realize that, the global implementation of these researchers’ recommendations should be started at the elementary school level at the very least. As Saunders (2004) put it: “It is unrealistic to think that the most gifted teacher could undo negative attitudes toward school and poor academic skills that had been fostered over the last several years.”

Another interesting consideration about these results is about what happens when Blacks show that their confidence is decreasing through the semester. What is happening to Blacks’ disidentification? Do they feel in an environment relaxed enough where they
can admit a certain level of vulnerability such as feeling insecure or lacking confidence? Admitting an issue is the first step towards resolving it. Maybe in terms of classroom environment Blacks were feeling more integrated although it is definitely not ideal that Blacks have lower achievement and CSE than the rest of the ethnicities. More research in needed to elucidate what is that Blacks need and research needs to be done longitudinal.

More research is definitely needed to identify how to help affected portions of the population improve and maintain their CSE and increase chances for retention in chemistry and the sciences. It is possible that what is important about CSE is that there is an increase especially in the case of Black men. Interviewing Black men is necessary to find out the intricacies of their functioning in academic settings and how to keep improving and maintaining a diverse environment. Possibly presenting Blacks with vignettes might be a good way to investigate how they feel in a more subtle way. In terms of sources of self-efficacy, the interventions seem to include all four sources: mastery experiences such as time with other students to discuss academics issues including course work, vicarious experiences such as listening to peers and advisors, social persuasion where students are being told that excellence is expected from them implying they are capable of it and the overall environment is supportive of their emotional states.

Students who took this course in general gained CSE except for the Black students, particularly the men. There are still obstacles keeping Blacks from integrating into the chemistry culture. Stereotype threat has been identified in minorities such as Blacks, Hispanics and women and it seems that its effects have been somewhat mitigated it except in the Black students. This study has helped us become aware that not all the work has been done or totally successful, that this is work in progress. We must
continually work towards its resolution. It is possible that at times we think that these kinds of problems have been resolved or are on the way to be resolved but we cannot let our guard down.

The following chapter describes the results, discussion and conclusions for the qualitative data. Interviews were considered as well as some of CSE and achievement measures for this part of the analysis.
Chapter VII Qualitative Analysis

The interviews were conducted between the first and second exams, the second and third exams and the third and fourth exams. I matched the results of the CSE questionnaires, exam results and comments from the interviews for each interviewee. A summary of the interviews, results of the CSE questionnaire and grades appear in Appendix E.

One of the reasons for including interviews in our study was first to ensure students understood the question about CSE from the questionnaire and then to find out what students described as sources of CSE. There was no evidence that students did not understand or misinterpreted the questions in the CSE survey. Also, we wanted to follow CSE change through the semester in relation to achievement and to identify what trends students with high CSE or low CSE had in common. In general interviews were intended to try to explain the results from the questionnaires through the semester. In terms of changes of self-efficacy, students reacted as expected in most cases, after a success their CSE increased and it decreased after a failure. Here are some examples of student quotes. The names used are pseudonyms:

“I feel terrible cause I studied like nine hours maybe that’s why too maybe that’s why. I studied nine hours and I got a fifty. I am so depressed.”

“I am more confident. I got a ninety-five”

Nidia

Rich
Students found all four sources of self-efficacy as helpful to learn chemistry.

Mastery

“OWL homework takes a lot of time to figure it all up, and that’s what you have to do”  
Kevin

“I read the chapters that we have to do for the exam and go over the problems in the chapters. I usually write the problems and the formulas”  
Alec

Vicarious

“I’m a very visual person so if I can see him give me lots and lots of examples of the same thing, I’ll get it…”  
Jurgen

“I watch to learn, I go to the lecture and I follow…”  
Wally

Social Persuasion

“Dr E has so many hours available to us, he’s so willing to help…”  
Sabrina

“… I went to his office and he took the time to talk to me”  
Jurgen

In terms of average scores of CSE obtained through the questionnaires for interviewees, there was a range at the end of the semester from 1.2 to 4.6. There were differences between the scores of CSE questionnaires and what participants said about their CSE at the time of the interviews in most cases. This is reasonable because students expressed how they felt about their learning chemistry at different times and under different circumstances (Hutchison, 2008). Also, the CSE score from the questionnaires was an average of 9 items and in the interviews they expressed their confidence for the course at that time. In some cases there was no difference but in others the CSE would change from the score in the questionnaire.

The CSE expressed by participants during the interviews was influenced by circumstances such as their performance in the previous test or if they were interviewed...
close to forthcoming test, they would express their confidence specifically for the test. It was a course policy to drop the lowest test score for the final grade average so it would be reasonable that at times student CSE might have not been impacted by a low grade if that grade could be dismissed. It can also mean that those students’ CSE was resilient. In other cases, students with low CSE were devastated by the first defeat.

Different patterns of CSE were identified during the interviews. In some cases CSE decreased consistently according to the interviews like Wally (4, 3, 2), Duane (5, 4, 2), Benny (3, 1, 1.5) and Gilda (3, 3, 2). Other students increased their CSE like Clara (3, 3.5, 4.5) Matt’s (4, 4, 4.5), Kevin (3, 4, 4) and Alec (3.5, 3.5, 4). Yet other cases like Ozzie (4, 4, 4), Camilla (3,3,3) and Calvin (5, 5, 5) where their CSE during the interviews did not change. And yet in other cases CSE increased and/or decreased in different ways like Laura (4, 2.5, 3) who did not recover her confidence and Dianne (4, 2.5, 3) or Angelica (3, 4.5, 1). It all depended on the individual’s confidence and again, circumstances.

Students with Low CSE and High achievement

The individual traits for students with low CSE could be summarized as follows: Benny was an extreme case of low self-efficacy. It probably went beyond self-efficacy and into low self-esteem. A positive attitude is needed to succeed and persevere (Chemers, 2001). Benny’s struggle was probably more with himself than with chemistry. Although Benny succeeded in this course it is yet to be seen how far he will be able to go with that negative attitude.

Laura was devastated since the second test; she did not recover from that blow after achieving reasonably good grades and a B for the course. Her case is an example of
women having a harder time to rebuild their confidence after a bad experience (Bandura 1997, Hutchison 2006). Camilla was in this category as well; she did not like chemistry or the instructor’s style. This according to self-efficacy theory is a negative influence in terms of emotional states (Hutchison, 2006) lowering her CSE.

Students with Low CSE and Low Achievement

Kendal and Angelica had low CSE because they knew they put hardly any effort into the class. Both admitted that if they had put the time, they might have done better. Gilda did not like chemistry. These students might have thought that if they had put in the effort, they could get a reasonably good grade. Wally, on the other hand, was always worried about his low performance in the tests. He was a typical case of someone with low CSE due to anxiety (Bandura, 1997).

Students with High CSE and Low Achievement

Lance and Armand are in this classification because they obtained Ds in the course and the CSE was not particularly low for Lance (average CSE = 3.1) and definitely high for Armand (average CSE = 3.6). In terms of their achievement, their exam scores tended to be mostly medium and could have improved with the assignments and other course work. Lance’s percent scores were 70, 75, 35, 65, 57, and Armand’s 70, 50, 55, 30, 27, and they knew that they would drop their lower score except obviously for the final. In Armand’s case, it is unclear even with the interviews why they let their exam grades drop.
Rosalie belongs in this group as well, her average CSE = 3.4 and she obtained a C in the course in her last interview she was upset and she did not come across as being very confident. Rosalie expressed at the end of the semester that it took her long to build her confidence but it was easy to drop it (Bandura, 1997; Hutchison 2006).

Students with High CSE and High Achievement

Sabrina, Gaston, Alec, Kevin, Jurgen, Julia, Isabel, Duane, Lilia, Dianne, Rich, Calvin, Ozzie, Clara, and, Matt seem to have figured how to study for chemistry and be successful in the course. They all achieved As and Bs in the course and their level of CSE was above three.

Discussion of Findings

A trend found was that those students with high CSE and high achievement favored mastery over vicarious experiences (Hutchison et al 2007) however some of them valued the opportunity to study or work with someone else. This was the case of Gaston who never had chemistry before and whom at the beginning depended heavily on studying with his friends and towards the end he expressed with self-assurance that he was going to study by himself. Another similar case was Jurgen who had taken high school chemistry before (a while back) and who was not very confident in his learning chemistry ability at the beginning but, as the semester advanced his confidence in chemistry increased. He also seemed more able to study on his own, at the end of the semester he mentioned although he could study alone with good results he liked to study with one other classmate.
No gender differences were found in terms of what students described as sources of CSE. Men and women mentioned mastery experiences such as OWL the online homework, reading the book, or the so-called inquiry activities and clicker questions that are a mixture of vicarious and mastery experience. The vicarious experiences included lectures, studying with classmates who explained concepts and problems in agreement with Hutchison et al (2006)) who found teaming important as a source of self-efficacy. In terms of social persuasion several students mentioned how caring the instructor was. Also according to Hutchison et al (2006) there is no clear definition between vicarious experiences and social persuasion when students get together to study. In the same topic, Zeldin et al (2006) stated “confidence and motivation may be supported by relationships with family members, peer groups, and significant others”. With respect to emotional states, most students expressed cheerfulness when they did well on the tests and anguish when they failed the tests.

It was intriguing that the two Asian students, one man and one woman were the ones with the lowest CSE in the cohort. Benny had the lowest through the semester followed closely by Nidia. As stated before Benny came across as having a very negative outlook in general. His confidence from the CSE questionnaires through the semester averaged 1.46 as seen in table 4.1 and from the interviews his average CSE was 1.8. Nidia did not come across as being particularly negative, she seemed even upbeat but her confidence was definitely low. Her CSE score average from the questionnaires was 2.3 and from the interviews her average CSE was 2.8. In Nidia’s case it is hard to tell why her CSE was so low. Both students ended the course with Bs.
Out of the four Black men in our cohort of interviewees Lance and Armand had higher CSE with averages of 3.1 and 3.6 as seen in tables 4.9 and 4.16 respectively. Unfortunately, their achievement did not match their CSE. Lance’s test scores were not that low, he could have easily passed the course with a B grade but it is very likely he did not complete assignments and/or missed the lecture often and missed opportunities to gain points. Armand’s achievement unfortunately dropped through the semester and ended with a D+. Alec had high CSE through the semester and it increased as seen in table 4.14, the last time I interviewed him, his CSE was 4 and he achieved an A in the course. Out of the twenty-six interviewees, only these 3 Black men: Kendal, Lance and Armand failed the course, and only Kendal had low CSE. Armand and Kendal thought that if they had put in an effort, they would have done well in the course, which is a typical male attitude found in the previous studies (Assessing Women in Engineering, 2005; Hawks and Spade, 1998; Seligman, 1990; Seymour and Hewitt, 1997): to blame failures on external causes and credit successes in their abilities. These results suggest that there are unresolved issues when it comes to Black men and more research is needed. Lance and Armand’s grades were not hopeless at all; it was not until the final that their grade was very low. It seems like they gave up possibly without even it being reflected in their CSE. This did not come through in the interviews. The issue about Black’s CSE was revealed in HLM.

In terms of the Black women one of them had the highest CSE Julia said her CSE was 5 during the second and third interview. Clara was careful about being too confident during the interviews but according to the CSE had scores above 4 through the semester. Rosalie had medium-high CSE through the semester: scores between 3 and 3.7 even
though she appeared to be quite distressed during the third and final interview, her CSE was above 3 and somewhat steady through the semester. These trends showed an increase in CSE for Black women who had a steady CSE; this is also in agreement with the trends obtained from the HLM analysis of the data.

Differences between students with High CSE and Low CSE

Most students with low CSE indeed had lower grades and students with high CSE had higher grades. Students with low CSE and achievement were, Kendal, Angelica, Gilda, and, Wally. In the cases of Benny, Nidia, Laura and Camilla they obtained Bs although they had low CSE. Those with high CSE and achievement were 15 in total, five women and ten men. But Rosalie, Armand and Lance (all Black) had low achievement and high CSE, especially Armand.

One trait students with low CSE had (except maybe for Kendal, Armand and Angelica) were devastated by a low grade in a test even if it came by the second one and there was still time to bring their grades up. These students found it difficult to bring up their hopes of doing well in the course or in the future, something inside was shattered, possibly their self-confidence. Even if some of these students ended the course with a B, (like Laura and Camilla) they still did not feel confident about learning chemistry and doing well in it, this showed more as emotional states: anxiety in Laura’s case and dislike in Camilla’s (Bandura, 1986, 1997). They gave up and changed majors. Some students with low CSE did not find chemistry interesting and it is hard to know if that is a cause or an effect (Gilda and Camilla).
Students with high CSE scored high on the tests in general. A couple of high CSE students failed one test: the fourth one failed 2 tests. But not doing well in a test had very little or no impact in their confidence, Most of the students with high CSE felt that they had a good background in chemistry, this was true for most of those who had taken it in high school, sometimes more than one semester although there were a couple of students (Dianne and Gaston) who had not taken chemistry before.

Students with high CSE were not devastated when they got a lower grade that they expected; sometimes they adjusted their expectation. They were able to put things in perspective, knowing they could drop one test score. For example, Clara adjusted her grade expectancy; she knew if she persisted she would succeed and kept her high spirits. She commented at some point during one of the interviews that she talked to her mother and she said Clara needed to study more. Experiences like that, amount to social persuasion, and can make a huge difference.

All students in general could get frustrated when working a problem, but those with high CSE tended to take some time off and then, came back to try again with a fresh state of mind. Those who succeed overcome the frustration and manage to keep a positive attitude. That positive attitude is definitively linked to self-efficacy. For example, Ozzie who got an A in the course, he said that when he became overwhelmed by the online homework he took a break. Ozzie complained constantly about the OWL, he had lot of problems with it but in general had a positive attitude. Ozzie got an A and his confidence was CSE = 4.1 (time 4) and he enrolled in General Chemistry the following semester.
In terms of studying habits, some students liked to study alone but some of those with low CSE eventually found an advantage in studying with someone else. It also seems that studying with one other person was preferred to studying with a larger group. Studying preference was not found to be favored by low or high CSE groups although some of the students with high CSE who had not taken chemistry in high school (like Juergen, Dianne and Gaston) counted with at least one person who were proficient in chemistry and that probably boosted their confidence.

Findings

I found that most of the students who had high CSE had high achievement as well. Those students who increased their CSE had access to a peer with high achievement or someone in a higher-level chemistry course. Those students with high CSE were not devastated by a low grade; they keep trying and/or adjust their expectations. When students with high CSE found a tough problem they might become frustrated but they took a break and keep trying.

Connections between Quantitative and Qualitative Aspects

Students interpreted the CSE questions correctly, according to the interviews. Out of our four Black men interviewees, two of them had high CSE and low achievement one had low CSE and low achievement. These findings support those of the quantitative data (descriptive statistics and HLM results).
These findings are in line with the self-efficacy theory (Bandura, 1986, 1997). There were some cases where students tended to overestimate or underestimate their capabilities but most students had a good idea where they belonged in the context of this course.

Limitations of the Study

The generalizability of the study is limited due to the fact that students were in a remedial course. Asian men sample decreased considerably in some cases to only three so one should be careful in the interpretation of the HLM results for this group. The ethnicities we used were the official self-reported ethnicities from the university roster. There are other possible considerations for the study that one could think about such as first generation in college by ethnicity that we did not explore.

Contributions of the Study

This study contributed to the overall knowledge of self-efficacy and specifically of chemistry self-efficacy. It is important to have discovered the evidence of disidentification present. This is the first study as far as we know of chemistry self-efficacy by ethnicity.
References


Kan, A., & Akbas, A. (2006). Affective factors that influence chemistry achievement (Attitude and self efficacy) and the power of these factors to predict chemistry achievement. *Journal of Turkish Science Education, 3*(1).


Lewis, S. E., & Lewis, J. E. (2005). The same or not the same: Equivalence as an issue in educational research. *Journal of Chemical Education, 82(9), 1408-1412*.


Appendices
Appendix A: Commonly Used Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Name</th>
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<tbody>
<tr>
<td>CSE</td>
<td>Chemistry Self-Efficacy</td>
</tr>
<tr>
<td>CAEQ</td>
<td>Chemistry Attitudes and Experiences questionnaire</td>
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<tr>
<td>ANOVA</td>
<td>Analysis of Variance</td>
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<tr>
<td>MANOVA</td>
<td>Multivariate Analysis of Variance</td>
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<tr>
<td>HLM</td>
<td>Hierarchical Linear Modeling</td>
</tr>
<tr>
<td>ACS</td>
<td>American Chemical Society</td>
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<tr>
<td>ACS Exam</td>
<td>American Chemical Society First Semester General Chemistry Examination</td>
</tr>
<tr>
<td>TOLT</td>
<td>Test of Logical Thinking</td>
</tr>
<tr>
<td>GALT</td>
<td>Group Assessment of Logical Thinking</td>
</tr>
</tbody>
</table>
Appendix B; First Day Survey combined with CSE Questionnaire

Please fill out your name, University Identification Number (U#) and your answers to the following questions on a scan-tron bubble sheet. The scan-tron will serve as the attendance check. Your answers to the 16 questions below are appreciated as we work to improve this course.

1. How many years (including this one) have you attended a college or university?
   a) 1st year  b) 2nd year  c) 3rd year  d) 4th year  e) more than 4 years

2. Are you a transfer student from another college or university?  a) Yes  b) No

3. What is your major or intended major?
   a) Chemistry  b) Pre-med or allied-health  c) Engineering  d) Other science  e) Non-science

4. How much chemistry did you have in high school?
   a) No chemistry in high school  b) 1 semester  c) 1 full year  d) 1-2 full years  e) More than 2 full years

5. Which best describes the highest level of math you’ve completed?
   a) I have not taken any math courses as advanced as algebra  
   b) algebra and/or trigonometry (MAC 1105)  
   c) pre-calculus (MAC 1140)  
   d) calculus I (MAC 2241, 2281 or 2311)

6. Which best describes the math course you are taking now?
   a) I am not currently taking a math course  
   b) algebra and/or trigonometry (MAC 1105)  
   c) pre-calculus (MAC 1140)  
   d) calculus I or calculus II (MAC 2241, 2242, 2281, 2282, 2311 or 2312)  
   e) other

7. Have you taken Chemistry for Today (CHM 2023 or equivalent)?  a) Yes  b) No

8. Do you currently plan to take General Chemistry I (CHM 2045)?  a) Yes  b) No

9. Do you currently plan to take General Chemistry II (CHM 2046)?  a) Yes  b) No

10. With regard to Chemistry for Today (CHM 2023 or equivalent), which best describes you:
    a) I am retaking Chemistry for Today  b) I am enrolled in Chemistry for Today for the 1st time

11. With regard to General Chemistry I Lab (CHM 2045L or equivalent), which best describes you:
    a) I am currently enrolled in the General Chemistry I Lab  
    b) I am planning to take General Chemistry I Lab  
    c) I have already completed General Chemistry I Lab  
    d) I have no plans to take General Chemistry I Lab

12. What grade do you expect to earn in Chemistry for Today I (CHM 2023)?
    a) A  b) B  c) C  d) D  e) F
13. Are you:  
   a) Male  
   b) Female

14. Are you a U.S. citizen?  
   a) Yes  
   b) No

15. Race/National Origin that best describes you (categories taken from USF admissions application):  
   a) American Indian and Native Alaskan  
   b) Native Hawaiian or other Pacific Islander  
   c) Asian  
   d) Black  
   e) White

16. Do you consider yourself Hispanic or Latino?  
   a) Yes  
   b) No

**Please indicate how confident you feel about**

* Questions pertinent to our study  
1. Applying a set of chemistry rules to different elements of the Periodic Table *  
Not confident — — — — — Totally confident

2. Tutoring another student in a first-year chemistry course *  
Not confident — — — — — Totally confident

3. Explaining something that you learnt in this chemistry course to another person *  
Not confident — — — — — Totally confident

4. Choosing an appropriate formula to solve a chemistry problem *  
Not confident — — — — — Totally confident

5. After reading an article about a chemistry experiment, writing a summary of the main points *  
Not confident — — — — — Totally confident

6. Learning chemistry theory *  
Not confident — — — — — Totally confident

7. Determining the appropriate units for a result determined using a formula *  
Not confident — — — — — Totally confident

8. After watching a television documentary dealing with some aspect of chemistry, writing a summary of its main points *  
Not confident — — — — — Totally confident

9. After listening to a public lecture regarding some chemistry topic, explaining its main ideas to another person *  
Not confident — — — — — Totally confident
Appendix C: Preparatory Chemistry First Day Survey Results (2006)

In Fall 2006 at total of 418 First Day Surveys were collected. The subgroup of 150 students who continued to General Chemistry I (CHM 2045) in Spring 2007 is included in the results.

1-How many years (including this one) have you attended college

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<td>Frequency</td>
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<tr>
<td>a) 1\textsuperscript{st} year</td>
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<td>b) 2\textsuperscript{nd} year</td>
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<td>c) 3\textsuperscript{rd} year</td>
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<td>d) 4\textsuperscript{th} year</td>
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<td>e) more than 4 years</td>
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2-Are you a transfer student from another college of university?

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<td>Frequency</td>
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<tr>
<td>a) Yes</td>
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3-What is your major or intended major?

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<tr>
<td>a) Chemistry</td>
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<td>b) Pre-med/health</td>
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<td>67.2</td>
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<tr>
<td>c) Engineering</td>
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<td>2.6</td>
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<td>d) Other science</td>
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<td>e) Non-science</td>
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4-How much chemistry did you have in high school?

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<td>a) No chemistry</td>
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<td>b) 1 semester</td>
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<td>c) 1 full year</td>
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<td>d) 1-2 full years</td>
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<td>e) more than 2 years</td>
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5-Which best describes the highest level of math you have completed?
### 6-Which best describes the math you are taking now?

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<td>a) Not taking math</td>
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<td>b) Algebra or trig</td>
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<td>c) Pre-calculus</td>
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<td>d) Calculus I or II</td>
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### 7-Have you taken Preparatory Chemistry (CHM2023 or equivalent)?

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<td>Frequency</td>
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<tr>
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<td>b) No</td>
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<td>1.2</td>
</tr>
</tbody>
</table>

### 8-Do you currently plan on taking General Chemistry I (CHM 2045)?

<table>
<thead>
<tr>
<th></th>
<th>Total population 2023 N=418</th>
<th>Taking 2045</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>Percent</td>
</tr>
<tr>
<td>a) Yes</td>
<td>378</td>
<td>90.4</td>
</tr>
<tr>
<td>b) No</td>
<td>38</td>
<td>9.1</td>
</tr>
<tr>
<td>Missing</td>
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<td>0.5</td>
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</table>

### 9-Do you currently plan on taking General Chemistry II (CHM 2045)?

<table>
<thead>
<tr>
<th></th>
<th>Total population 2023 N=418</th>
<th>Taking 2045</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>Percent</td>
</tr>
<tr>
<td>a) Yes</td>
<td>334</td>
<td>80.1</td>
</tr>
<tr>
<td>b) No</td>
<td>82</td>
<td>19.6</td>
</tr>
<tr>
<td>Missing</td>
<td>1</td>
<td>0.3</td>
</tr>
</tbody>
</table>
10- With regards to Preparatory Chemistry (CHM 2023 or equivalent) which best describes you:

<table>
<thead>
<tr>
<th></th>
<th>Total population 2023 N=418</th>
<th>Taking 2045 N=150</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>Percent</td>
</tr>
<tr>
<td>a) I am retaking it</td>
<td>14</td>
<td>3.3</td>
</tr>
<tr>
<td>b) First time enrolled</td>
<td>402</td>
<td>96.2</td>
</tr>
<tr>
<td>Missing</td>
<td>2</td>
<td>0.5</td>
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</table>

11- With regards to General Chemistry I Lab (CHM 2045L or equivalent) which best describes you:

<table>
<thead>
<tr>
<th></th>
<th>Total population 2023 N=418</th>
<th>Taking 2045 N=150</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>Percent</td>
</tr>
<tr>
<td>a) Currently enrolled</td>
<td>69</td>
<td>16.5</td>
</tr>
<tr>
<td>b) Plan to take it</td>
<td>315</td>
<td>75.4</td>
</tr>
<tr>
<td>c) Have completed it</td>
<td>6</td>
<td>1.4</td>
</tr>
<tr>
<td>e) No plans to take it</td>
<td>28</td>
<td>6.7</td>
</tr>
<tr>
<td>Total</td>
<td>418</td>
<td>100</td>
</tr>
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</table>

12- What grade do you expect to earn in Chemistry CHM 2023? CHM 2045?

<table>
<thead>
<tr>
<th></th>
<th>Total population 2023 N=418</th>
<th>Taking 2045 N=150</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>Percent</td>
</tr>
<tr>
<td>a) A</td>
<td>328</td>
<td>78.7</td>
</tr>
<tr>
<td>b) B</td>
<td>85</td>
<td>20.3</td>
</tr>
<tr>
<td>c) C</td>
<td>4</td>
<td>0.8</td>
</tr>
<tr>
<td>d) D</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>e) F</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Missing</td>
<td>1</td>
<td>0.2</td>
</tr>
</tbody>
</table>

13- Are you:

<table>
<thead>
<tr>
<th></th>
<th>Total population 2023 N=418</th>
<th>Taking 2045 N=150</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>Percent</td>
</tr>
<tr>
<td>a) Male</td>
<td>125</td>
<td>29.9</td>
</tr>
<tr>
<td>b) Female</td>
<td>292</td>
<td>69.9</td>
</tr>
<tr>
<td>Missing</td>
<td>1</td>
<td>0.2</td>
</tr>
</tbody>
</table>

14- Are you a US citizen?

<table>
<thead>
<tr>
<th></th>
<th>Total population 2023 N=418</th>
<th>Taking 2045 N=150</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>Percent</td>
</tr>
<tr>
<td>a) Yes</td>
<td>381</td>
<td>91.1</td>
</tr>
<tr>
<td>b) No</td>
<td>30</td>
<td>7.2</td>
</tr>
<tr>
<td>Missing</td>
<td>7</td>
<td>1.2</td>
</tr>
</tbody>
</table>

15- Race/National Origin that best describes you (categories taken from USF admissions application):
<table>
<thead>
<tr>
<th></th>
<th>Total population 2023 N=418</th>
<th>Taking 2045 N=150</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>Percent</td>
</tr>
<tr>
<td>a) American Indian</td>
<td>3</td>
<td>0.7</td>
</tr>
<tr>
<td>b) Hawaiian/Pacific</td>
<td>17</td>
<td>4.2</td>
</tr>
<tr>
<td>c) Asian</td>
<td>40</td>
<td>9.9</td>
</tr>
<tr>
<td>d) Black</td>
<td>69</td>
<td>17.0</td>
</tr>
<tr>
<td>e) White</td>
<td>277</td>
<td>68.2</td>
</tr>
<tr>
<td>Missing</td>
<td>12</td>
<td>2.9</td>
</tr>
</tbody>
</table>

16-Do you consider yourself Hispanic or Latino?

<table>
<thead>
<tr>
<th></th>
<th>Total population 2023 N=418</th>
<th>Taking 2045 N=150</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>Percent</td>
</tr>
<tr>
<td>a) Yes</td>
<td>81</td>
<td>19.4</td>
</tr>
<tr>
<td>b) No</td>
<td>321</td>
<td>76.8</td>
</tr>
<tr>
<td>Missing</td>
<td>12</td>
<td>1.2</td>
</tr>
</tbody>
</table>
Appendix D: Interview Questions

<table>
<thead>
<tr>
<th>Question</th>
<th>Direct from questionnaire</th>
<th>Rephrased</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is your major?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have you taken chemistry before?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If the participant admits to having had chemistry:</td>
<td></td>
<td>Why?</td>
</tr>
<tr>
<td>Why are you taking this course then?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>How confident do you feel about applying chemistry rules to different elements in the periodic table?</td>
<td>How (good) is your understanding the periodic table in terms of position and properties of elements?</td>
<td></td>
</tr>
<tr>
<td>How confident do you feel about helping a fellow student to study and/or understand concepts in your chemistry course?</td>
<td>If a friend asked you to help him/her understand something about chemistry, do you think you could do it?</td>
<td></td>
</tr>
<tr>
<td>How confident do you feel about choosing the right formula to solve a chemistry problem?</td>
<td>When you’re doing homework or in a test, Is it easy for you to choose the right formula to solve a problem?</td>
<td></td>
</tr>
<tr>
<td>How confident do you feel about determining the right units after using a formula to solve a chemistry problem?</td>
<td>How about the units, do you check them when you do chemistry problems? Do you get them right?</td>
<td></td>
</tr>
<tr>
<td>How confident do you feel about learning chemistry theory?</td>
<td></td>
<td>How about the theory in chemistry? Do you understand it, is it hard?</td>
</tr>
<tr>
<td>How confident do you feel about passing the next (level) chemistry course?</td>
<td></td>
<td>What grade do you expect to get in this chemistry course? How about the following course?</td>
</tr>
<tr>
<td>If you watch a TV documentary about some chemistry aspect, how confident do you feel about summarizing the main points?</td>
<td>If you watch a TV show about chemistry, could you make a summary of it?</td>
<td></td>
</tr>
<tr>
<td>If you attend a public lecture about chemistry, how confident do you feel about explaining the main points to someone else?</td>
<td>How about a public lecture that deals with chemistry? Have you attended one? If you attended one about chemistry do you think that you explain its main points to someone else?</td>
<td></td>
</tr>
<tr>
<td>What is the best part about learning chemistry?</td>
<td></td>
<td>Why?</td>
</tr>
<tr>
<td>What is the worst part about learning chemistry?</td>
<td></td>
<td>Why?</td>
</tr>
<tr>
<td>What is the most helpful for you to learn/understand chemistry?</td>
<td></td>
<td>Why?</td>
</tr>
<tr>
<td>What is the hardest thing for you to learn/understand in chemistry?</td>
<td></td>
<td>Why?</td>
</tr>
<tr>
<td>What topics are easy or difficult for you?</td>
<td></td>
<td>Why?</td>
</tr>
<tr>
<td>Question</td>
<td>Answer</td>
<td></td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>--------</td>
<td></td>
</tr>
<tr>
<td>Do you like to study chemistry alone or in groups?</td>
<td>Why?</td>
<td></td>
</tr>
<tr>
<td>How helpful do you find working/studying in groups?</td>
<td>Why?</td>
<td></td>
</tr>
</tbody>
</table>
Appendix E: Summary of Interviews

This is a summary of the interviews conducted as the qualitative part of this study. It is a look through the personal stories of each of the twenty-six interviewees through the semester with the purpose of understanding how and why CSE and achievement varied with experiences in the Preparatory Chemistry course. I also explored the sources of self-efficacy participants mentioned as part of their learning experience.

I created a table for each interviewee participant that shows the results of their CSE questionnaire given to the whole cohort of students that took Preparatory Chemistry in the fall of 2007. The table contains interviewee participants’ grades for the four exams and final as well as the final letter grade obtained in the course. It also contains their CSE expressed during the first, second and third interviews.

In the tables:
Int- interview, time - instructional unit at time, Quest- questionnaire

*Benny*

Table E.1 CSE and Achievement for **Benny**: Asian Man

<table>
<thead>
<tr>
<th>Final Grade</th>
<th>Time 0</th>
<th>Time 1</th>
<th>Int 1</th>
<th>Time 2</th>
<th>Int 2</th>
<th>Time 3</th>
<th>Int 3</th>
<th>Time 4</th>
<th>Final</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>1.0</td>
<td>1.0</td>
<td>3.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.5</td>
<td>2.2</td>
<td></td>
</tr>
<tr>
<td>CSE Quest</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exam Grade in %</td>
<td>60</td>
<td>50</td>
<td>30</td>
<td>55</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Benny is an Asian man who had the lowest confidence in our entire cohort through the semester. Every CSE questionnaire given in class totaled 1 (on a scale from 1 to 5) except for last one that totaled 2.2 although he got a B in the course. When we talked during his first interview he said his CSE was 3, middle of the scale. He had achieved 60% in his first test. He was very emotional right from the beginning; he had trouble following the lecture:
“When he draws stuff on the board, when he writes things to explain on the board. I’m trying to grasp it myself, and I’m like I cannot write this down. I can write but... I cannot understand”

I asked him if he felt he knew how to study chemistry:

“No, I honestly don’t know (how to study). I’m still trying to figure that out. Cause for me, I go to tutoring too. I try ‘cause I need helping almost every subject”

Then I asked if he tried to study with someone else:

“I rarely study in groups; I’m not a social person. I don’t mind studying in groups but I guess I get left out. I don’t know why... I guess it’s my nature”

When we talked in the second interview after the second test (he scored 50) he said his confidence was 1 (on a scale from 1 to 5). He was in low spirits:

“Actually I think it’s my thinking skills. I think it’s my thinking, the way I think”

“I spend every day at least an hour, at least. Trying to go through the book. Trying to concept map but then... sometimes it’s just the motivation. That’s what’s really lacking a lot. Cause I started the OWL homework on Friday for the balancing equations, I started to do the first section and did some of them wrong and I just started to cry after about 10-20 minutes and then I just started thinking. Oh! What am I going to do? And then when I came back I tried to find some music to motivate myself and luckily I got all except for the double replacement reactions done and for the review”

Benny came for the third interview, he scored 30% in the third test and he said his confidence was 1.5. Everything seemed dark as usual:

“Couple of chapters after we last talked didn’t do cause maybe it was not lack of motivation but I simply got stuck and I tried hard to answer even one problem and I just broke down completely and I just couldn’t take it anymore so one section I did”

“I try to keep myself positive but it’s just like last week I lost my calculator”
Benny was very emotional and in low spirits every time we talked. There was always something very wrong happening. His low self-efficacy was part of his negative way of seeing everything.

“I try to keep upbeat and positive and try to ask questions especially when I ask my tutor and the success is there but sometimes I just drop. When I try to ask questions even when I have the questions prepared and I write the questions clear but sometimes I don’t know what I write even if it’s legible I go ‘why did this question come?’ And when I work with the tutor sometimes he says ‘figure it out’ but sometimes I simply get lost...”

Benny used his mastery and vicarious experiences to learn chemistry and it is very probable he took in the instructor’s social persuasion but every aspect seemed overwhelmed by negativity, he did not register for General Chemistry 1 the following semester.

Nidia

<table>
<thead>
<tr>
<th>Final Grade</th>
<th>CSE Questionnaire</th>
<th>Exam Grade in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>Time 0</td>
<td>Time 1</td>
</tr>
<tr>
<td></td>
<td>1.6</td>
<td>2.1</td>
</tr>
<tr>
<td></td>
<td>65</td>
<td>70</td>
</tr>
</tbody>
</table>

Nidia is an Asian woman that had very low CSE through the semester although she ended the semester with a B as we can see in the table above. According to the CSE questionnaires her confidence was very low through the semester and according to the interviews it only increased slightly. Her average in for the exams was 62% but she probably pulled her grade to a B with the class work. Here is what she had to say about what she found helpful to learn chemistry during the first interview:

“In class when I look at the slides from power point but at home I have to work more by myself than I do in class and read the book. Dr E’s diagrams help a lot”

“Also doing the OWL homework is very helpful”
“I would rather study alone, I understand better. In a group it sometimes is OK when studying for a test but in general I study better alone”

For the second interview Nidia was still at a CSE = 3 although she scored a little higher than on the first test, a 70%. Here is what she said about studying for that test:

“Chemistry, well I think I like studied a lot for the last test and it helped obviously and I could study because one of my friends is a great teacher, you know, she explained it to me, I think I work better with one on one so she explained, like for seven hours we studied for the test so we studied, it was good”

For the third interview Nidia’s her achievement had dropped, she scored a 50% and so had her CSE; she said it was at 2.5

“I feel terrible cause I studied like nine hours maybe that’s why too maybe that’s why. I studied nine hours and I got a fifty. I am so depressed. I felt that when he gave us the test I had no time to do the problems”

“Oh my God I don’t want to fail at the end and ruin it”

She was shaken about her grade and worried about the course. She also had changed her opinion on what she found helpful to learn chemistry at that point:

“OWL was helping me but now I’m just taking my time but I feel I’m not learning anything”

Nidia improved her score on the fourth test and she must have done everything she needed to do in terms of class work to pull a B as final grade. Nidia depended on her mastery and vicarious experiences and during the third interview her emotional state was intense. It was interesting to notice that the online homework did not seem to help at that point. In general her CSE was one of the lowest in our whole cohort. Nidia enrolled in General Chemistry the following semester. Sometime in the middle of that semester I saw her and asked her how she was doing in the class to which she responded: “not good”. Her confidence was still low because in the end she obtained a B.
Kendal

Table E.3 CSE and Achievement for **Kendal**: Black Man

<table>
<thead>
<tr>
<th>Final Grade</th>
<th>Time 0</th>
<th>Time 1</th>
<th>Int 1</th>
<th>Time 2</th>
<th>Int 2</th>
<th>Time 3</th>
<th>Int 3</th>
<th>Time 4</th>
<th>Final</th>
</tr>
</thead>
<tbody>
<tr>
<td>D+</td>
<td>2.9</td>
<td>3.5</td>
<td>2.2</td>
<td>1.5</td>
<td>3.0</td>
<td>2.5</td>
<td>3.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CSE Questionnaire</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exam Grade in %</td>
<td>55</td>
<td>-</td>
<td>25</td>
<td>20</td>
<td>32</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Kendal is a Black man who ended the semester with a D+ and his confidence was basically low through the semester as shown in the table above. He was a Business major who thought he might want to go to Medical school eventually. During our first interview he mentioned that he took the class a year ago but dropped it after a few weeks because he was overwhelmed by it. His CSE was 2.9 at the very beginning of the semester (time 0). During his first interview, after the first test where he scored 55% he said his CSE was 3.5 that being his highest CSE through the semester.

When I asked what helped him learn chemistry he said:

“If you go to class and then you do the OWL homework, it helps you, it balances it. But for the last exam that I had to do I realized that if you printed out the notes from the first page and you use that as a guide it will help you so... I’m comfortable right now”

About his confidence he said:

“I don’t practice enough and I feel that if I practice enough I’d be 100% comfortable than where I’m at now”

During the second interview his confidence was very low, he took the exam but there was some problem and the instructor wanted to see Kendal to clarify some detail before recording the grade. Kendal said he was intimidated and would not go.

“(My confidence is) “One and a half. I ...slack in the class I guess the more I miss out and then it’s harder for me to catch up so...”

When I asked him if he knew how to study chemistry he answered:

“I don’t normally study chemistry”
During the third interview his CSE was 2.5 after he scored a 25% on the third test. Here is what he had to say:

“If I studied a lot it’d probably be a lot easier but I haven’t studied much with school and my Economics class. I kind of have to do my Economics class ‘cause it’s my major; Business, so I have been putting all my time into that. More than I probably should”

Kendal was probably just not interested in chemistry or the sciences at all. His CSE was low because did not dedicate any time at all to chemistry and he knew it. Being a Business major he lived in a different world. Kendal admitted openly he did nothing to learn chemistry other than maybe attend class. He was taking the course because an uncle told him he didn’t need to be a Science major to go to Medical School but his heart was probably never there. This was the second time he attempted Preparatory Chemistry.

Angelica

Table E.4 CSE and Achievement for Angelica: Hispanic Woman

<table>
<thead>
<tr>
<th>Final Grade</th>
<th>Time 0</th>
<th>Time 1</th>
<th>Int 1</th>
<th>Time 2</th>
<th>Int 2</th>
<th>Time 3</th>
<th>Int 3</th>
<th>Time 4</th>
<th>Final</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSE</td>
<td>2.7</td>
<td>3.0</td>
<td>3.0</td>
<td>2.8</td>
<td>4.5</td>
<td>-</td>
<td>1.0</td>
<td>2.6</td>
<td></td>
</tr>
<tr>
<td>Questionnaire Exam Grade in %</td>
<td>65</td>
<td>50</td>
<td>25</td>
<td>55</td>
<td>52</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Angelica is a Hispanic woman who ended the course with a C and whose confidence was low through the semester as well as can be seen in the table above. She had a part-time job and worked 20-22 hours/week. In the first interview, after she scored 65% in the first exam Angelica said her confidence was 3. When I asked her about the way the class was being taught and what she found helpful to learn chemistry she said:

“In general there are a lot of resources that are there and it’s up to me if I do it or not and how I use my time and everything”

“I think he’s (instructor) doing a good job, it’s just the fact that I need more time to read and go over the material”
“The sessions, the little groups and being able to ask my peers questions and this and that. Them being able to explain things and if they don’t understand it then the TA comes in which I find really good”

In the second interview when Angelica talked about her performance she said:

“I wasn’t expecting that, I was expecting a sixty nine, seventy, seventy five but I got a fifty”

I asked her if she knew what went wrong, she was nonchalant and said:

“It was probably the dumb little things that he told us, watch out for these bla, bla, bla”

I asked how the class was going because she said her confidence was 4.0 to 4.5

“And I kind of find myself studying more. Oh I know how to do this, it’s kind of I know how to do this, piece of cake and I quit doing it, yea”

Angelica must have known she wasn’t putting the time and effort required for her to do well in the class, especially when she was working so many hours at her job. Sometime during our conversation she mentioned she had started to work less hours. In the third interview after she scored 25% on the third test she finally said her confidence was 1. She was just as nonchalant about her grades in the course. When I asked her if she knew the material for the final that was cumulative she said:

“Do I know? No, not yet but I will. I will know stuff that I have to go through and everything, a lot and again understanding, comprehending 100%”

Her statement shows that she probably knew she was failing because she was not doing what she needed to do but she felt that if she decided to do it she would likely pass the class. This shows that Angelica could improve her grade if she decided to and that she had somehow confidence she could do it again if she decided to. I asked her if she thought she would pass the class, she said:

“Like with more studying, yea, and focusing in just that, yea”

Angelica appreciated mastery and vicarious experiences to learn her chemistry. It is very likely that she needed to work and she used her job to justify her lack of commitment and motivation to study chemistry. She had a certain confidence that she could do it if she wanted to. Her CSE was low because she
knew she wasn’t doing what was required. In the end she passed the class with a lower grade than she could have achieved if she had studied. It was fine with her; she never showed that she cared about her low grades. She was going into Mechanical Engineering and she needed to take General Chemistry eventually. I happened to see her some time after the course ended and she told me she went to a junior college to take General Chemistry.

**Gilda**

Table E.5 CSE and Achievement for **Gilda**: Hispanic Woman

<table>
<thead>
<tr>
<th>Final Grade</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time 0</td>
<td>3.0</td>
</tr>
<tr>
<td>Time 1</td>
<td>3.2</td>
</tr>
<tr>
<td>Int 1</td>
<td>3</td>
</tr>
<tr>
<td>Time 2</td>
<td>2.8</td>
</tr>
<tr>
<td>Int 2</td>
<td>3</td>
</tr>
<tr>
<td>Time 3</td>
<td>2.2</td>
</tr>
<tr>
<td>Int 3</td>
<td>2</td>
</tr>
<tr>
<td>Time 4</td>
<td>2.9</td>
</tr>
<tr>
<td>Exam Grade in %</td>
<td>65</td>
</tr>
<tr>
<td>Grade in %</td>
<td>55</td>
</tr>
<tr>
<td>Exam Grade in %</td>
<td>40</td>
</tr>
<tr>
<td>Grade in %</td>
<td>30</td>
</tr>
<tr>
<td>Final Grade</td>
<td>50</td>
</tr>
</tbody>
</table>

Gilda is a Hispanic woman whose CSE was around 3 and underwent small variations through the semester as seen in the table above and ended the course with a C as final grade. She started and ended the semester with a confidence about 3 having increased after the first exam just a little and dropped to 2.2 by the third exam came about as the table shows.

During the first interview Gilda said her confidence was 3, she had scored a 65% on the first test. When I asked her what she found helpful to learn chemistry she said:

“... *I think the activities would be more helpful if we went over the stuff in class or did in the class all week instead of stuff in the book or in the workbook... I understand the point but we would get more out of it... In this class the on line homework is helpful*”

“I get out more out of reading the book or doing homework than during the lecture”

“(Chemistry) It’s not interesting to me so it’s hard to focus on it”

When I asked her about the test she said:

“The first test I got a lot of them wrong because I made really stupid mistakes. I just didn’t understand it completely. When I studied I read what things were but I didn’t know how to do them when they’re in a problem”
Gilda scored 55% on the second exam and said that her confidence was 3. This is what she had to say about the test and her chemistry learning:

“I thought it was going a lot better than it was on my test I didn’t do as good as I thought. I studied a different way this time. I studied a lot and most of the stuff that I focused on wasn’t on the test so... and I realized that on a few questions I made very stupid mistakes I realized when I looked at my notes that I had the right formula, I set up everything and then one of the questions I used gold instead of silver so my answers are not... I didn’t realize until later that I used the wrong numbers, I learned how to study last time I just plugged in the wrong numbers”

“I studied by myself for two days and then I studied with somebody else in my activity group”

She felt she had learned something about how to study chemistry although she needed more practice and possibly that is why her CSE stayed at the same level as last time we spoke.

For the third interview Gilda had scored a 30% on the third test, at that point she said her confidence was 2. It is close to the CSE questionnaire given before the test where her CSE was 2.2.

“I haven’t understood what we’re doing, I didn’t do good on the test”

“I studied for it I guess I didn’t study well enough. I didn’t think it was going to be as hard as it was”

I asked her if she thought she needed to study more, she was overwhelmed:

“I don’t know what studying means... I do the problems from the book. I’m going to work on the optional homework today, chapter sixteen”

“I think it’s just me, I don’t think it’s anything else in the course”

Gilda preferred mastery experiences and studied with peers so vicarious/social persuasion was also among the CSE sources she favored. Gilda’s CSE scores follow her performance in the course. She started around the middle of the scale, probably being cautious to see how hard the topics were going to be for her. Her grades dropped consistently through the semester as seen in table 4.5 and so did her confidence. She achieved a passing grade but her confidence did
not improve through the semester. She did not do well enough to improve her confidence. It is possible that since she did not find chemistry interesting as she mentioned in the first interview she might have not put enough effort. Gilda favored mainly mastery experiences although she also mentioned vicarious experiences. She did not enroll in General Chemistry the following semester.

**Camilla**

Table E.6 CSE and Achievement for **Camilla**: White Woman

<table>
<thead>
<tr>
<th>Final Grade</th>
<th>CSE Questionnaire</th>
<th>Exam Grade in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>2.3 3.3 3 2.9 3 2.9 3 2.7</td>
<td>65 50 45 70 45</td>
</tr>
</tbody>
</table>

Camilla is a white woman who although she ended the course with a B, her CSE was low. From the questionnaires her CSE through the semester went from 2.3 to 3 to slightly below 3 as seen in table 4.6. I would consider this CSE rather low since B is a good grade. Camilla was one of the few students who did not like the instructor’s style as she said in the first interview:

“*I personally don’t like the way that E teaches, I don’t think he teaches the class, I think he just goes off on random tangents and doesn’t stay focused*”

“*Personally that just annoys me because I just like to be in class and just... know what I need to know*”

“*I would like for him just to talk about chemistry and ... not go on to other subjects, show more examples*”

Camilla did not like to group work at least in the beginning. She took charge of her own learning which could be a sign of higher self-efficacy but she still expressed that her confidence in learning chemistry was at 3 on a scale from 1 to 5 after she scored 65% in the first test.

“*I don’t like that you have to work with somebody else because I more of an independent learner*”

By the second interview her grade had dropped to 50% but her confidence in the course was still at 3. Here is what she said:

“*I did pretty bad in the test, yea...I didn’t expect to do that bad*”
At this point I asked her if she considered studying with a classmate to which she replied:

“I don’t talk with anybody in the class”

When we talked during the third interview and after having scored a 45% on the third test she was nonchalant when she responded to my asking how she did in the test.

“I did bad. I’m kind of used to that with chemistry but I do all that extra stuff so I’m not too worried about it like I do every OWL question”

She also confessed right then that she studied with someone else:

“I kind of have my boyfriend ask me questions about it (chemistry). I’ve been studying with him a little bit”

And also:

“I was in a group that didn’t work together very well but then I found this girl and we get along pretty well. ... she understands a lot of it and explains it”

Camilla liked to learn through mastery experiences and later she admitted learning from vicarious/social persuasion experiences. It’s very apparent that she did not like chemistry much and the disappointment in her grades lowered her CSE. During the first interview she had already stated she was changing her major. At the end of the third interview I asked her if she still was going for Psychology. Here is what she said:

“I fell in love with psychology and I didn’t realize cause chemistry in high school was pretty easy for me but the teacher taught in a completely different way so I think it was a mixture that I fell in love with psychology and chemistry...not that it disappointed me but I lost interest”

She did not enroll in General Chemistry the following semester
Wally

Table E.7 CSE and Achievement for Wally: White Man

<table>
<thead>
<tr>
<th>Final Grade</th>
<th>CSE Questionnaire</th>
<th>Exam Grade in %</th>
<th>Time 0</th>
<th>Time 1</th>
<th>Int 1</th>
<th>Time 2</th>
<th>Int 2</th>
<th>Time 3</th>
<th>Int 3</th>
<th>Time 4</th>
<th>Final</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
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<td>2</td>
<td>2.8</td>
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<td>3.4</td>
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<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.1</td>
<td>50</td>
<td>4</td>
<td>2</td>
<td>-</td>
<td>-</td>
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</tr>
</tbody>
</table>

Wally is a White man who ended the semester with a final letter grade of C and his CSE was low through the semester. According to the interviews his confidence dropped through the semester as seen in table 4.7. Wally had a job where he worked 10-12 hours/week. At the time of the first interview he said his CSE was 4 and he seemed self-confident although he scored a 55% on the first exam; here is what he said helped him learn chemistry:

“...the OWL has helped me a lot because you give us a quiz and I’m not so sure on it and I do the OWL and I’m like, oh I’m pretty confident on this now”

“Oh, activities are helpful, they are helpful in the fact that I might know something somebody else doesn’t. If they know something I don’t, they catch me in my mistakes. I’m more of a self study guy but groups are helpful too”

“I watch to learn, I go to the lecture and I follow. I take notes all the time but it’s not the way I...but it helps. When you’re there and you don’t know something, yes it helps”

By the second interview his grade had dropped to 50%. His confidence had dropped to 3; he was overwhelmed especially because he had an accident and hurt his foot badly. Here are some of his comments:

“The OWL’s just complicated; the book doesn’t make much sense”

-“Well I was doing some of the OWL last night and just one part of it took me...forever...”

“I was on oxycodone when I took the test so...I could really... that one the one before I was just not prepared but this test I was prepared but I wasn’t in the room that I was in...”

By the third interview he was even more frustrated although he scored a little higher on the third test: a 60%. He then said his confidence was 2:
“I go to every class. I just don’t I mean I learn the stuff but I just can’t put it on paper”

“It’s just I study for the test, a lot and I still got a D. I went to that test confident and I still did bad so I don’t know. There were about two, three problems that I didn’t know and that would have given me a B-, C and I got a D, I got a sixty on it so...”

Wally pulled a C in the class but his grades were not anything he was used to getting in high school. He depended on his mastery experiences as well as some vicarious. He was having problems managing his time especially because he said he had a long commute to campus and he needed to work so he had that job. He enrolled in General Chemistry the following semester and ended the course with a D.

Laura

<table>
<thead>
<tr>
<th>Final Grade</th>
<th>Time 0</th>
<th>Time 1</th>
<th>Int 1</th>
<th>Time 2</th>
<th>Int 2</th>
<th>Time 3</th>
<th>Int 3</th>
<th>Time 4</th>
<th>Final</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSE Questionnaire</td>
<td>2.3</td>
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<td>4</td>
<td>2.9</td>
<td>2.5</td>
<td>2.9</td>
<td>3</td>
<td>3.7</td>
<td></td>
</tr>
<tr>
<td>Exam Grade in %</td>
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<td>55</td>
<td>80</td>
<td>55</td>
<td></td>
<td></td>
<td></td>
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</table>

Laura is a White woman who ended the course with a B as final grade but her CSE was another story. As seen in table 4.8, the first day of class (time 0) Laura’s CSE was 2.3 and after that her confidence was around 3 through the semester according to the CSE questionnaires. When we talked during the first interview and after the first test where she had scored 70% and her CSE was 4. This is what she had to say about it:

“I got a seventy. I wasn’t that happy about it but at the same time I wasn’t devastated. But now I think a lot of people had to take that first test so that they would know how to study to get a good grade”

Laura sounded fairly confident and among other things she expressed great satisfaction with the lecture and the instructor:

“...my confidence is steady so far”
“Dr E really wants everybody to get it he is not one of those teachers that don’t care, that is helpful because he takes the extra step. He explains things very thoroughly”

During the second interview, after the second test where Laura scored a 45, I asked her about her confidence at that point; she said it was 2.5. She was crushed:

“I have decided that I don’t ever want to take chemistry again.”

“I wanted to be a psychiatrist so I didn’t have an interest in chemistry at all but I had to take it for pre-med but I think I’m going to get a PhD in clinical psychology. It doesn’t require chemistry or biology or anything “

She was visibly frustrated because she found that she did not study everything she needed to:

“I was trying to do OWL that took me about ten hours. I hate the OWL homework I can’t finish it. I just feel frustrated”

I asked her how the chemistry class was going, she answered:

“Worse, cause I don’t feel I’m going to be able to do it”

“I mean I think it’s just like getting harder to like and... it’s harder and you can’t just sum it up in a few words on a slide that’s all it’s getting harder”

Laura stayed in the course and on the third test she scored 55% and she said her CSE was 3. She said she hadn’t changed her mind about having changed careers:

“I need a break from math and science. I need to get a job”

Laura was devastated by her grade on the second test. The third test score was a little better (55%) and she had better grades in the other tests (70% and 80% and 55% in the final). Because one grade was dropped in the end she had enough points to achieve a B in the course. She probably completed assignments that helped boost her grade.

In terms of sources of self-efficacy Laura mentioned mastery and vicarious experiences as well as the social persuasion from the instructor and her emotional estates were evidently undermining her overall confidence. At the end
of the semester it seemed that she was emotionally exhausted and that is probably why she needed a break from science.

**Lance**

**Table E.9 CSE and Achievement for Lance: Black Man**

<table>
<thead>
<tr>
<th>Final Grade</th>
<th>Time 0</th>
<th>Time 1</th>
<th>Int 1</th>
<th>Time 2</th>
<th>Int 2</th>
<th>Time 3</th>
<th>Int 3</th>
<th>Time 4</th>
<th>Final</th>
</tr>
</thead>
<tbody>
<tr>
<td>D+</td>
<td>3.3</td>
<td>3.0</td>
<td>3.2</td>
<td>4.0</td>
<td>3.1</td>
<td>3.0</td>
<td>3.2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Lance is a Black Man who ended the course with a final grade of D+ and whose CSE trough the semester was around 3. When I interviewed him for the first time he had scored a 70% on the first test and his CSE was 3. When I asked him what helped him learn chemistry he answered:

“I would say the OWL (is the most helpful) even though like most of the time you forget about it and sometimes you don’t do it because it’s a lot of work it breaks you down to get a better understanding”

“The activities, I struggle with them”

I asked him why; here is what said he had trouble with:

“Summarizing and stuff, explaining (is difficult)”

In the second interview after he scored a 75% on the first test he said his CSE was 4. His confidence was boosted after he scored a fairly good grade. He sounded upbeat:

“I’m studying more, reading the book so I’m understanding better. I’ve been studying longer and more often too. The activities are getting easier to follow”

In the third interview Lance’s confidence (CSE) went down to 3 after having scored a 35% on the third test. I asked him to tell me about the course, his learning and about his confidence; he said:

“It’s still the same but when I’m like confident about the test that I’m going to get a good grade like I know the information. When it comes to the test it seems that I do worse when I like go in and not be like confident”
“I think that I over think my answers too much and when it seems simple, I think it’s more complicated than it really looks. It’s like it can’t be that easy so I try it another way and I get it wrong”

This last quote denotes that Lance was not very confident about his knowledge and experience. He knew an answer and he was still not completely sure he knew that it was solidly right. This was a reflection of his low CSE. Lance practiced his mastery experiences and he mentioned some vicarious experiences as well. His exam grades were not that low.

**Sabrina**

Table E.10 CSE and Achievement for *Sabrina*: Hispanic Woman

<table>
<thead>
<tr>
<th>Final Grade</th>
<th>Time 0</th>
<th>Time 1</th>
<th>Int 1</th>
<th>Time 2</th>
<th>Int 2</th>
<th>Time 3</th>
<th>Int 3</th>
<th>Time 4</th>
<th>Final</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1.2</td>
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<td>90</td>
<td>73</td>
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</tbody>
</table>

Sabrina is a Hispanic woman who started with low CSE in the semester but increased it to high very quickly and ended the course with and A as we can see in the table above. By the time I interviewed her for the first time she had scored a 90% on the first test and said her confidence was 4. When I asked her what she found helpful to learn chemistry she said:

“I think I tend to be more of a loner although I do see the benefits of working in a group ah if you’re all in the same page”

“I’m not very fond of lectures but in Dr E’s case I actually like them because they are not monotone or just a list of information. And you know he’s getting to understand it, to conceptualize it, to see it and it’s a much better way to learn. I’ve had other professors that talk or say basically what you can read in a book”

“Dr E has so many hours available to us, he’s so willing to help. I think if you’re not doing well it’s …by choice you know, I’m not saying an ‘A’ good but
definitely passing this course and if you’re not… if you’re failing it’s because you’re not putting the work required”

Sabrina did well on the second test although she scored a little lower but she still was confident; her CSE was 4.5 and it was not all about grades:

“I didn’t do as well as I wanted but I did well”

“I’m enjoying the class more because I can grasp the concepts quicker, everything is going really well”

During the third interview Sabrina said she had scored a 90 on the third test and although she was confident (CSE = 5.4) she was getting tired;

“I am getting burned out so I’m getting worried about the final, my confidence is a 4 because of how tired I feel for the final. Otherwise I have an A in the class so far”

Sabrina started with low CSE scores at times 0 and 1 but she gained confidence right after the first exam and she kept that high CSE. She had the achievement to match her confidence (or vice versa). Sabrina ended the course with an A and increased CSE as a result of the high scores in the exams. She valued her mastery experiences as well as the vicarious and appreciated the social persuasion offered by the instructor. She enrolled in General Chemistry the following semester and obtained an A- in that course.

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Rosalie

Table E.11 CSE and Achievement for Rosalie: Black Woman

<table>
<thead>
<tr>
<th>Final Grade C</th>
<th>Time 0</th>
<th>Time 1</th>
<th>Int 1</th>
<th>Time 2</th>
<th>Int 2</th>
<th>Time 3</th>
<th>Int 3</th>
<th>Time 4</th>
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</thead>
<tbody>
<tr>
<td>CSE Questionnaire</td>
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<td>3.7</td>
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<tr>
<td>Exam Grade in %</td>
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<td>55</td>
<td>32</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

168
Rosalie is a Black woman who obtained a C in the course and who after some variation through the semester as seen in the table above ended the class with slightly higher CSE than she started. During the first interview she said her confidence was 3 after she had scored 60% in the first exam. When I asked what she found helpful to learn chemistry she said:

“When he’s explaining it I understand, but when I’m on my own I’m just as lost as I could possibly be, so…”

“Hmm, when I study with somebody in class so [she] understands usually what I don’t so she’s pretty much in the level that I am so it’s easier for me to understand her”

“I need somebody to go through the chapter with me and make sure that I’m understanding what I’m reading”

She depended greatly on someone else to explain to her what she did not capture in the lecture. In the second interview her confidence was 3.75, a little higher although she scored 55% on the second test. I asked her how things were with her learning chemistry, she said:

“I study in a different way. I read the slides and the sections in the book to be prepared when I do the homework”

“At first I didn’t look at the lecture’s slides. They help pin point the topics. I am also studying more hours”

“I study with Helen”

Rosalie was probably more confident because she was studying more on her own although she was still somewhat dependent on her classmate. For the third interview her confidence had dropped to her initial state, she said it was 3 probably because she had scored 40%, lower on the third test than before. Rosalie sounded emotionally devastated when she talked about her grade:

“I ran out of time. I knew everything, it’s just the time ran out on me and I basically bubble in the answers and that just messed up my grade completely”

But she was looking forward to the next test and that’s probably why her confidence didn’t drop any further although she expressed concern about her algebra grade at that time:
“No I’m not confident about this test because I haven’t studied yet. But it doesn’t seem that hard though”

“I mean it’s not hard material actually it is the easiest. It’ll probably be the easiest test we’ve had so far”

Rosalie passed the course with a C and according to the scores from the CSE questionnaires she had a slight confidence gain. Her confidence improved likely through mastery, vicarious experiences and social persuasion. The negative impact of her failures weighed heavily:

“I’m kind of a negative person I have to work on my positive attitude”

“I was very confident, I studied for two weeks before the test you know, maybe a couple of times a week with somebody else and we asked each other questions and we did the homework over again you know. I was very confident and then I get the test back and I didn’t do as well as I did, that just dropped my confidence. It took me forever to get my confidence up”

Rosalie was dependent on studying with her peer mostly so for her the vicarious experiences were crucial for her learning although she study on her own. Rosalie enrolled in General Chemistry the following semester and obtained a C- in that course.

### Gaston

#### Table E.12 CSE and Achievement for Gaston: Hispanic Man

<table>
<thead>
<tr>
<th>Final Grade</th>
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<th>Time 1</th>
<th>Int 1</th>
<th>Time 2</th>
<th>Int 2</th>
<th>Time 3</th>
<th>Int 3</th>
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<td>B+</td>
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<td>CSE Questionnaire</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Exam Grade in %</td>
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</tbody>
</table>

Gaston is a Hispanic man who came into the course having no high school chemistry and obtained a B as final grade in the class. By looking at table 4.12 we can tell how his CSE increased. The first day of class according to the CSE questionnaire resulted in his confidence was 2.2. During his first interview he said his confidence (CSE) was 4, this was after he achieved a 60% in the first test. When we discussed what he found helpful to learn chemistry he said:
“sometimes I do not understand something and I have to rely in another student to teach me. I would say that a big amount of what I know about chemistry I’ve learned from other students. As I mentioned I didn’t take chemistry in high school so...”

During the second interview Gaston said his confidence was 4.5 although he mentioned he was disappointed in his grade (65%). Gaston still talked mostly about his vicarious experiences with his friends/peers:

“I didn’t do as good as I thought I was going to do. I think I have everything down and I know how to do everything but I didn’t”

“I might be wrong to say it’s not difficult and get a bad grade in my test but the thing is...nothing specifically you just got to practice more...”

“for example that other kid Erik, el de los ojos claros, he sometimes explains to me and I go, OK I get it! It wasn’t that hard”

During the third interview Gaston said confidence was 4. At this point he said he could study alone and get a good grade. His confidence came through in these quotes:

“... A couple of weeks, maybe a month (into the semester) it might have been a little different to my style and everything but...I think I got used to it and I already know what he’s going to teach, the way he’s going to teach (it)”

“I keep on going up by five points in every test. I started with a low one on the first test. Like I started with a sixty five and the second test I got a seventy and then a seventy five”

When I asked him about his confidence in learning chemistry at this point, he said:

“It increases, every, every day I get better in chemistry”

We talked about preparing for the next test and the final he said:

“I’m just going to study by myself, read the book, go over the book again and again...”

So in terms of CSE it was contradictory to what one would expect because during the second interview when he talked about getting a lower grade than he
expected he expressed his highest point (4.5) in self-efficacy but that is how it was.

Gaston’s CSE remained high through the semester although it dropped a little by time 4. In terms of his confidence at the beginning of the semester according to what he said, he was dependant on his peers support to understand the material. Slowly he became self-reliant. He felt that he was able to study on his own and achieve a good grade. He had practiced enough with classmates and friends. Mastery experiences became more important than vicarious experiences/social persuasion (Hutchinson 2006). At the end he was ready to study on his own and succeed. Gaston enrolled in General Chemistry the following semester and obtained a B in that course.

**Alec**

<table>
<thead>
<tr>
<th>Final Grade</th>
<th>CSE Questionnaire</th>
<th>Exam Grade in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-</td>
<td>Time 0 3.0</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>Time 1 3.6</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>Int 1 3.5</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>Time 2 3.3</td>
<td>85</td>
</tr>
<tr>
<td></td>
<td>Int 2 3.5</td>
<td>64</td>
</tr>
<tr>
<td></td>
<td>Time 3 3.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Int 3 4.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Time 4 3.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Final</td>
<td></td>
</tr>
</tbody>
</table>

Alec is a Black man that had a CSE of about 3 through the semester but during the last interview he said he was up to 4. He made an A in the class. His grades were good except for exam 3 where he slipped a little as seen in the table above. When we spoke during the first interview he said his confidence was 3.5 after scoring 80 on the first test although Alec was very pleased with the way was going:

“This class is the most fun that I’ve ever had taking chemistry”

Here is what he found helpful to learn chemistry:

“I read the chapters that we have to do for the exam and go over the problems in the chapters. I usually write the problems and the formulas and sometimes I print the formulas’ page (from OWL) so I can use it to study for the exam”
“The way the teacher uses analogies and explains when he’s on the board and explains in detail how to go about a problem (is helpful). The way he (instructor) teaches is very understandable”

“Usually I just study with friends or by myself cause I find it easier actually. I study by myself or I ask somebody who knows it... in class...to help”

The second interview went by uneventfully since he scored a 90% in the second test. But he was cautious, he said his CSE was still at 3.5 (rather low for a 90% in my book). During the third interview, after he scored 55% on the test he said:

“It’s pretty easy. I think I’ll do better again because I didn’t study as hard as I did for the other tests”

Alec was nonchalant about that grade probably because he knew the instructor dropped the lowest test score and there was still another test before the final.

Alec mentioned mastery and vicarious experiences; he liked the instructor and the lecture so probably social persuasion and definitively emotional states influenced his confidence. The positive outlook on his part showed Alec’s CSE was resilient and it paid off, in the end he got an A in the course. He enrolled in General Chemistry the following semester and obtained a C in that course.

Kevin

Table E.14 CSE and Achievement for Kevin: White Man

<table>
<thead>
<tr>
<th>Final Grade</th>
<th>Time 0</th>
<th>Time 1</th>
<th>Time 2</th>
<th>Time 3</th>
<th>Time 4</th>
<th>Final</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-</td>
<td>CSE</td>
<td>2.8</td>
<td>3.4</td>
<td>3.0</td>
<td>3.6</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>Questionnaire</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Exam Grade in %</td>
<td>55</td>
<td>55</td>
<td>60</td>
<td>55</td>
<td>57</td>
</tr>
</tbody>
</table>

Kevin is a White man who had a high CSE through the semester and he achieved a B in the course. According to what he said during the second and third interviews his CSE was a 4 both times. Kevin scored 55% in the first exam and at that time he said his confidence was 3 as seen in the table above. Here is what he described as helpful (or not) during the first interview:
“OWL takes a lot of time to figure it all up, and that’s what you have to do but, some questions are too hard”

“I’m learning how to study to take the test”

“I can say examples are helpful, when I see people work things out. Also the lecture itself, when he goes to the board and the power point and clicker questions”

“Our group works good with one of the other girls, the other two sit apart”

“I try to study with a group”

On the second test he scored 55% again but he said his confidence was 4 at that point. Probably because things were making more sense:

“I think his PowerPoints, what he does on everything and he kind of went off track at the beginning because this is something you’ll learn later on. I think I guess he’s catching up with himself now”

Kevin says the instructor was “catching up with himself” when in reality Kevin himself was understanding more connections of concepts now. That seemed to continue when we talked for the third interview:

“it’s tough but…it’s being explained a little bit better except for the last couple of chapters. He went a little bit fast, kind of rushed”

“Yea, he seems to be... well... I guess he’s catching up with himself cause earlier he would say ‘you’ll understand this later on’ and I guess he’s now catching up with that”

And this is probably why Kevin said his CSE was a 4 during the third interview.

Kevin found the online homework hard and it was definitely not his favorite. He used mastery experiences although he probably preferred vicarious experiences.

“I did pretty decent on the third test”

According to this last statement he had adjusted to lower expectations because he scored 60% on the third test and in the end he pulled a B- in the class.
He did not enroll in General Chemistry the following semester because he couldn’t fit it in his schedule.

**Jurgen**

Table E.15 CSE and Achievement for **Jurgen**: White Man

<table>
<thead>
<tr>
<th>Final Grade</th>
<th>Time 0</th>
<th>Time 1</th>
<th>Int 1</th>
<th>Time 2</th>
<th>Int 2</th>
<th>Time 3</th>
<th>Int 3</th>
<th>Time 4</th>
<th>Final</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-</td>
<td>2.6</td>
<td>3.7</td>
<td>4.0</td>
<td>3.9</td>
<td>4.0</td>
<td>3.8</td>
<td>4.0</td>
<td>3.4</td>
<td></td>
</tr>
</tbody>
</table>

Jurgen is a half White-half Hispanic man who had classified himself as White in the roster but later told me his mother is Cuban. Jurgen started the course with rather low (CSE=2.6) as seen in the above table and quickly gained confidence through the semester. His gain of confidence is probably the result of his achievement in the tests. Also Jurgen during the first interview he already said his CSE was 4. Here is what he found helpful to learn chemistry:

“**I feel like I need to get through it (OWL) or else I’m going to get a bad grade in the class**”

“**When he repeats things in class and he shows not just the theory but how the problems work and over and over and different problems of the same theory whatever he’s teaching, I’m a very visual person so if I can see him give me lots and lots of examples of the same thing, I’ll get it...Just honest repetition and explaining the same thing in different ways**”

“**And I have a study partner that I work with and we’ll just review and I’ll just do that for the next few days before the test and that should prepare me**”

For the second interview he again stated that his confidence was 4 after scoring 90% in the second test. I asked how the course was progressing in terms of his learning chemistry he said:

“**Like I usually I have one person that I run stuff by and that’s how I learn. Honestly, usually it’s during class (that I learn) like he’ll be talking or something and go off a tangent and I ask the person to clarify for me, OK then I get it. That’s how kind of learn**”

He had a lot to say about the instructor:
“…his interactive style of teaching is the sole, one of the main contributors to higher grades. The fact that someone goes out of their way and not only that but he actually adapts his teaching style I mean minute to minute based on whether we get it or not. He’s not on this fixed cookie-cutter time schedule; he has to get through this material not matter what, cause that’s just ridiculous. He will put the class behind making sure that we have grasped the proper topics. We might be behind the other class but it’s more important that we’re understanding. And he does that through the clicker questions he uses like a, a friendly modified Socratic method, you know, asking questions to the class, not calling on people necessarily but… I went to his office and he took the time to talk to me”

On the third test Juergen scored only a 45% but his confidence barely suffered and part of it must be that the lowest grade was dropped as part of the course policy. He ended the semester with an A and improved confidence:

“I think I can stand on my own. I’m pretty happy with myself. I’ve learned a lot, a hell of a lot in the class. I’ve learned a lot and I’m able to answer the questions that he posed in classes and find the right answers most of the time. Yea, I’m pretty confident”

For Jurgen vicarious experiences seemed extremely important at the beginning of the semester (he wanted to see how the instructor solved every problem or answered every question). It was apparent that towards the end he became more self-reliant as we perceive from the above quote. He could understand and master the material in the course without the shadow of a doubt. He enrolled in General Chemistry the following semester and obtained a B in that cours
Armand

Table E.16 CSE and Achievement for Armand: Black Man

<table>
<thead>
<tr>
<th>Final Grade</th>
<th>Time 0</th>
<th>Time 1</th>
<th>Time 2</th>
<th>Time 3</th>
<th>Time 4</th>
<th>Time 5</th>
<th>Final</th>
</tr>
</thead>
<tbody>
<tr>
<td>D+</td>
<td>2.9</td>
<td>3.9</td>
<td>3.5</td>
<td>4.0</td>
<td>3.6</td>
<td>3.0</td>
<td>3.6</td>
</tr>
<tr>
<td>CSE Questionnaire</td>
<td>70</td>
<td>50</td>
<td>55</td>
<td>30</td>
<td>27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exam Grade in %</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Armand is a Black man that started the course with a CSE of 2.9 and he quickly increased to high CSE through the semester according to the CSE questionnaires. He obtained a D+ as final grade. During the first interview he said his confidence (CSE) was 3.5 after he scored a 70% on the first test. He was pleased with the way the course was set up and the way the instructor taught. When I asked him what he found helpful to learn chemistry he said:

"Definitely lectures. I like how he goes over everything on the clickers. I like how interactive he is with the students, how he makes sure everyone has a grasp on everything and the OWL homework helps too"

He did not see any value on the inquiry activities:

"Some of them (activities) are a little challenging but they’re just so basic…it feels like busy work. It just feels like high school busy work"

During the second interview when I asked about his confidence he said it was a 3 after he scored 50% on the second exam. But he told me he scored a 60% when in fact it was a 50%.

"I got a sixty. Not as well as I wanted to. I should have studied harder thought. I took the test a little lightly so I mean it’s my own fault… I should have studied harder thought"

During the third interview he said his confidence (CSE) was still 3 after he had scored a 55% on the third test. But there were still more tests to be taken and mastered:

"Uh I feel confident about the stuff I just need to study harder for the test tomorrow, I think I should be alright if I do alright in the test tomorrow and on the final. For the final right now I’d give it a three cause I haven’t studied for the final… Well I don’t feel as confident as I will once I study”

At the end of the third interview he said about the course:
“I was pretty satisfied with the class and everything, it was structured very well, they teach you for Gen Chem. Hmm if I had put the effort I could have had an ‘A’ in the class”

Armand acknowledged mainly mastery and vicarious experiences as helpful in the course. Armand seemed to have the confidence, further more, he was probably overconfident and very likely did not dedicate enough time studying chemistry especially at the end. It was in the final exam when his achievement really dropped. As seen on table 4.16 Armand’s tests scores showed consistent decline through the semester. The material at the beginning was simpler, easier and it got complicated very quickly and he probably did not exert a consistent effort. He did not enroll in General Chemistry the following semester since he got a D.

---

**Julia**

**Table E.17 CSE and Achievement for Julia: Black Woman**

<table>
<thead>
<tr>
<th>Final Grade</th>
<th>Time 0</th>
<th>Time 1</th>
<th>Time 2</th>
<th>Time 3</th>
<th>Time 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-</td>
<td>-</td>
<td>3.3</td>
<td>4.0</td>
<td>3.9</td>
<td>5.0</td>
</tr>
<tr>
<td>CSE Questionnaire</td>
<td>5.0</td>
<td>4.0</td>
<td>5.0</td>
<td>3.9</td>
<td></td>
</tr>
<tr>
<td>Exam Grade in %</td>
<td>85</td>
<td>95</td>
<td>80</td>
<td>90</td>
<td>52</td>
</tr>
</tbody>
</table>

Julia is a Black woman who started the semester in the middle of the scale in terms of CSE and very soon increased her confidence most likely due to her high achievement in the class as we can tell by looking at the table above. Here is what she found helpful to learn chemistry:

“OWL, the lectures although sometimes they are confusing when he jumps from topic to topic. And reading ahead definitely helps”

“Alone, I like to study at my own pace and my own style”

For the second interview Julia had scored a 95 on the second test and her CSE was 5. Things were going really well on the course for her:

“I got a 95% (on the test) Yes, I did a lot better on this test. I also studied differently for this test than for the first one. I feel like I possibly get as ‘A’ in this class”
For the third interview her test score was a little lower 80%, but her confidence was still high at 5:

“I’m still pretty sure of myself. I didn’t do as well in my last test as I wanted. Now I realize I have to go back and study the way I had been studying but other than that...it’s pretty good”

Julia favored mastery experiences although vicarious must have played part in her success. She used to hang out with Sabrina, another high CSE/high achievement classmate, they studied together and they both liked and appreciated the instructor and achieved an A in the course. Julia enrolled in General Chemistry the following semester and obtained a B in that course.

Isabel

Table E.18  CSE and Achievement for Isabel: Hispanic Woman

<table>
<thead>
<tr>
<th>Final Grade</th>
<th>Time 0</th>
<th>Time 1</th>
<th>Int 1</th>
<th>Time 2</th>
<th>Int 2</th>
<th>Time 3</th>
<th>Int 3</th>
<th>Time 4</th>
<th>Final</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSE Questionnaire Grade in %</td>
<td>3.3</td>
<td>3.3</td>
<td>4.0</td>
<td>3.8</td>
<td>4.0</td>
<td>4.1</td>
<td>4.5</td>
<td>4.6</td>
<td></td>
</tr>
<tr>
<td>Exam Grade in %</td>
<td>92</td>
<td>95</td>
<td>85</td>
<td>90</td>
<td>73</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Isabel is a Hispanic woman who started with a medium CSE and increased it to high during the semester as we can tell from table 4.18 probably as a result of her high achievement. She ended the semester with an A in the course. Here is what she found helpful to learn chemistry:

“Pictures, I like books that have a lot of pictures. And right now the clicker questions The OWL homework too”

During the second interview she said things were not as easy as at the beginning but she kept her confidence and she knew what to do:

“The online homework is getting harder, because they don’t explain really. They just throw questions at you as if you already know the material. It’s getting harder with the red-ox and everything it’s getting harder”

“The slides posted on line help a lot too. That’s what I study with. I don’t really use the book. I did it for the first test and I realized it was the same
material. If I don’t understand something I use the book but otherwise I use the slides”

Isabel’s studying methods had been successful so she just continued the same way:

“Yes, I’ve been studying a lot. Yes, alone”

Isabel’s main source of CSE was mastery experiences. She ended the course with an A, and it didn’t seem that she had ever doubted otherwise. She mostly trusted her mastery experiences. She enrolled in General Chemistry the following semester and obtained a B+ in that course. Her final statement was:

“I really liked the class. It was really, really good. I wish he would teach the next course”

**Duane**

Table E.19  CSE and Achievement for **Duane**: Hispanic Man

<table>
<thead>
<tr>
<th>Final Grade</th>
<th>Time 0</th>
<th>Time 1</th>
<th>Int 1</th>
<th>Time 2</th>
<th>Int 2</th>
<th>Time 3</th>
<th>Int 3</th>
<th>Time 4</th>
<th>Final</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>3.6</td>
<td>4.1</td>
<td>5.0</td>
<td>3.8</td>
<td>4.0</td>
<td>3.7</td>
<td>2.0</td>
<td>3.9</td>
<td></td>
</tr>
</tbody>
</table>

Duane is a Hispanic man whose CSE was medium to high through the semester and his final grade in the course was a B. However according to the interviews he started with very high CSE that dropped a little for the second and ended with only a 2 as seen in the table above. His achievement was not extremely high or low except for exam 4 where he scored 90%. He was very conscious of the effort it was going to take him to get a good grade in chemistry. Here is how he saw things;

“I study for ten hours for this test plus all the reading three weeks in advance plus the homework. I would like to see all of the OWL homework I’m about 75% ready (for the test) right now. I have more studying to do this afternoon through tonight two weeks before the exam”

“I always study with somebody else. Oh yea, my group is great. There’s just three of us. It’s better and whatever I don’t know the other person knows so we kind of help each other out”
During the second interview his CSE was 4 but he wasn’t so happy about his grades:

“I got a seventy on it (last test). It’s not bad, yea but it’s not great if I want to get an ‘A’ in the class”

And during the third interview his confidence had sunk some more:

“Yes on chemistry I haven’t done as well even though I study a lot. I’m not getting where I want… It’s not so much the equations and the math problems. It’s more the reasoning and the concepts”

Duane was hoping for an A but he got a B. Not a bad deal but not what he wanted either. His confidence increased a little according to the CSE questionnaires but according to the last day we spoke during the third interview his confidence was at it’s lowest, a 2. Duane studied alone and in a group so mastery and vicarious experiences were present so were social persuasion and emotional states. Maybe with a little push of positive experiences his confidence will increase some more. Duane enrolled in General Chemistry the following semester and obtained an A- in that course.

Lilia

Table E.20 CSE and Achievement for Lilia: Hispanic Woman

<table>
<thead>
<tr>
<th>Final Grade</th>
<th>Time 0</th>
<th>Time 1</th>
<th>Time 2</th>
<th>Time 3</th>
<th>Time 4</th>
<th>Final</th>
</tr>
</thead>
<tbody>
<tr>
<td>A- CSE Questionnaire</td>
<td>3.8</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
<td>3.8</td>
<td>4.0</td>
</tr>
<tr>
<td>Exam Grade in %</td>
<td>95</td>
<td>85</td>
<td>55</td>
<td>80</td>
<td>68</td>
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</tr>
</tbody>
</table>

Lilia is a Hispanic woman who had high efficacy all through the semester and high achievement as well since she ended the course with an A-. When we met for the first interview she said her CSE was 4.5 and here is what she said about what she found helpful to learn chemistry:

“The OWL homework as much as people hate it because it’s long and tiring if you write the wrong letter, if you forget to capitalize it you always get it wrong, you have to do it over and over again so that’s really helpful”

“The way I study is by teaching someone else. When you study by yourself you read over it and really grasp the idea and if your teaching someone else and
they don’t understand you read over and over again and that’s how you practice it”

Unlike most of the students Lilia liked the discussion/activities sessions, she saw benefit, where other students did not:

“I like the way that Dr E explains everything cause he explains it to the point where every one gets it and I think that the discussions groups are actually helping but the quizzes since they’re short, it’s easy to get things mixed up but... I like the way the discussions relates to everything we’re doing”

For the second interview she had scored 85 on the second test somewhat lower than the first and her CSE was 4 also a little lower than for the first interview:

“Well, the class got harder and actually we’re going to start needing some actual math like balancing equations”

“I mean I read the chapter and then like I reviewed for half an hour and that’s all I did. And the OWL homework. For the first exam I studied with other people and I got a 95 on that one. So I studied by myself on this one but, yea.”

And for the third interview her score on the third test was even lower but her CSE remained at 4. Here is what she had to say:

“I didn’t do too well in the test (third) last time but I feel I might do better this time ...in this test... Well there’s still a lot of math. It can get complicated, the questions he asks”

Lilia indeed did better on the fourth test and she got an A- in the course. She valued mastery and vicarious experiences and appreciated high scores on her tests. This statement from the first interview summarizes her outlook on the course:

“I feel pretty confident cause I learned all these stuff before and I am a quick learner and I like chemistry so...”
Lilia relied on mastery and vicarious experiences. She did not learn “all these stuff” before because somehow where she went to high school she was taught organic chemistry instead of general chemistry. She enrolled in General Chemistry the following semester and obtained a B+ in that course.

**Dianne**

Table E.21 CSE and Achievement for **Dianne**: White Woman

<table>
<thead>
<tr>
<th>Final Grade</th>
<th>Time 0</th>
<th>Time 1</th>
<th>Int 1</th>
<th>Time 2</th>
<th>Int 2</th>
<th>Time 3</th>
<th>Int 3</th>
<th>Time 4</th>
<th>Final</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>3.7</td>
<td>4.0</td>
<td>4.0</td>
<td>3.9</td>
<td>2.5</td>
<td>3.9</td>
<td>3.0</td>
<td>4.2</td>
<td></td>
</tr>
</tbody>
</table>

Dianne is a White woman who had not taken chemistry in high school and she finished the course with a B. According to her CSE questionnaires she had a rather high CSE through the semester but according to the interviews her CSE dropped a bit through the semester as seen in table above 4.21. During the first interview she said she scored 60 on the first test and her CSE was 4. Here is what Dianne found helpful to learn chemistry:

“The book is really helpful. I prefer to figure it out on my own and try to explain it to myself rather than take somebody else’s words and be more confused”

“I try to do every night a little bit of the OWL homework... It’ll work for me if I study a lot...”

When we met for the second interview Dianne had scored a 55% in the second test and her confidence had dropped to 2.5:

“I guess I have to do more work than I have been doing”

“I have to change something to improve this grade”

For the third interview her score on the third test had dropped even more and she said her CSE at this point was 3.

“On a scale of one to five I feel a three right now but I feel that if I study – which I haven’t had the time to yet but I will- I’ll feel more confident like a four or closer to a five just because I’m going to put in the time for it”

“Me and my roommate are studying together”
“It’s been better, it’s been better. Concepts are going together now; problems are becoming easier, it’s been better than it has been There’s still a lot I have to go over. I hate to say I’m totally confident about something and get over confident”

“Concepts are going together now; problems are becoming easier, it’s been better than it has been. I think everything is tied together and well rounded and is coming together in a full circle”

Dianne was still confident in spite of her grades having dropped. Maybe this was because she felt her understanding in the course kept improving. She knew that if she studied she would be successful in the course and she did. Dianne persevered in her mastery and vicarious experiences; she did not let her negative outcomes influence her confidence too much (the lowest grade was dropped as policy of the class) so in the end all her optimism and hard work paid off. Dianne enrolled in General Chemistry the following semester and obtained a D+ in that course.

Rich

<table>
<thead>
<tr>
<th>Final Grade</th>
<th>Time 0</th>
<th>Time 1</th>
<th>Int 1</th>
<th>Time 2</th>
<th>Int 2</th>
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<th>Int 3</th>
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<td>Exam Grade in %</td>
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<td>57</td>
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</table>

Rich is a white man who had high CSE through the semester and achieved an A in the course as we see in the above table. Here is what he mentioned as helpful during the first interview:

“From my experiences in high school I think Dr E is doing a good job...There’s a lot of self-teaching that you have to do”

“Those clicker questions (are helpful) because he goes over the information. He asks the question and then applies what he taught you, then he goes over it. That’s helpful”
When I asked him about his confidence he said it was 4.5 even if he was a bit disappointed in his grade (70%):

“I mean I understood everything. I pretty sure I got all the math part. It’s the concept questions, the particles and I know a lot of the information but it’s hard to apply it”

During the second interview Rich was quite pleased with his grade, his confidence was 4.8:

“I am more confident. I got a ninety-five”

And he mentioned he received help from one of his peers:

“Yea, especially Tim. Tim is…if I have a question he’s always there. Like Tim will spend ten minutes with me explaining, he’s good at that stuff this one”

In the third interview his confidence was 4.6, it dropped slightly after he scored 70% on the third test. Here is how he felt:

“I got a seventy but after going back to his office and looking I found two wrong things; had it right but I bubbled it wrong. There was one problem like I knew how to do I had to pick one thing to try to solve it instead of trying to find the one (mumble) of it, that’s what made me mess up”

Rich finished the course with an A. Mastery experiences were important and clearly vicarious experiences probably in combination with social persuasion helped him boost his confidence. Emotional states played a very important role as we can see through his comments after finding the results of his tests either increasing or decreasing even if only slightly his CSE. Rich enrolled in General Chemistry the following semester and obtained a B in that cours
Calvin

Table E.23 CSE and Achievement for Calvin: Hispanic Man

<table>
<thead>
<tr>
<th>Final Grade</th>
<th>Time 0</th>
<th>Time 1</th>
<th>Int 1</th>
<th>Time 2</th>
<th>Int 2</th>
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Calvin is a Hispanic man who had high self-efficacy through the semester as the above table reveals that matched his performance since he achieved an A in the course. He had a very good high school chemistry background according to his own testimony. Here is how he learned chemistry in this course:

“The clicker questions, the OWL that help me a lot, the lectures and the activities. Sometimes for the theory I use diagrams so I can remember. I write diagrams for example about moles, everything about moles”

“I like that the professor use a lot of examples to explain the theory”

During the second interview he said his confidence was 5 although he was a slightly disappointed in his performance on the test:

“Well I thought I was going to have like a ninety-five. An eighty-five it’s OK”

In the third interview although his grade had slipped a little his confidence was 5:

“Right now it’s fine. Everything is good”

Calvin did fine in the course. He was confident and had high achievement. Mastery experiences appeared to be the most important sources of his CSE. He was confident enough to also help other students (like Gaston among others) by explaining concepts and solving algorithmic problems (Dalgety & Coll 2006). Calvin enrolled in General Chemistry the following semester and obtained an A-
Ozzie

Table E.24 CSE and Achievement for **Ozzie**: White Man

<table>
<thead>
<tr>
<th>Final Grade</th>
<th>Time 0</th>
<th>Time 1</th>
<th>Int 1</th>
<th>Time 2</th>
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Ozzie is a White man who was home schooled. He had high CSE through the semester and high achievement as well. He ended the course with an A. During the first interview here is what he had to say about chemistry

“I’m pretty confident. Yea... Chemistry is although very challenging, it is very interesting to me, when I’m interested in something I put a lot of effort. I do something with chemistry every day: the OWL or I read my book or looking at the activity book”

“I know without a shadow of a doubt, what I am doing and the way OWL presents it, it can be very cloudy, very confusing“

The first part of the above statement shows a good deal of confidence, Ozzie had a problem with the online homework but found the lecture helpful.

“Some of the things that Dr E writes on the board and can visualize what is happening at a particulate level, has been very helpful for me and the way he can explain why he uses certain equations, if this isn’t changing it’s a constant, then you can rearrange the equation like this, so the visual thing presented for me then is pretty helpful”

During the second interview he talked again about his frustrations with the online homework and how he handled it:

“And when I get discouraged from doing like OWL and stuff I just put it off for a while, like I don’t want to do it cause it’s so frustrating cause it usually gives me a headache and I’m like ahh I seriously spent three hours with a headache like I was like I’m gonna cry”

So it is important to see that all students, even those with high achievement and CSE do get frustrated, and discouraged but it is the way the
frustration is handled that might be different as well as the effect of the frustration in their confidence.

Ozzie did not come back for a third interview because he was sick and he needed time to catch up with some lectures he missed. He clearly was on top of the situation all the time and, mastery experiences were the most important source of efficacy for him. Ozzie enrolled in General Chemistry the following semester and obtained a B in that course.

**Clara**

Table E.25 CSE and Achievement for **Clara**: Black woman

<table>
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<tr>
<th>Final Grade B</th>
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<th>Time 1</th>
<th>Int 1</th>
<th>Time 2</th>
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<td>Exam Grade in %</td>
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</table>

Clara is a black woman whose confidence was basically above 4 through the semester in the five CSE questionnaires. When I interviewed her for the first time after the first test in which she got 60% she said her confidence was a 3 on a scale from 1 to 5 which is lower than what she demonstrated in the class surveys. But Clara came through more self assured and confident when it came to describing how she studied: through mastery experiences:

“I like to do it by myself. And if I need help I know how to ask”

When I asked her if she liked studying with a group. She said:

“I like working alone. I can do it my way”

Here is what she found helpful to learn chemistry:

“I really like the O-W-L homework... that actually because it help me understand and when I miss something you can go back and see what you get wrong and that makes me understand more...and especially if I do it before class”

“If I hit a road block and I come to class and he (instructor) explains what’s going on”
In the second interview after her second test in which she obtained 70% she declared her confidence at that point was 3.5. I asked what it would take to feel a 4.5, she said:

“I’m just very concise. I want to get everything right and until I get everything right I’m not completely there”

Another insight was that we gained was that she had adjusted her expectations for chemistry grades:

“I was proud of my seventy. I normally would cry if I got a seventy. I was pretty happy”

Clara was being very cautious about what she said to me at that point but her high self-efficacy showed:

“I’m probably going to make a B or I’m probably going to make an A depending on how much I study but...I don’t know if that makes sense”

In the third interview she said her confidence was 4.5

“My confidence in learning chemistry is I know I understand it, I mean the tests are fair and I know that sometimes if I don’t study enough I’ll see that he discussed this bla, bla, bla and yea it was there and it’s my fault if I didn’t learn it but over all I think I can learn it very well. It’s all doable”

Clara was pleased with the course and its outcome:

“Yes, I was glad that I took this class because I hadn’t taken chemistry since...a while ago so if I had jumped into gen chem I wouldn’t have done as well, cause I saw my roommate, her homework. I’m glad I got this refresher”

Clara might have been cautious at times about expressing her confidence to me but in the CSE questionnaires it was high through the semester. This matched the fact that she preferred mastery experiences and at times vicarious but she had no problem with that. With respect to emotional states she could adjust her expectations to the kind of grades she got in chemistry that is a very positive aspect that is needed to persevere and ultimately succeed. Clara enrolled in General Chemistry the following semester and obtained a B- in that course.
Matt

Table E.26 CSE and Achievement for **Matt**: Hispanic Man

<table>
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<tr>
<th>Final Grade</th>
<th>Time 0</th>
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<th>Int 1</th>
<th>Time 2</th>
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</tr>
<tr>
<td>CSE Questionnaire</td>
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<td>4.7</td>
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</tr>
<tr>
<td>Exam Grade in %</td>
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<td>90</td>
<td>73</td>
<td></td>
<td></td>
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</tbody>
</table>

Matt is a Hispanic Man who had high CSE and achievement through the semester as we can see in the table above. During the first interview when I asked him what he found helpful to learn chemistry he said:

“I know 95% of your lecture 5% I'm learning“

“I study by myself a lot. Yes, I always understand not just memorize because there's specific things to memorize”

“I think lecture is pretty good. In fact I want to see if h e's teaching Chem I next semester so I can sign up with him because I really like the way he teaches so...”

“(The course is)...Pretty simple, pretty easy. I'm feeling comfortable...”

We only had two interviews because he was sick and missed the week of the second interview. He always came through as being very secure and confident with respect to learning chemistry. Clearly mastery experiences were the most important source of his confidence. Matt ended the course with an A and enrolled in General Chemistry the following semester and obtained a B+ in that course.
Carmen Alicia Garcia was born in Mexico City. She obtained her B.Sc. in Chemistry from the UNAM in Mexico where she met her husband, now Dr. Luis Garcia Rubio. They moved to Hamilton, Ontario where they had two children. While he pursued his Ph.D. Alicia was a TA for the Chemistry Department at McMaster University for several years while their children were small. In 1984 the family moved to Tampa. Alicia ran the Environmental lab at USF from 1988 to 2000, and then she worked for a year at Dr Poor’s lab in Public Health. After that she came back to school and in 2005 obtained her M.A. in Chemical Education with Dr Jennifer Lewis.