STAYING IN CHEMISTRY: FACTORS THAT PREDICT UNDERGRADUATE RETENTION AND RECRUITMENT AT A TOP-RANKED CHEMISTRY PROGRAM AND UNIVERSITY

BY

GRETCHEN ADAMS

DISSERTATION

Submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy in Chemistry
in the Graduate College of the
University of Illinois at Urbana-Champaign, 2016

Urbana, Illinois

Doctoral Committee:

Professor Steven C. Zimmerman, Chair, Director of Research
Professor Lizanne DeStefano
Professor Ryan C. Bailey
Professor Catherine J. Murphy

Abstract

Top-tier, research I university chemistry programs across the country have the opportunity to answer President Obama's call to increase the number of high quality STEM majors graduating with chemistry degrees. Chemistry majors at institutions such as the University of Illinois at Urbana-Champaign can participate in world-class research and learn from expert faculty in the field. However, given the university's size and emphasis on research as a top priority, this presents some challenges for chemistry majors as they navigate their undergraduate careers.

The purpose of this two-part research study was to investigate the factors that lead to the retention and recruitment of chemistry majors at a large, research I university and highly ranked chemistry program. By using a mixed methods approach, key factors that lead to retention and recruitment were determined.

Part One of the research study employed a regression analysis on chemistry degree attainment based on predictor variables available on graduated students contained in the university database system. The results of the analysis showed that up to 43% of the variance could be accounted for by four factors: first-semester GPA, discontinuing math course enrollment, starting math course, and participation in undergraduate research. Furthermore, the Part One analysis revealed that both women and underrepresented minorities are underrepresented in the chemistry major and *below* the national trend on chemistry degrees awarded every year.

The results from Part One and the established research literature informed the development of Part Two. This portion of the study surveyed 209 current chemistry majors and

44 former majors still enrolled at the university. In addition, 45 current majors and 22 former majors participated in individual and focus group interviews asking them to reflect on their experiences in the chemistry major. The results of the survey and interviews revealed that the two main reasons students *left* the major were a result of: 1) the perception that a chemistry degree was not a useful degree to earn for their future and 2) finding an interest in another major over chemistry. Many other reasons were cited for leaving the major, including issues with chemistry courses, issues with math courses, lack of a chemistry community within the major, and inexperience with the chemistry labs. For those that remained in the major or switched into the major, the main reason for persisting with the degree was because of a connection with chemistry arising from interest, alignment with career goals, participation in research, having a sense of belonging within the major, and positive experiences with most coursework and professors.

Differences emerged when the results were disaggregated by gender and race/ethnicity. Both subpopulations are not recruited and retained in the major at the same rate as majority students. Women that left the major more often cited several reasons for leaving beyond what men cited such as: a lack of community within the major, issues with coursework, stereotype threat, and psychological predictors associated with self-confidence, self-identity, and fixed intelligence. Females that remained in the major cited few differences with males with the exception of putting a greater emphasis on having a chemistry community of peers in the major. For underrepresented minority majors, the unique factors contributing to their retention were feeling *actively* engaged in a chemistry community and better high school preparation for university coursework.

The insight gained from this study can lead to effective programmatic and curricular changes that are important and achievable at large, top-tier chemistry programs. These changes are discussed. This research study also adds to the body of literature that the retention of chemistry majors at large, top institutions may be linked to a perception that the chemistry degree is not useful as compared to other degrees. The study also finds that female underrepresentation still exists at these types of institutions despite the minimal gap at the national level.

ACKNOWLEDGEMENTS

The completion of this doctoral program was not possible without the committed support and guidance of family, faculty members, and friends. Above all, the support and encouragement of my *amazing* husband Bill was instrumental in meeting the challenges and time demands of a rigorous program as well as the many sacrifices that were required to achieve this. I have two incredible children, Brady and Ella, who astonish me by all of their talents and wonderful character. I also have fantastic parents and in-laws that always believe in me without question.

My dissertation committee members are outstanding professionals, both as renowned academic researchers as well as their strong dedication to student success. I am honored that they agreed to serve on my committee and support me through this process. Each member has played a significant role and I am truly *thankful* for all of their time, energy, commitment, encouragement, and mentorship.

And finally, I would also like to thank special friends Jennifer McNeilly and Don DeCoste for their invaluable support over the years and countless discussions on my research.

TABLE OF CONTENTS

CHAPTER 1: INTRODUCTION

According to the Science and Engineering (S&E) Indicators 2016 by the National Science Foundation, "undergraduate students majoring in S&E fields persist and complete their degrees at a higher rate than non-S&E students[1]." However in 2012, the Obama Administration also announced our nation needs to "increase the number of students who receive undergraduate degrees in science, technology, engineering, and math (STEM) by 1 million over the next decade[2]." The Department of Commerce estimates that (ref 2, p 1):

> STEM occupations will grow 1.7 times faster than non-STEM occupations over the period from 2008-2018. In order to meet these workforce needs, the United States will need approximately 1 million more STEM professionals than are projected to graduate over the next decade.

The President's Council of Advisors on Science and Technology (PCAST) reports "merely increasing the retention of STEM majors from 40% to 50% would generate three-quarters of the targeted 1 million additional STEM degrees over the next decade[3]." Although there is some controversy over these statements[4], when looking within S&E fields, persistence and completion of bachelor's degrees is higher in agricultural, biological, social sciences, and engineering than in physical sciences (which includes chemistry), mathematics, and computer sciences where it is the lowest (51.7% versus 71.4% for agricultural/biological sciences and 60.8% for engineering).[1,5] Thus, retaining chemistry students is of utmost importance.

Furthermore, a significant number of undeclared and non-S&E majors switch into STEM fields, signaling that recruitment is also important. According to the Science & Engineering Indicators, "Because many students begin college in the large pool of non-S&E and undeclared majors, even the relatively small proportion who later switch to S&E constitutes a large number[1].” However, looking within S&E fields, undergraduate attrition in the agricultural/ biological sciences, mathematics/physical/computer sciences, and engineering is greater than transfers into those fields, but transfers into social/behavioral sciences are greater than attrition.[1]

The University of Illinois at Urbana-Champaign is a national leader in the quality and diversity of STEM degrees offered. It is a top-ranking university that also ranks 37th in granting the most STEM degrees.[6] Furthermore, the Department of Chemistry’s graduate program in a widely cited ranking system is 6th in the nation.[7] The students who graduate with an undergraduate chemistry degree from the University of Illinois have the opportunity to attend the top graduate schools and professional health schools, and can work for industrial companies across the globe. But what motivates a student to pursue and successfully earn a chemistry degree, particularly from a top-tier, research I institution and highly ranked chemistry program? What are the factors that predict success? Does academic preparation play a role, even though the students at the University of Illinois have much higher average ACT test scores (28.5) relative to the national average (21.0).[8,9] Does a science community or special program make a difference? Is it just a matter of interest? Are there early indicators and how does this relate to psychological predictors? What about factors related to gender, race, ethnicity, or the type of high school attended? Latest Census Bureau projections show that “increased enrollment in higher education is projected to come mainly from minority groups, particularly Hispanics[1].” Examining subpopulations of students is just as critical as investigating the student population as a whole.

By understanding the factors that lead to retention and recruitment of chemistry majors at an institution such as the University of Illinois, interventions and curricula could be created and implemented to improve retention, boost recruitment, and promote improved experiences for undergraduate chemistry majors attending a top-tier research I institution. Whereas the Chemistry Department is a service department, providing courses for over 5,000 students each year, the department also has an obligation and vested interest in providing the best academic experiences possible for their chemistry majors, consisting of about 600 total majors in any given semester. These students have the potential to make future breakthroughs in the chemical, health, and general scientific fields. Some of the reasons students switch out of chemistry, a department cannot control. However, some of the reasons, such as curricular and programmatic changes in the department and on campus, are under their control. Investigating these reasons is critical to understanding what possible changes need to take place.

The most probable impact of the results of this two-part study is in guiding potential changes at the University of Illinois. Further, it is likely that the results can be translated to any large, top-tier university chemistry program nationwide, because most of these institutions have similar institutional organizations and student populations.

RESEARCH QUESTIONS

This research study sought to answer the following principal question:

What are the main factors that lead to retention and recruitment of chemistry majors at a large, top-tier, research I university and highly ranked chemistry program?

To answer this primary question, the study was broken down into two segments:

Part One: *To what extent do pre- and early-college experiences predict the attainment of a* *chemistry degree? Do any differences exist by gender, race, or ethnicity?*

Literature data supports my hypothesis that quantitative variables such as ACT/SAT Math score, first-semester college GPA, high school preparation, and participation in undergraduate research contribute to attaining the chemistry degree. However, a more thorough analysis was implemented because several other types of data were available on students, providing data that could be analyzed. Thus, there was interest in determining to what extent these variables predict chemistry degree attainment, as it pertains to students at a large, highly ranked STEM university and chemistry program. Did the same trend exist by gender, race, and ethnicity at this type of university that exist nationally?

Part Two: *How and in what ways do these predictor experiences and research-based factors affect retention of chemistry majors and students recruited into the major?*

Based on the results of Part One, how did these factors affect students' decisions to remain in the chemistry major, choose another major, or pursue the chemistry major when they were initially not declared in this field? How did these factors relate to psychological indicators connected to STEM retention? Are there other factors not included in the research literature? Since this university is known for their STEM programs, did most of the students that switched out of the chemistry major simply move to another STEM field? Of the students that switched into the major, did most of the students come from a STEM field? What motivated students to switch majors and why did they switch?

By using a mixed-methods approach (utilizing both quantitative and qualitative methods), in conjunction with established research literature on STEM retention and recruitment, I was able to determine *key factors* that lead to retention and recruitment of chemistry majors at the University of Illinois. Furthermore, the insight gained from this study can lead to effective programmatic and curricular changes that are important and achievable at large, top-tier chemistry programs like at the University of Illinois. This understanding includes critical perspectives from subgroups of chemistry majors, specifically based on gender, race and ethnicity.

CHAPTER 2: LITERATURE REVIEW

Numerous studies have been implemented over the years to investigate the factors that lead to retention and recruitment into STEM fields. As expected, there are many reasons that must be considered to understand what leads to persistence and attrition of students. The most common include high school academic performance, high school experiences, college academic performance, psychological predictors, and student engagement with the STEM major and coursework. Finally, subpopulations of students, determined by gender and underrepresented minority status are also considered and explored, as these populations tend to be underrepresented in math-intensive STEM fields.

High School Academic Performance, High School Experiences, and College Academic Performance

SAT/ACT test scores have a long-standing tradition of being used to assess students' critical thinking skills needed for academic success in college.[10] These scores provide a nationally-normed benchmark for students regardless of high school size; whether it is public or private, or the student is homeschooled.[10] Others have found that high school GPA is a stronger predictor of college success for freshman engineering students, demonstrating a commonly held belief that the best predictor of future behavior is past behavior.[11–13] Linking SAT performance to high school performance has been pointed to as a stronger model for predicting success than either variable alone.[10] Academic measures of ACT/SAT score and high school GPA are significantly related to first-year college GPA and STEM degree attainment.[14–16] For example, in a sample consisting of 630 entering freshman majoring in STEM fields, the students retained in STEM (40.5% of the sample) had significantly higher means in high school class rank, math SAT score, and verbal SAT score in comparison to those students who switched out.[10] However of those that left the STEM major, 38.6% still earned a GPA higher than a 2.0, signaling more than just high school performance played a role in retention. Hazari et. al. found that high school math preparation was the overall strongest predictor of university physics performance, with physics being imperative as a gateway course sequence to pursuing a STEM degree.[17] High school physics experiences were also important and could differentially predict male and female performance related to learning requirements such as long-written problems and cumulative tests/quizzes; yet other factors including a father's encouragement and a family's belief that science leads to a better career also played a role in their university physics performance as well.[17]

For many students, choosing to major in a STEM field prior to entering college is a combination of high school academic preparation, interest generated in the middle school and high school years, and proper planning. Prior research indicates that academic preparation, achievement, and attitudes towards math and science while in high school contribute to the likelihood of a student pursuing a STEM major.[18–20] A two-part analysis, conducted by Mau, assessed the school-based factors related to students choosing to complete a major in STEM.[21] The results indicated that the majority of students who concentrated in STEM made that choice during high school and that choice was related to a growing interest in math and science and ratings of their abilities in math and science, rather than college enrollment or achievement.[21] The study also found that high school course enrollment in STEM classes may be in indicator of STEM-related persistence.[21]

Research studies also suggest that adolescents' pursuit of STEM majors or careers is not deterred by a lack of interest, but by students "inability to transform their interests into realistic strategies to achieve their career goal[18,22–25]." This includes proper high school course selections, extracurricular activities, and college planning.[18,22–25] Subsequently, greater efforts are now made at the high school level to prepare students to enter STEM fields such as improved mentoring, course counseling and advising, college-related activities and workshops, and teacher professional development and support.[18]

The type of high school attended has scarcely been investigated, yet it could affect the types of experiences students have in relation to math and science. In a study by Felder et. al. with chemical engineering students, differences in academic performance were observed between students from rural and small town backgrounds (designated as "rural") versus students from urban and suburban backgrounds (designated as "urban").[26] The urban students outperformed the rural students in their introductory course and subsequent chemical engineering courses.[26] After four years, 79% of the urban students had graduated or were still enrolled in chemical engineering versus 64% of the rural students.[26] In almost every measure of scholastic aptitude or achievement examined, urban students surpassed rural students.[26] Reasons for these differences with the rural students include lower social pressure to attend college, lower levels of parental education, limited high school course offerings, and quality of high school math and science instructors.[26]

Once in college, students who start off completing more STEM credits in their first year and those who perform better academically than their peers are more likely to go on to complete a STEM degree.[13,21] Jensen et.al also investigated scientific reasoning ability in college and found that reasoning ability correlates with high-level performance and final course grades, however it does not predict retention or declaration of a STEM degree.[27] Instead, the study suggests that increased reasoning skills are a product of learning experiences in the major.[27] The quality of students' academic experiences such as level of challenge, hands-on nature, peer teaching, and adequacy of preparation for careers (including high school and college coursework and SAT scores) are predictors of grades and STEM majors in college.[28–30] And not surprisingly, Levin & Wyckoff found that if a student's reason for choosing a STEM program was genuine (intrinsic) and focused on interest, the predicted probability of successful persistence was increased.[12] Thus, engagement with the STEM major and coursework are critical to retention.

Student Engagement with STEM Major and STEM Coursework

Student engagement with their major is associated with persistence in and recruitment into STEM majors. This includes participating in meaningful classroom experiences, undergraduate research, mentoring, and STEM-community programs. Graham et. al. describes a "persistence framework" that integrates evidence from psychology and education research into a guide for launching and evaluating initiatives aimed at increasing persistence of interested STEM students.[31] Putting the persistence framework into action requires the following (ref 31, p 1456):

(i) Faculty and instructional staff should teach undergraduate research courses, use active learning in introductory STEM courses, and encourage students to form learning communities;

(ii) Students should be educated about the benefits of learning communities and supported to create their own;

(iii) Departments should examine curricula and reward structures to incentivize effective teaching, and then align them to enable early research and active learning in introductory courses;

(iv) Provosts, deans, and chairs should advocate for and dedicate resources to changing classroom practice by creating opportunities for instructors to learn new teaching techniques;

(v) Public and private funding entities should apply the persistence framework to evaluation of new initiatives in STEM undergraduate education; and,

(vi) Accreditation agencies should incorporate measurements of STEM persistence into their periodic institutional reviews.

Furthermore, a number of studies on the impact colleges have on student outcomes suggest faculty interactions play an important role in undergraduate students' academic success.[32–35] Some of those outcomes include increased levels of satisfaction in coursework, cognitive development, and persistence through graduation.[36]

Professionals in the scientific community represent important potential sources of mentoring. Mentoring can be viewed as a form of societal capital where faculty and other professionals with whom college students associate can provide much needed insight, advice, experience, advocacy, and power.[37] When examining the experiences of students who have persisted in STEM, mentoring relationships consistently appear as a critical factor.[37] In a study of 79 upper-level students who had enrolled as science majors at a research university, pursuers reported greater science career mentoring than those who left the major.[37]

Academic advising, a form of mentoring, is critical to STEM retention and recruitment. This is especially true at larger institutions where faculty are not as accessible. Kapraun describes several key components of an academic advising program that emphasizes retention.[38] First, there must be an institutional commitment to academic advising. Specifically, faculty must believe that advising is one of their functions and the administration must provide the resources needed to implement this effectively. Second, the faculty should formulate and endorse a clear statement of advisor responsibilities for the purpose of facilitating student retention, particularly on an individual student basis. Third, advisors must be properly trained. Fourth, upper-class students in the major should be selected and trained as peer advisors to support faculty advisors. Next, a well-defined referral system must be established so that faculty and peer advisors can properly refer students to the appropriate on-campus services available. Finally, an online information support system is needed where comprehensive student information is available in one place.[38] Implementing these components will allow for faculty advising that is meaningful and effective for students.

One of the most frequent places students encounter faculty is in the classroom, thus these experiences are critical to engaging students. In a longitudinal study by Felder, Felder, & Dietz, a cohort of students (123 students) took five chemical engineering courses taught by the same instructor in five consecutive semesters.[39] The courses emphasized active and cooperative learning and a variety of teaching techniques to address the broad learning styles of students.[39] The experimental group academically outperformed a traditionally-taught comparison group (189 students) that proceeded through the curriculum with professors that taught traditionally (lecture-based, note taking, etc.).[39] In addition, the experimental group was retained in chemical engineering at a higher rate (85% versus 65%, p=.01) and were twice as likely to express an intention to pursue graduate study in chemical engineering.[39]

Another popular, innovative teaching style in the classroom utilizes a model called Peer-led Team Learning (PLTL). Supplemental Instruction (SI), another nationally recognized model, is very similar in nature to PLTL.[40] These models are used in undergraduate STEM courses that introduce peer-led workshops as an integral part of the course.[41,42] Students who have done well in a course are recruited to become Peer Leaders and run the workshops. The Peer Leaders meet with small groups of students each week to discuss and engage in problem solving related to the course material.[41,42] Published studies representing courses at over 20 institutions have demonstrated an average increase of 15% ABC as a fraction of the initially enrolled students compared to traditional lecture.[43–49] A study by Becvar found that using PLTL led to an increased number of STEM majors progressing through their gatekeeper chemistry course, exposure of all general chemistry students to actual chemical scenarios that required scientific thinking, better conceptual understanding of the process of chemistry for improved problem-solving abilities, and many Peer Leaders considering teaching at the secondary level as a career.[50]

Another study by Richardson & Dantzler examined the effect of an NSF-funded engineering program focused on improving undergraduate engineering education.[51] The primary goal in developing the curriculum was to improve student learning. Changes included rearranging course topics to achieve better integration between chemistry, mathematics, and physics.[51] Students worked in four-person teams in these new courses including their engineering course, and all courses (except labs) were taught in new computer-equipped classrooms.[51] In addition, students attended their chemistry, mathematics, physics, and engineering courses with the same group of students and worked together in their same team of four students across subjects.[51] When analyzing seven years of data under this program versus a comparison group, the overall graduation percentages for students in the program were significantly different ($p < .001$). However, significant differences were not consistent when disaggregating by race/ethnicity.[51]

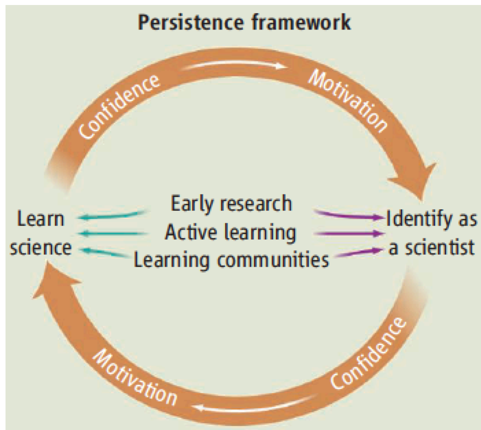
To create enhanced experiences for students, universities have established living and learning communities where beginning students are clustered by major in the residence halls and scheduled to take the same section of several freshman classes.[52] Within these communities, academic support (such as tutoring) is provided and activities to foster a sense of community.[52] Other learning communities programs do not cluster by groups in the residence halls, but continue to link courses for small groups of students and attend classes/activities that provide similar support and foster a community around their major.[53] deProphetis Driscoll et. al. found a significant increase in the number of students graduating with chemistry degrees when learning communities were added to their core introductory science courses.[53] In fact, linking key STEM courses (e.g. general chemistry and precalculus) with the same group of students and emphasizing common concepts between subjects created a multidisciplinary collaboration that showed an increase in students' skill transfer between classes, promoted a greater sense of community, and higher retention in STEM among participating students.[54]

Student engagement with their STEM major can also be accomplished through participating in undergraduate research. Undergraduate research experiences have been shown to influence retention and student assessment of learning gains (e.g., problem solving, confidence in ability to contribute to science).[55] From an analysis of 76 student interviews across four different colleges, 91% of all statements referenced gains from their experiences.[56] These benefits include personal/professional gains; “thinking and working like a scientist”; gains in various skills; clarification/confirmation of career plans (including graduate school); enhanced career/graduate school preparation; shifts in attitudes to learning and working as a researcher; and other benefits.[56] According to work presented by Schowen, research participation has a record of producing young scientists with a clearer commitment to, and better preparation for, graduate education, along with a stronger understanding of career options in the chemical sciences.[57] Research experiences also provide a deeper understanding of and more positive attitude toward chemistry through students’ personal and professional growth.[57] Finally, undergraduate research produces more qualified and prepared chemical scientists for the future.[57] In summary, Schowen states that “education in the undergraduate [chemistry] major is incomplete without research experience[57].”

Thus, student engagement with the STEM major is critical to retention and several facets contribute to that experience. For example, the University of Maryland–Baltimore County Meyerhoff Scholars Program has increased student achievement, retention, and graduate study in STEM fields.[31] Of their 508 STEM majors between 1993 and 2006, Meyerhoff has an 86% STEM retention rate, twice the nationwide average for all students and more than four times the average retention for African-American students.[58] Successful programs such as

Meyerhoff tend to employ three key components: 1) early research experiences, 2) active learning in introductory courses, and 3) membership in STEM learning communities.[31] See Figure 1.

Figure 1. Persistence Framework[31]



Psychological Predictors

A large body of research also includes how psychological predictors such as feelings related to confidence, motivation, ability, interest, identity, and self-worth can help predict STEM success, including the chemistry major. Besterfield-Sacre et. al. states that "success depends not only on the knowledge and skills learned during the first year, but also on the attitudes individual students bring with them to college[59]." Thus, by measuring attitudes both before college and how they change over time, more targeted programs can be developed to reduce attrition and improve academic success.[59] When measuring students' attitudes in curricular assessments, "attitude" is often seen as a uni-dimensional construct by chemistry instructors.[60] To obtain a useful assessment of student attitudes, one must distinguish among several different mental constructs rather than grouping them all together as "attitude".[60] These distinct mental constructs can include (ref 60, p 1864):

Attitude – a learned predisposition to respond favorably or unfavorably toward an attitude object

Beliefs – personal knowledge or understandings that are antecedents of attitudes and subjective norms; they establish behavioral intentions

Interests – personal or situational preferences for particular activities

Values – enduring beliefs regarding what should be desired, what is important, and what standards of conduct are acceptable, which influence or guide behavior

Self-Concept – evaluation an individual makes and customarily maintains with respect to himself or herself in general or specific areas of knowledge

Self-Efficacy – self-perception of an ability to do something very specific

Self-Esteem – one's level of satisfaction with one's self-concept

Reardon et. al. found that for students beginning their semester in an introductory chemistry class, generalized self-efficacy is the best determinant for students' chemistry course perceptions.[61] In a three-year study of the attitudes of engineering students and how they relate to performance and retention, students who left the freshman engineering program in "good academic standing" had lower general impressions of engineering when they started the engineering program, signaling predictors based on attitude, beliefs, and interests.[59] So from the beginning, these students liked engineering less than those who stayed. They also reported from the beginning, a lower positive perception of the work engineers do and for the profession.[59] In addition, they did not enjoy math and science courses as much as the other students. Finally, students who left in good standing exhibited lower confidence in basic engineering knowledge and skills at the start of their freshman year than did the students who persisted.[59]

Crocker et. al. states that people are highly selective about the domains on which they stake their self-worth, or self-esteem.[62] These domains for college students include academics, appearance, approval from others, competition, family support, God's love, and virtue.[62] However within these domains, people differ in the contingencies of self-worth they must satisfy to have high self-esteem.[62] The link between self-esteem and behavior of college students has been difficult to establish. Crocker's study suggests that the link depends less on whether self-esteem is high or low and more on what people stake their self-worth on.[62]

When students construct their identity, or sense of self, students may vary in how much they value different experiences.[63] How students weight competition in their courses or major, their academic competence, approval from others, family support, and whether science is central to their lives may affect their identities in different ways, which may or may not cause students to change majors.[64] A study by Shedlosky-Shoemaker & Fautch found that students who left the chemistry major tended to have higher self-doubt in general abilities and a greater desire to avoid failure (i.e., performance-avoidance orientation).[64] In addition, the degree to which competition and academic competence impacted participants' self-worth related to persistence.[64] Furthermore, the degree to which students perceived science as central to their identity did not appear to predict which students left the major.[64]

An Investment Model Scale has been developed and tested to measure four key predictors of persistence, including commitment level with three bases of dependence – satisfaction level, quality of alternatives, and investment size (magnitude and importance of the resources that are attached to the relationship).[65] Thus, the commitment level of a student in STEM is dependent upon their satisfaction level, quality of alternatives (of leaving the major to pursue a different one), and the investment in the major.[65] Students also make decisions regarding STEM persistence based on subjective task value.[66] Subjective task value (STV) can construe the value of mathematics and science courses. STV is based on four dimensions: 1) utility value – related to student's future goals, 2) intrinsic value – based on enjoyment, 3) attainment value – consistency with student identity, and 4) cost – perceptions of time taken away from other activities or the potential negative responses from peers.[66]

When considering what predicts persistence in STEM fields including chemistry, one approach is to consider individual differences as predictors of attrition in the major.[64] These individual difference measures are in relation to perceptions of ability and performance, motivation, and identity.[64] Perceptions of ability and performance include self-confidence[59,67,68], with students leaving STEM reporting higher self-doubt, or questioning their academic ability[69] and more likely to perceive intelligence as fixed (i.e., entity theorists[70]). These perceptions among those who leave the chemistry major may then focus more on performance (i.e., performance approach or performance-avoidance orientation).[71] Motivation plays a key role in persistence as well. Some students are more driven to conquer challenging material[63], having greater mastery orientation and thus a stronger desire to understand the content.[71] More motivated students have a higher inclination to seek out and enjoy effortful thought.[72] Measuring intrinsic motivation can be broken down even further into the following variables: perceived choice, feelings of pressure, intentions to invest effort, perceived major-related competence, and value of the major.[64,73] Based upon the research literature, understanding why students pursue or leave a STEM field is extremely involved – complexities involving personal experiences throughout one's lifetime and how those experiences interplay with psychological predictors.

Underrepresented Groups in STEM: Gender

Numerous studies have examined subpopulations and how gender, race, and ethnicity relate to STEM retention and recruitment. Many students with strong SAT scores, impressive grades, and success in high school honors mathematics and science courses leave the college science pipeline, but the loss is disproportionately among women and minorities.[58] Thus, factors other than school preparation, science aptitude, and interest must be responsible for the low achievement and low persistence in these subgroups of undergraduate science and engineering students.[58] Since the late 1990s, women have earned about 57% of all bachelor's degrees and about half of all S&E bachelor's degrees.[1] In 2013, men earned a majority of bachelor's degrees awarded in engineering, computer sciences, and physics (81%, 82%, and 81%, respectively). Women earned about half or more of the bachelor's degrees in psychology (77%), agricultural sciences (54%), biological sciences (59%), chemistry (48% in 2013; 49% in 2011), and social sciences (55%).[1] Thus nationally, a minimal gap now exists in chemistry based on gender.

There has been vast research on STEM persistence and recruitment of women into STEM fields, particularly focusing on academic preparation and self-confidence, cultural barriers, and career/life balance factors.[74] Key findings suggest that advanced level and AP math and science classes in high school are the most important predictors of success in STEM majors and degree completion.[17,75] The middle school years have been shown to be important developmental stepping-stones for potential STEM majors, as studies show math achievement gaps by gender starting to appear in the 13-16 year age group and a small percentage of middle school age girls selecting a STEM career as their first choice.[20,74,76–78] Fortunately, data shows that women are now well represented in advanced high school math and science courses and achieving scores comparable to men.[79,80]

Yet, the gender gap in some undergraduate STEM majors still remains, especially in math-intensive fields. Despite similar academic performance in math and science, research has shown that women are more sensitive to the pressures of introductory “weed out” courses than men, and may have to deal with negative, perceived or real, bias from male peers and faculty.[74,81,82] Women are more likely than men to switch to a career which offers more humanitarian or personally satisfying work, suggesting that women’s early experiences in STEM courses, both grades and classroom experiences, influence their likelihood of persisting in STEM majors.[74,81,83] Ost confirmed that females are more sensitive to grades received in physical sciences courses, consistent with theories of stereotype vulnerability.[84,85] Brainard & Carlin found that the first two undergraduate years and introductory grades were critical in determining whether a student decides to stay in engineering as a major.[86] Female students in particular, freshman through seniors, report higher test anxiety; a combination of the extent that they worry about test performance and the extent of emotional impact of tests.[87,88] Furthermore, Griffith found that students at selective institutions with a large graduate to undergraduate student ratio and that devote a significant amount of spending to research have lower rates of persistence in STEM fields.[75] However, Griffith also found that a higher percentage of female and minority STEM field graduate students positively impacts the persistence of female and minority students, but there is little evidence that having a larger percentage of female STEM faculty members increase the likelihood of persistence for women in STEM majors.[75] However, overall, Stout et. al. found that contact with same-sex experts (advanced peers, professionals, professors) in academic environments promoted positive implicit attitudes, stronger implicit identification with STEM and STEM careers, greater self-efficacy in STEM, and more effort on STEM tests.[89] Hill et. al. also concluded that barriers to pursuing STEM fields among females are often self perceived and caused by stereotypes of females not being welcomed in STEM studies and cultural aspects of our society.[90] However Cromley et. al. argues that variables other than stereotype threat might better explain gaps in STEM achievement and retention.[91] Cech et. al. analyzed persistence in engineering and related STEM majors, as well as career interests. They concluded that the primary causes of underrepresentation of women in STEM included women having a lower self-assessment in STEM skills, family planning and work-life balance issues, and a professional role confidence which measures the personal comfort that a qualified female feels with fitting into STEM as a career.[92] In a research study conducted by Wilson et. al. with over 600 students at both a research and teaching institution, gender differences in self-efficacy did not exist in STEM disciplines overall, however differences were significant in select disciplines such as chemistry, computer science, and engineering.[93] Brandt researched the female persistence of STEM majors at two technological institutions, examining their self-confidence, opinions, and backgrounds.[74] The results confirmed strong academic preparation, but also revealed a high level of self-confidence in their abilities and future outlook, especially in students attracted to STEM at an early age.[14,28,74,82]

Biological evidence, such as better spatial ability in men, is contradictory and inconclusive.[92] Although cross-cultural and cross-cohort differences suggest a powerful effect of sociocultural context, evidence for specific factors is inconsistent and contradictory.[94] However, some factors unique to underrepresentation in math-intensive fields include (ref 94, p 218):

a) Math-proficient women disproportionately prefer careers in non-math intensive fields and are more likely to leave math-intensive careers as they advance;

b) more men than women score in the extreme math-proficient range on gatekeeper tests, such as the SAT Mathematics and the Graduate Record Examinations Quantitative Reasoning sections;

c) women with high math competence are disproportionately more likely to have verbal competence, allowing greater choice of professions; and

d) in some math-intensive fields, women with children are penalized in promotion rates.

In addition, gender differences have been observed in critical thinking, favoring males.[88] Ceci, Williams, & Barnett indicate that women's preferences, potentially representing both free and constrained choices, constitute the most powerful explanatory factor for underrepresentation.[94] A secondary factor is gatekeeper test performance, most likely from sociocultural rather than biological causes.[94] Many researchers suggest mentoring as a key component to retaining women in STEM fields.[95,96]

Underrepresented Groups in STEM: Underrepresented Minorities

The racial/ethnic composition of S&E bachelor's degree recipients has changed over time, reflecting population changes and increasing college attendance by members of minority groups.[1] Between 2000 and 2013, the proportion of S&E degrees awarded to White students among U.S. citizens and permanent residents declined from 71% to 62% (from 69% to 62% specifically in chemistry). The proportion awarded to Hispanic students increased from 7% to 11% (from 7% to 8% in chemistry). The remaining groups have remained flat overall since 2000 with Asians/Pacific Islanders at 9% (but increased from 12% to 15% in chemistry) and Black and American Indian/Alaska Native students (combined) remained at 10% (with a small decrease in chemistry from 9% to 8%).[1]

When researching group differences at the high school level, a study by Andersen & Ward investigated group differences in the effects of the expectancies and values that 1,757 high ability (top 10% of race group on a mathematics achievement test) ninth-grade students had for science and mathematics on plans to persist in STEM in the future.[66] The goal of the study was to identify the significant predictors of plans to persist in math and science courses in high school for ninth grade, high ability students for each race/ethnicity group.[66] Previous research has shown that reentry into the STEM pipeline is rare after high school and that career plans made in high school predict future completion of STEM degrees.[21] Socioeconomic status (SES) and science attainment value evidence large differences between White students and African American and Hispanic students.[66] However, SES did not significantly predict planned STEM persistence for any group of these high-ability students.[66] In the African American group, persisters in STEM scored significantly higher than nonpersisters in mathematics achievement, science intrinsic value (enjoyed or were good at math and science), and science attainment value (consistency of a math or science identity with the student's identity).[66] In the Hispanic group, persisters scored significantly higher than nonpersisters in STEM utility value (needed courses for college) and science attainment value. In the White group, there were significant differences between persisters and nonpersisters on science self-efficacy, science intrinsic value, mathematics attainment value, and science attainment value.[66] All differences favored the persister group.[66]

Once in college, factors that keep underrepresented minorities from persisting with STEM include academic and cultural isolation, motivation and performance vulnerability in the face of low expectations, peers who are not supportive of academic success, and discrimination, whether perceived or actual.[32,97–101] These factors can have a stronger effect at institutions with predominantly majority populations, which award about 75% of all bachelor's degrees earned by African Americans.[102]

A study by Reardon et. al. on self-efficacy among ethnic groups found significant differences in performance among ethnic/racial groups, but these students began their semesters with very small differences in their perceptions regarding their introductory chemistry class.[61] It may be that those students who have already made the choice to participate in chemistry already have a certain minimum sense of self-efficacy in the subject.[61] In another study by Wilson et. al. of over 600 students at both a research and teaching institution, African-American and Hispanic students demonstrated a higher level of general self-efficacy compared to their White and Asian peers, but these differences decreased substantially (no gaps existed) in the classroom when academic self-efficacy was measured.[93] When shifting from the world at large to the academic classroom, there was a strong and prevailing influence of the STEM culture and community on how students defined their capacity to succeed.[93]

A study by Newman showed that faculty play an important role in encouraging or dissuading African-American STEM majors to persist in their respective major.[36] Additionally, the involvement in faculty research laboratories and the referral by faculty to other opportunities and internships gave participants practical application of their coursework.[36] However, some faculty also had a negative impact on students' academic and career goals through a hierarchical authoritarian disposition; one which students were at the lowest position.[34] Professors had a detrimental influence on students when they gave the impression that they did not want to spend their valuable time with undergraduate students. Finally, the African-American students in this study did not give a clear indication of how learning from non-African American faculty members positively or negatively impacted their academic careers, however some students expressed that they desired relationships with same-race faculty and peers.[36]

Furthermore, a study by Hernandez et. al. followed a large sample of high-achieving African-American and Latino undergraduates in STEM disciplines attending 38 institutions of higher education in the U.S. over three years.[103] They found that engagement in undergraduate research was the only factor that buffered underrepresented students against an increase in performance-avoidance goals over time.[103] Additionally, growth in scientific self-identity exhibited a strong positive effect on growth in task and performance-approach goals over time.[103] They also found that only task goals positively influenced students' cumulative GPA.[103] Finally, performance-avoidance goals predicted student attrition from their original STEM major and attrition from any STEM major.[103]

Several university programs have been successfully implemented to increase STEM retention among underrepresented minorities. As mentioned previously, these programs use three common interventions: (i) early research experiences, (ii) active learning in introductory courses, and (iii) membership in STEM learning communities.[31] Some of these programs include the University of Maryland-Baltimore County Meyerhoff Scholars Program[58], the Biology Scholars Program at the University of California, Berkeley[104], the Posse programs[3], and the LA-STEM and Howard Hughes Medical Institute (HHMI) Research Scholars Program at Louisiana State University[105]. To highlight one program, the Meyerhoff Scholars Program (named after its founders, philanthropists Robert and Jane Meyerhoff) focuses on producing bachelor's degree recipients, particularly African Americans, who go on to doctoral programs in science and engineering.[58] Students are nominated by high school teachers and counselors and then interviewed. Selected students receive 4-year scholarships as part of the program. The Meyerhoff model has four overall objectives: (a) academic and social integration, (b) knowledge and skill development, (c) support and motivation, and (d) monitoring and advising.[58] There are five elements necessary for achieving these objectives (ref 58, p 1871):

> (i) recruiting a substantial pool of high-achieving minority students with interests in mathematics and science who are most likely to be retained in the scientific discipline,
>
> (ii) offering merit-based financial support,
>
> (iii) providing an orientation program for incoming freshman,
>
> (iv) recruiting the most active research faculty to work with the students, and
>
> (v) involving the students in scientific research projects as early as possible, so that they can engage in the excitement of discovery.

Encouraging high academic performance in the first two years is critical.[58] When comparing Meyerhoff Scholars to a comparison group, both groups earned similar grades and graduated at similar rates.[58] However, the Meyerhoff Scholars were twice as likely to earn a science or engineering bachelor's degree and 5.3 times more likely to enroll in post-college graduate study.[58] In addition, Meyerhoff students were twice as likely to earn science and engineering B.S. degrees as Asian, White, and non-Meyerhoff African American students with similar preparation and interests.[58]

Based upon the literature review, student persistence is extremely complex, especially when considering underrepresented populations. The factors that contribute to chemistry retention and recruitment will specifically be investigated next, as it pertains to students at a top-ranked chemistry program and STEM research institution. This particular population of students has not been thoroughly researched and studied.

CHAPTER 3: RESEARCH METHODS

RESEARCH DESIGN: MIXED METHODS

The overall research design employed a mixed-methods approach, consisting of quantitative statistical analyses of predictor variables available for former students and surveys for students currently enrolled. Qualitative methods including focus groups and individual student interviews were also conducted. The research questions in Chapter 1 were posed with the goal of understanding both the *impact* of pre and early college experiences on chemistry degree attainment and to determine *in what ways* students are affected. Thus, using both quantitative and qualitative research methods provided generalizability about the types of factors that lead to degree attainment, while also targeting specific reasons why students choose to remain in the major, leave the major, or pursue the major.[106,107]

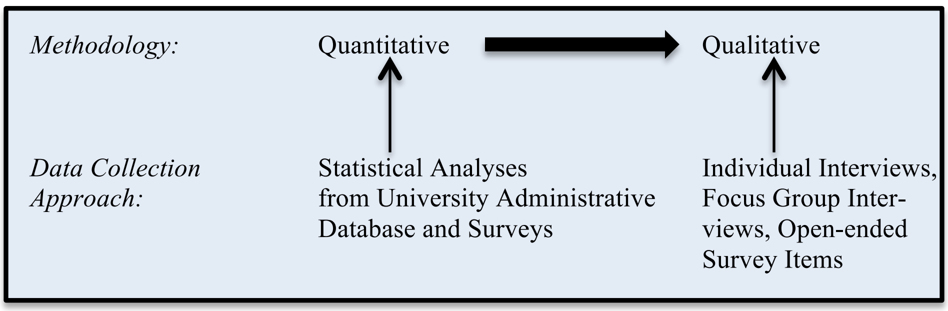
Theoretical Framework

A mixed-methods approach seeks to integrate social science disciplines with predominantly quantitative and predominantly qualitative approaches to theory, data collection, data analysis and interpretation.[108] The purpose is to (ref 108, p 1):

> strengthen the reliability of data, validity of the findings and recommendations, and to broaden and deepen our understanding of the processes through which program outcomes and impacts are achieved, and how these are affected by the context within which the program is implemented.

According to Greene, a mixed methods way of thinking rests on assumptions that there are multiple legitimate approaches to social inquiry and that any given approach to social inquiry is inevitably partial.[109] David Berliner observed that educational phenomena are much more complex than most natural phenomena in domains like physics and astronomy.[109] Given this complexity, better understanding of the multifaceted character of educational phenomena can be obtained from the use of multiple approaches and ways of knowing.[109] By using different sources and methods at various points in my research study, I built on the strength of each type of data collection and minimized the weaknesses of any single approach.[110]

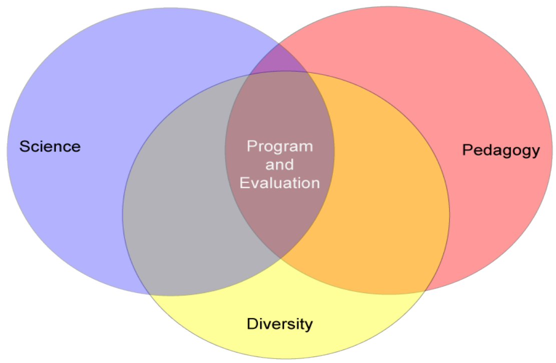
Figure 2. Mixed-Methods Approach



To further elaborate, this study used an integrated mixed methods design in which the methods intentionally interacted with one another during the course of study. It specifically used the method of *iteration*; a mixed methods study in which the results of one method are used to inform the development of another.[109] In my research study, the results of Part One were used to inform the development of Part Two, specifically in creating the survey and interview protocols.

It is also increasingly recognized that all data collection—quantitative and qualitative—operates within a cultural context and is affected to some extent by the perceptions and beliefs of investigators and data collectors.[107] Thus, an *Educative, Values-Engaged Approach* to the research was also important. This approach defines STEM educational quality at the intersection of STEM content, pedagogy, and diversity, all three of which are important to large universities.[111] Thus, my research study seeks to enhance STEM educational excellence and equity.[111] All three of these domains were significant to the research so as to improve STEM education as a means of effecting societal change.[111] These three facets were addressed in Part Two of the study which focused on student surveys, focus groups, and individual interviews.

Figure 3. Educative, Values-Engaged Approach[111]



Part One: Tracking and Analyzing Past Graduating Classes

This part of the study used an applied multiple regression model to predict the outcome of graduating with a chemistry degree by examining several predictor variables for two cohorts of entering freshman that were allowed up to six full years to graduate. This relationship between the outcome variable based on its relationship with the predictor variables is defined as:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_k + \varepsilon$$

with *k* independent variables,

where Y = outcome of graduating with a chemistry degree (response variable)

β_0 = regression coefficient of the intercept

$\beta_1, \beta_2, \ldots \beta_k$ = partial regression coefficients

$X_1, X_2, \ldots X_k$ = predictor variables

ε = random error

Procedure:

Data were pulled from university administrative databases by staff members of the ATLAS (Applied Technologies for Learning in the Arts and Sciences) Data Group in the College of Liberal Arts & Sciences. Once the relevant data were extracted, all identifying characteristics (name, university identification number, etc.) were removed. Two cohorts were examined – entering freshman in the fall of 2008 and the fall of 2009. The freshman students that initially enrolled as chemistry majors were tracked to determine if they earned their degree within six years and if so, in what discipline. In addition, freshman students that did not initially enroll as chemistry majors but graduated with a chemistry degree were also tracked. The potential predictor variables available within the data set for each student are included in Table 1.[112]

Table 1. Potential Predictor Variables Included in Data Set
(The full definition of each variable can be found in Appendix A.)

1st semester GPA	Participation in undergraduate research	Reported AP chemistry score	ACT Composite score	Starting chemistry course
2nd semester GPA	Chicago Public High School Graduate	Reported AP calculus score	ACT Math score	Starting math course
3rd semester GPA	Ethnicity/race; URM identification; Gender identification	Reported AP scores; not chemistry or math	ACT Science Reasoning score	Termination of math course enrollment
4th semester GPA	First generation college student	Total number of reported AP courses	Chemistry placement exam score	Termination of chem course enrollment
Last recorded GPA	James Scholar participant	High school type	Math ALEKS® placement test score	Merit Program participant

Data Analysis:

Data analyses were conducted using Excel and SAS. Each separate cohort (fall 2008 and fall 2009) were consolidated into those students that initially declared chemistry majors and those students that earned the chemistry degree but were not initially declared chemistry majors. Then they were coded as either earning a chemistry degree or not earning a chemistry degree. To determine if there were any significant differences between the two cohort populations (fall 2008 and fall 2009), t-tests were run on the predictor variables. No significant differences occurred below the $p = .05$ level with almost all variables except for ACT Math score ($p = .0455$), Math ALEKS® placement test score ($p = .0131$), underrepresented minority student status ($p < .0001$), and gender ($p = .0230$). Thus, the two cohorts were combined into one sample since both groups were similar in makeup based on the predictor variables (22 of the 26 variables showed no significant differences). Combining the cohorts created a larger sample size in which to analyze the data, particularly by gender. This also showed consistency in student makeup from year to year and with the university admissions process.

To simplify the model and reduce multicollinearity, a Spearman correlation matrix was created to identify the predictor variables that were highly correlated. A Spearman correlation is used when one or both of the variables are not assumed to be normally distributed and interval (but are assumed to be ordinal).[113] For those predictor variables that resulted in a moderate to strong correlation with one another ($r_s > 0.55$), the variable that had a larger correlation with the response variable (attaining a chemistry degree) was used. To check the validity of the Spearman correlation matrix, a principal component analysis (PCA) was also conducted on the predictor variables. PCA is a reduction method that is used to identify groups of observed variables that tend to hang together empirically. Principal component analysis is appropriate when measures on a number of observed variables have been obtained and a smaller number of artificial variables (called principal components) are developed that accounts for most of the variance in the observed variables. The principal components are then used as predictor or criterion variables in subsequent analyses.[114] Since principal component analysis seeks to "consolidate" variables as well, it was a good validity check for the Spearman analysis. In summary, a Spearman correlation matrix was the preferred method in this study because it does not assume that each variable is normally distributed and does not require a large sample size like PCA does. To obtain reliable results using PCA, the minimal number of subjects providing usable data for the analysis should be the larger of 100 subjects or five times the number of variables being analyzed.[114]

Once a set of simplified and non-correlated predictor variables was identified, a maximum R^2 improvement “MAXR” regression analysis was performed to predict what factors contribute to earning a chemistry degree (i.e., the proportion of total variation of outcomes explained by the model). The “MAXR” selection model specifies that model formation be based on the maximum R^2 improvement. This method tries to find the best one-variable model, the best two-variable model, and so on. The “MAXR” method begins by finding the one-variable model producing the highest R^2. Then another variable, the one that yields the greatest increase in R^2, is added. Once the two-variable model is obtained, each of the variables in the model is compared to each variable not in the model. For each comparison, the “MAXR” method determines if removing one variable and replacing it with the other variable increases R^2. After comparing all possible switches, the “MAXR” method makes the switch that produces the largest increase in R^2. Comparisons begin again, and the process continues until the “MAXR” method finds that no switch could increase R^2. Thus, the two-variable model achieved is considered the "best" two-variable model the technique can find. Another variable is then added to the model, and the comparing-and-switching process is repeated to find the "best" three-variable model, and so forth.[115]

Statistically significant findings ($p < 0.05$) are presented in Chapter 4. A full report of results can be found in the Appendices.

Part Two: Understanding Chemistry Majors

Part Two of the study sought to strengthen the validity of the data from Part One and deepen our understanding of why students choose to remain in the major, leave the major, or pursue the major. By using the results of Part One and established research literature, a set of framework questions were developed that shaped the types of survey and interview questions used with students in Part Two. Here are the investigative questions that guided Part Two:

1. What factors (e.g., classroom instruction, high school preparation, study skills, personal influences) influence academic performance in the first semester?
2. What factors (e.g., interest, academic performance, self-identity, confidence, self-doubt, sense of belonging, career goals) influence a student's decision to remain in the chemistry major or pursue the chemistry major?
3. How do special activities (e.g., undergraduate research, mentoring, study groups, STEM programs and activities) influence chemistry retention and recruitment?
4. How do math experiences (e.g., high school preparation, university course status and sequence) influence chemistry retention and recruitment?
5. How do chemistry experiences (e.g., high school preparation, university course status and sequence) influence chemistry retention and recruitment?

From these framework questions, survey and interview protocols were developed and approved by the Institutional Review Board (IRB). To read these protocols and IRB approval in their entirety, see Appendices I – L.

Procedure:

This segment of the study surveyed and interviewed a cross section of current University of Illinois students (freshman, sophomore, junior, and senior standing) that initially enrolled as chemistry majors and those students that did not initially enroll as chemistry majors but later switched. Survey items and interview questions were developed from the results of Part One and established research literature on retention and recruitment of majors in STEM fields. The survey contained both closed (Likert scale) and open-ended items to explore factors that contribute towards their successful or non-successful attainment of a chemistry degree. On the tenth day of class of the fall semester (September 8, 2015), ATLAS Data Group delivered the names and email addresses of the current students that were declared chemistry majors and those students that were former majors. The data had to be pulled on the tenth day of class because that was the deadline for declaring majors for the fall term. Using this information and SurveyMonkey® to administer the survey to the students, the students were invited via email to complete the online survey with consent starting Wednesday, September 9th through Wednesday, September 30th (3-week time frame). No compensation was given to the students to complete the survey, however it should be noted that I also serve as the Director of Undergraduate Studies for the Chemistry Department, so it was expected that students would voluntarily participate anonymously based on my status and relationship with the department. SurveyMonkey® sent reminder emails to the students every week and just prior to the survey closing. All data was downloaded from SurveyMonkey® to Excel for analysis.

Interviews consisted of individual interviews and focus-group interviews. Focus-group interviews allowed interaction and in-depth discussion between students for a dynamic variety of perspectives, while individual interviews allowed students to discuss personal and/or sensitive issues knowing they had full confidentiality and no other participants dominating the discussion. Focus-group interviews also allowed me to interview several students at one time, which was a timesaving measure and allowed more students to be interviewed.

Students were invited to participate in an interview in the same email that invited them to take the survey. Interested students indicated whether they preferred to participate in an individual interview or focus-group interview. As a follow-up, necessitated by the lower response rate by former majors, individual recruitment emails were sent again directly to these students in addition to the default SurveyMonkey® emails. Based on student response, three focus groups were created: one all-male chemistry major focus group, one all-female chemistry major focus group, and one underrepresented minority chemistry major focus group. Focus groups took place in a private classroom or office, often with an interviewer (me) and a recorder (associate with the I-STEM Initiative Office). Individual interviews took place in a private office with the interviewer (me). Upon student consent, interviews were audio-recorded and hand-written notes were taken. Interviews took place from September 2015 through November 2015 (with one last interview taking place in January 2016 because of scheduling issues). Because of the number of interviews that took place, only the focus-group interviews were transcribed from the audio recordings. Very detailed hand-written notes were taken during each individual interview and the audio recordings were only referenced for exact quotations or to clarify confusion.

Data Analysis:

Data analyses were conducted using Excel and SAS. First, a comparison was made between the graduating student sample from Part One and this sample from Part Two of current students. Because the current students have not yet completed their degrees, comparisons were explored by class standing to view general trends based on overall retention rate, retention rates disaggregated by various demographics and course sequencing, and sample makeup comparisons of currently declared chemistry majors. A "MAXR" regression analysis was also performed on the 4th Year students (current seniors who are furthest in their degree programs) to assess how their results compared to the graduated students in Part One. Finally, ANOVA tests were implemented to explore incoming predictor variable differences between the graduating student sample from Part One and the current student sample (by class standing). This test assessed whether each incoming class were similar or displayed significant differences in their academic preparation and abilities related to high school and early college experiences as compared to the student sample in Part One. If similar, then the conclusions drawn from Part One could be applied to the current sample of students and thus the factors investigated from Part One (e.g., math experiences, chemistry experiences, high school preparation, academic performance) were valid and appropriate to explore with the current students in the survey and interviews. If there were several significant differences found, then proceeding forward with Part Two based on the results of Part One would not be as valid and it would be more appropriate to proceed based solely on the research literature.

Next, a comparison was made between the actual sample of current and former chemistry majors (current population) and those who actually completed the online survey (survey sample). A similar comparison was also conducted between the current population and the interview sample, although the main goal of the interviews was to oversample underrepresented students in the major to gain their valuable insight and perspectives on their experiences. To account for differences between the population and survey sample, weighted sampling was performed to report the overall trends (means and standard errors) on the close-ended survey items. In addition, ANOVA and Chi-square analyses were conducted to explore significant differences among students that leave the major, remain in the major, or switch into the major. Furthermore, cross tabulations were completed by gender and underrepresented minority groups to further disaggregate the data, including by those who left the major, persisted in the major, and switched into the major.

For open-ended survey items and interview results, a coding system was developed based on grounded theory. Grounded theory is a general methodology for developing theory that is grounded in data systematically gathered and analyzed.[116] The theory evolves during actual research, and it does this through continuous interplay between analysis and data collection.[116] In this methodology, theory may be generated initially from the data (theory will emerge), or, if existing (grounded) theories seem appropriate to the area of investigation, then these may be elaborated and modified as incoming data are meticulously played against them.[117] Grounded theory differs from more deductive types of general theory because of its generation and development through interplay with data collected in actual research.[116] The theory is similar to the data from which it was established. The concepts that emerge to develop the theory are appropriately abstract but context-specific, detailed, and tightly constructed to the data.[118]

In this study, the open-ended survey responses and interview responses were read and reviewed. As repeated ideas became apparent, they were tagged with codes. Data were re-

reviewed at least one more time to verify created codes for the ideas expressed by the students. The process of comparing the codes with each other, to find higher order commonality, produced the concepts from the codes. By comparing each concept in turn with all other concepts, further commonalities were found which formed the broader emerged categories.[118] The number of times students cited each emerged category was summed. Students could have cited multiple different emerged categories in their responses to a question.

One criticism of grounded theory is the claim to use and develop inductive knowledge, when it is more about understanding a narrative in which the analytical procedures cannot be "neutral".[119] Due to the qualitative nature of the open-ended survey items and interviews and the use of grounded theory to analyze the data, I fully acknowledge my interpretive role in what was observed, heard, and read during this portion of the research process.[116] Thus, my interpretation of the data into the coded categories and analysis is from my perspective and affected by my experiences and background. To account for this personal bias, I met with two separate validation teams to review the qualitative data, methodology, and emerged categories from my analysis. One validation team consisted of three professional chemical educators at the university that have frequent contact and vast experience with chemistry majors. The other validation team consisted of three professionals with experience in educational psychology and evaluation, with one having additional professional experience as a mathematics educator.

Significant findings for Part Two are presented in Chapter 4. A full report of results can be found in the Appendices.

CHAPTER 4: RESULTS

Part One: Tracking and Analyzing Past Graduating Classes

DESCRIPTIVE STATISTICS

Degrees Awarded. The total number of chemistry degrees awarded for the two cohorts combined was 226 (57 Specialized and 169 LAS). Of the 192 students that initially declared chemistry as their major, 74 earned a chemistry degree. Thus, even though 118 initial students were “lost” to a different major or did not finish a degree, there was a +34 student gain from start to finish. (For a full report of retention rates for the initially declared chemistry majors, consult Appendix B.) As expected, the majority of degrees were awarded to White and Asian students, however the percent totals for all groups did not match the national trend for 2013.[1] See Table 2. Of special notice, Asian students were over double the national rate and African-American students were less than half, even though the initial percent of chemistry majors from these two groups more closely resembled the national rates. In addition, males earned more of the chemistry degrees at UIUC versus the national average, which showed the gap diminished at ~50% (women earned 47.9% of the chemistry degrees in 2013; 49.1% in 2012; and 49.1% in 2011).[1] Again, the initial percent of female chemistry majors (47.4%) closely resembled these national rates, yet there was a decline by the time degrees were awarded.

Table 2. Chemistry Degrees Awarded

	Total Number of Degrees Awarded	*Percent of Total*	*National Trend (as of 2013)*[1]
Overall	226	100%	100%
African American and American Indian/Alaska Native	8	3.5%	8.3%
Asian	72	31.9%	14.7%
Hispanic	12	5.3%	8.3%
White	115	50.9%	62.2%
Other or International	19	8.4%	6.5%
Male	136	60.2%	52.1%
Female	90	39.8%	47.9%

*For a further breakdown of degrees awarded, see Appendix C.

Chemistry and Math Preparation. For those students that earned the chemistry degree, the majority took Chemistry 102 (87 students; 38%) and Chemistry 202 (99 students; 44%) as their first course. A smaller proportion of students started in Chemistry 101 (23 students; 10%), with an even smaller fraction bypassing General Chemistry altogether (17 students; 8%). Regarding high school preparation, 118 students (52%) reported taking the Advanced Placement (AP) Chemistry test. The average ACT Science Reasoning score was a 29, with a mode of 26 and median of 29. This average is well above the national and state averages of 21.[9] In math, most students started somewhere in the calculus sequence, with 94 students (42%) starting in calculus I, 68 students (30%) starting in calculus II, and 48 students (21%) starting in calculus III. A small proportion started in pre-calculus (11 students; 5%) and 5 students (2%) started higher than calculus by taking matrix theory or differential equations. In terms of academic preparation, 157 out of the 226 students (69%) reported taking the Advanced Placement (AP) Calculus test. Furthermore, the average ACT Math score was 32, with a mode of 34 and median of 32. Again, this average is well above the national and state averages of 21.[9] Thus, as expected, the average ACT Composite score of 29 was also higher than the national and state averages of 21.[9] In terms of overall college preparation, 176 of the 226 students

(78%) reported taking the AP test in at least one subject area.

Students who Switched into Chemistry. Of the 152 students that graduated with a chemistry degree that were not initially declared as a chemistry major, 32 (21% of the total) graduated in the Specialized Curriculum and 120 (79% of the total) graduated in the LAS Curriculum. 40 out of the 152 students (26%) earned a double major in chemistry and some other field. When examining these students' admit major, 87 students (57%) were already declared a STEM major. However, the largest number of students in any one field were considered *undeclared*. See Table 3.

Table 3. Admit Major (Starting Major), N = 152

Admit Major	No. of Students	Admit Major	No. of Students
Aerospace Engineering*	2	Economics	1
Agricultural & Consumer Economics	1	Electrical Engineering*	3
Agricultural Engineering*	1	Engineering Physics*	1
Architectural Studies	2	Food Science & Human Nutrition*	2
Biochemistry*	18	General Engineering*	2
Biology*	20	History	1
Chemical Engineering*	21	History of Art	1
Civil Engineering*	1	Materials Science & Engineering*	2
Classics	1	Mathematics*	6
Communications	1	Mechanical Engineering*	1
Computer Engineering*	2	Physics*	1
Computer Science*	1	Psychology*	2
Crop Sciences*	1	Recreation, Sport, & Tourism	1
Undeclared	**56**		

*STEM major

Participation in Undergraduate Research. Of the 226 students that graduated with a chemistry degree, 70 students (31% of the total) participated in undergraduate research for credit, with the majority (54 students) participating in their third and fourth years. Of the 70 students, 36 students graduated in the Specialized Curriculum and 34 students graduated in the LAS Curriculum.

Students that Did Not Earn a Chemistry Degree. Of the 118 students that initially declared chemistry as their major, 52 students (44% of the total) earned a STEM degree in another field and 39 students (33% of the total) earned a non-STEM degree. 27 students (23% of the total) left the university without a degree. See Table 4. Thus, the overall graduation rate of students initially declared as chemistry (85.9%) is similar to the overall campus graduation rate of 85.1%.[8] Students "left" the chemistry major primarily in their second and third years (53 students and 37 students, respectively). Only 9 students left their first year. This small number makes sense because most majors require prerequisite courses before switching and students must remain in the same college for one year. The same trend followed whether the students switched to a STEM or non-STEM degree.

Table 4. Types of Degrees Earned, N = 118

STEM Degree (N=52)	No. of Students		NON-STEM Degree (N=39)	No. of Students
Biochemistry	2		Anthropology	1
Biology Education	1		Communication	3
Chemical Engineering	13		Community Health	5
Civil Engineering	1		Economics	5
Crop Science	1		Elementary Education	2
Earth, Society, and Environment	3		English	2
Electrical Engineering	2		Gender & Women Studies	1
Food, Science, and Human Nutrition	4		Geography	1
Geology	2		Germanic Languages & Literature	1
Integrative Biology	4		Health	1
Molecular & Cellular Biology	11		History	2
Nuclear Engineering	1		Kinesiology	6
Physics	2		Music Education	1
Psychology	5		Political Science	1
			Recreation, Sport, & Tourism	1
Did Not Finish Degree	**27**		Sociology	4
			Spanish	2

When comparing the three groups of students (Leavers: students initially declared chemistry but did not earn a chemistry degree; Persisters: students initially declared chemistry and graduated with a chemistry degree; and Switchers: students not initially declared chemistry but graduated with a chemistry degree), significant differences exist for several predictor variables, especially between the Leavers and the other two groups. This includes first-semester GPA ($p <$ .0001), total number of Advanced Placement (AP) courses reported ($p < .0001$), ACT Math score ($p < .0001$), and ACT Science Reasoning score ($p < .0001$). Even though several variables were significant at the p < .01 level, they each only accounted for a small amount of the variance ($\eta_p^2 < 0.11$). See Appendix D for a full comparison of these three groups.

PREDICTOR VARIABLES FOR REGRESSION ANALYSIS

Before performing the regression analysis, a Spearman correlation matrix was created to identify the predictor variables that were highly correlated. See Table 5.

Table 5. Highly Correlated Predictor Variables (moderate to strong correlation)

Predictor Variables	Spearman Correlation, r_s	p-value
First GPA, Second GPA, Third GPA, Fourth GPA with Final GPA	$0.73 < r_s < 0.79$	$p < .0001$
AP Chem, AP Math, and AP Other with Number of AP Courses	$0.54 < r_s < 0.69$	$p < .0001$
AP Math, Number of AP Courses, ACT Comp, ACT Math, Chemistry Placement Exam, Math ALEKS® exam with Starting Math Course	$0.52 < r_s < 0.62$	$p < .0001$
Termination of Chemistry Course Enrollment with Termination of Math Course Enrollment	$r_s = 0.48$	$p < .0001$

A principal component analysis also showed that many of these same variables could be grouped together by GPA, high school preparation variables (e.g. AP and ACT scores), and termination of chemistry and math course enrollment. See Table 6. (For full results, consult Appendix E.) Thus overall, the principal component analysis validated the results of the Spearman correlation matrix in that similar variables tended to “hang” together.

Table 6. Principal Component "Constructs" (Interpreted Component/Factor Patterns)

Component	Construct
***Component 1**: 1st GPA, 2nd GPA, 3rd GPA, 4th GPA, Final GPA, James	GPA
***Component 2**: AP Math, AP Other, Number AP, ACT Comp, ACT Math, Math Course	High School Preparation
***Component 3**: ALEKS®, Chem Course, Chem Combination, Chem Placement	Chemistry Class
Component 4: CPS, Urban	Urban Students
Component 5: Not URM	Not URM Students
***Component 6**: Termination of Math Course Enrollment, Termination of Chemistry Course Enrollment, Chemistry Degree	Stopping Courses and Chemistry Degree Attainment
Component 7: Asian	Asian Students
Component 8: Gender	Male/Female Students
Component 9: Rural	Rural Students
Component 10: Micro	Microurban Students
Component 11: First Generation (Research)	First Generation Students

*At least 3 variables with significant loadings on the retained component/factor.

Of those Spearman correlated variables, the predictor variable that had the largest correlation with attaining a chemistry degree was chosen. When choosing the final variables for the regression analysis, the variables that had a larger correlation with chemistry degree attainment, yet were not highly correlated with each other, were used. Predictor variables supported by the research literature were also taken into consideration. See Table 7.

Table 7. Predictor Variables Used for Regression Analysis

Predictor Variables	Spearman Correlation, r_s	*p*-value
First Semester GPA	$r_s = 0.27$	$p < .0001$
Starting Math Course	$r_s = 0.38$	$p < .0001$
Termination of Math Course Enrollment	$r_s = 0.59$	$p < .0001$
Number of AP Courses	$r_s = 0.26$	$p < .0001$
Suburban High School versus Other (Note: All other HS types were negatively correlated with degree attainment.)	$r_s = 0.19$	$p = .0006$
Starting Chemistry Course (Chem 102 and Chem 202 versus Chem 101)	$r_s = 0.19$	$p = .0007$
Participation in Undergraduate Research	$r_s = 0.32$	$p < .0001$
Underrepresented Minority (URM)*	$r_s = -.03$	$p = .6162$
Gender (Female)*	$r_s = -.03$	$p = .6165$

*These two variables were included in the regression analysis due to the large amount of research literature on URMs and gender. In addition, the percent totals of degrees by these groups were below the national averages.

MAXIMUM R^2 IMPROVEMENT "MAXR" REGRESSION ANALYSIS

Entire Sample. The results of the "MAXR" regression analysis showed that the best model to use was the 4-variable model with predictor variables: termination of math course, participation in undergraduate research, starting math course, and first-semester GPA. This model resulted in R^2 = 0.4328 and C(p) = 6.0279. See Table 8. (The full regression analysis can be found in Appendix F.)

Table 8. Best 4-Variable Model (N = 298)

Analysis of Variance					
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	4	28.89941	7.22485	55.90	< .0001
Error	293	37.86904	0.12925		
Corrected Total	297	66.76846			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	-0.34221	0.12806	0.92295	7.14	0.0080
FIRSTGPA	0.08038	0.04055	0.50777	3.93	0.0484
MATHCRSE	0.05940	0.01622	1.73415	13.42	0.0003
RESEARCH	0.19262	0.05257	1.73532	13.43	0.0003
ONEMATH	0.61499	0.06392	11.96384	92.57	< .0001

Gender. Because the sample sizes were large enough, a "MAXR" regression analysis was also performed by gender. For females, the results of the "MAXR" regression analysis showed that the best model to use was the 3-variable model with predictor variables: termination of math course, participation in undergraduate research, and starting math course. This model resulted in R^2 = 0.4724 and C(p) = 2.0219. For males, the results of the "MAXR" regression analysis showed that the best model to use was the 4-variable model with predictor variables: termination of math course, participation in undergraduate research, first-semester GPA, and attending a suburban high school. This model resulted in R^2 = 0.4220 and C(p) = 2.6967. See Tables 9-10. (The full regression analyses can be found in Appendix G and Appendix H.)

Table 9. Best Variable Model for Females (N = 131)

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	-0.14366	0.07891	0.43454	3.31	0.0710
MATHCRSE	0.09338	0.02237	2.28443	17.42	< .0001
RESEARCH	0.22144	0.08198	0.95653	7.30	0.0079
ONEMATH	0.53643	0.08913	4.74884	36.22	< .0001

Table 10. Best Variable Model for Males (N = 167)

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	-0.49929	0.17178	1.03096	8.45	0.0042
FIRSTGPA	0.13312	0.04989	0.86893	7.12	0.0084
RESEARCH	0.19127	0.06609	1.02229	8.38	0.0043
SUBURB	0.13869	0.06261	0.59889	4.91	0.0281
ONEMATH	0.73122	0.08649	8.72251	71.47	< .0001

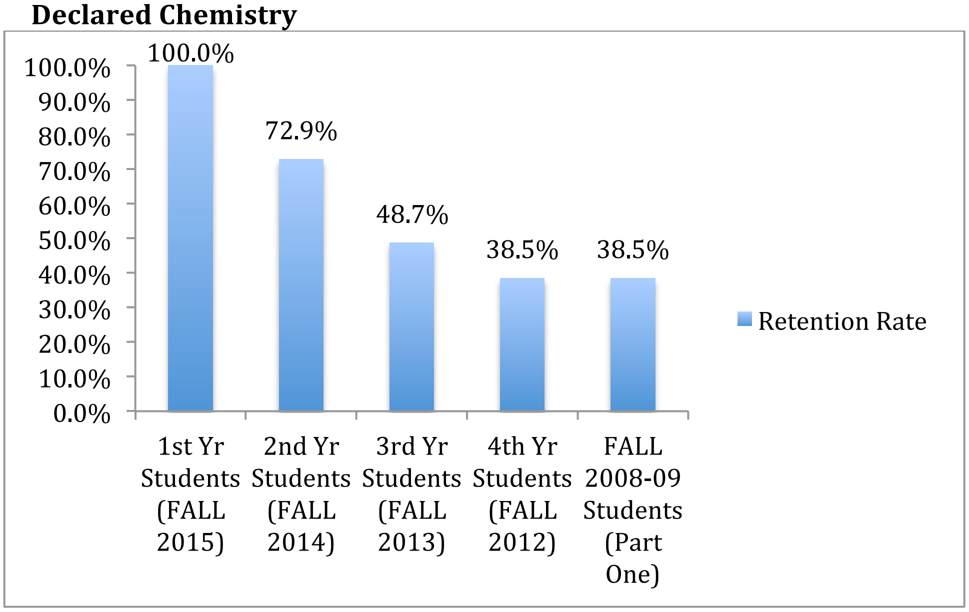
Part Two: Understanding Chemistry Majors

SAMPLE GROUP COMPARISONS

Graduated Student Sample (Part One Sample) Compared to Current Student Sample. The ANOVA test conducted between the graduated student sample from Part One and the current student sample (by class standing) revealed very few significant differences among measurable predictor variables. Of the five samples of students who initially declared chemistry as a major (graduated students, 1st year students, 2nd year students, 3rd year students, and 4th year students), there was a significant difference (p = .0013) in the Chemistry Placement Exam score between the graduated students (mean was slightly below), 2nd year students (mean was slightly above), and the remaining student samples. There was also a significant difference in ACT Composite score between the 1st and 2nd year students and the other student samples (p = .0254), with the 1st and 2nd year students averaging a higher score. Finally, there was a significant difference between the 3rd year students and the rest of the student samples in ACT Science Reasoning score (p = .0236), with the 3rd year students averaging slightly below everyone else. However, except for the differences cited above, all other variables tested (first-semester GPA, second-semester GPA, third-semester GPA, fourth-semester GPA, total number of reported AP courses, ACT Composite score, ACT Math score, ACT Science Reasoning score, Chemistry Placement Exam score, and Math ALEKS® Placement Test score) revealed no significant differences among student samples at the $p < .05$ level. For a full report of ANOVA results, consult Appendix M. Thus, each student sample from year to year remained fairly consistent in measurable predictor variables, especially in early college GPAs and ACT Math scores.

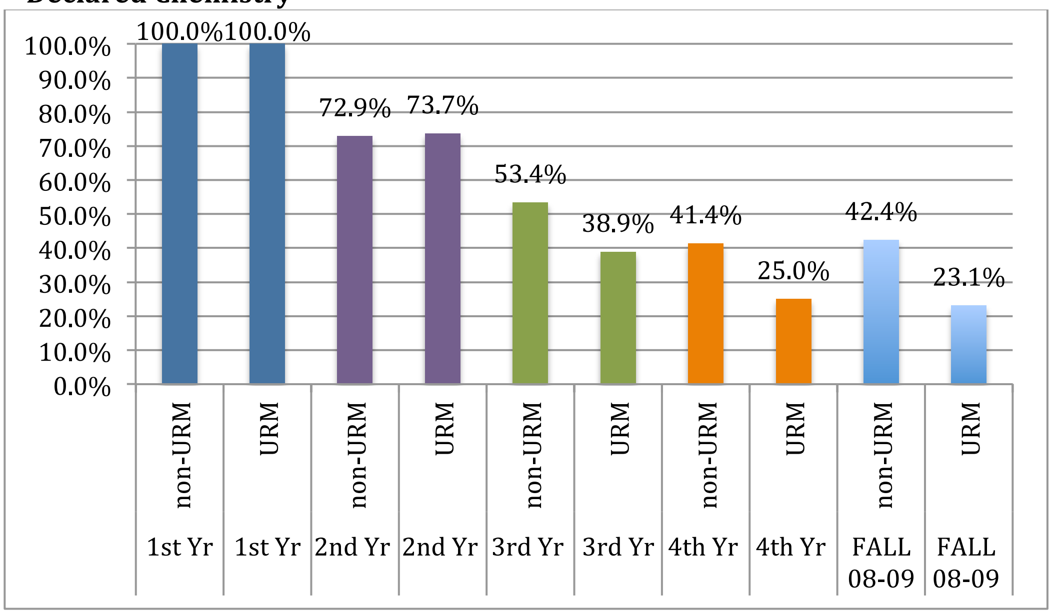
When comparing the overall retention rate in chemistry to the graduated student sample from Part One, the current student sample is trending towards similar outcomes. See Figure 4. Each year the retention rate declines with the 4th year students (current seniors) matching the retention rate of the graduated students.

Figure 4. Retention Rate vs. Incoming Freshman Students Initially Declared Chemistry



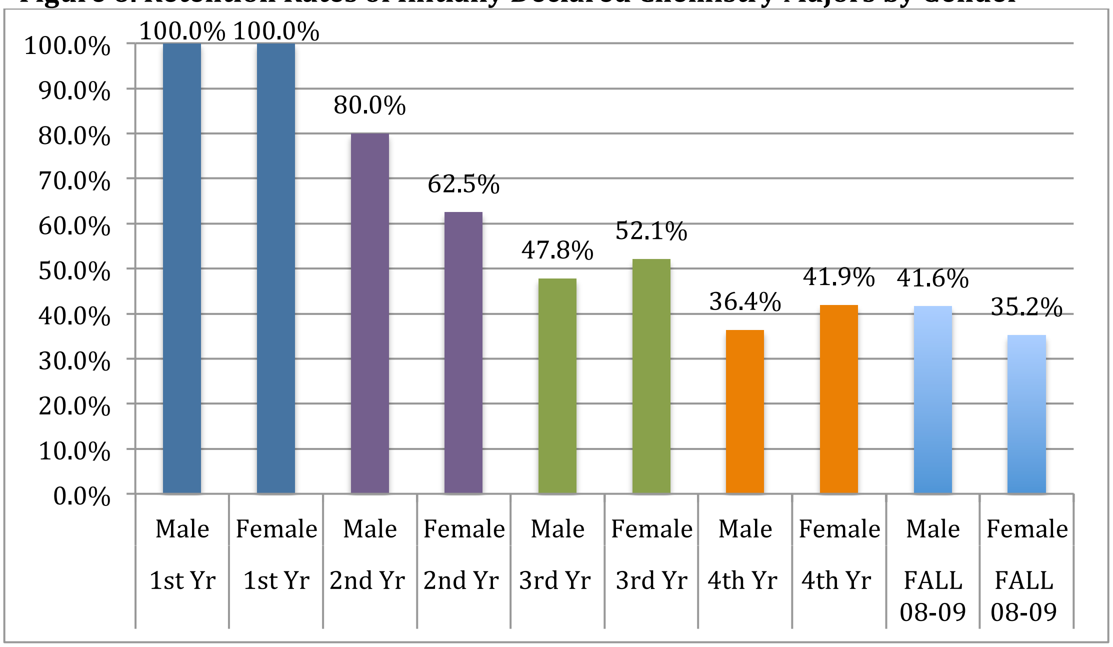
When disaggregating the overall retention rates by various demographics, the current student sample is trending towards similar outcomes as the graduated students. For example, when comparing underrepresented minorities (African American, Hispanic, and Native American) to the majority students (White and Asian students), the trend shows lower retention rates for underrepresented minorities versus majority students. See Figure 5.

Figure 5. Retention Rates of Underrepresented Minority Students Initially Declared Chemistry



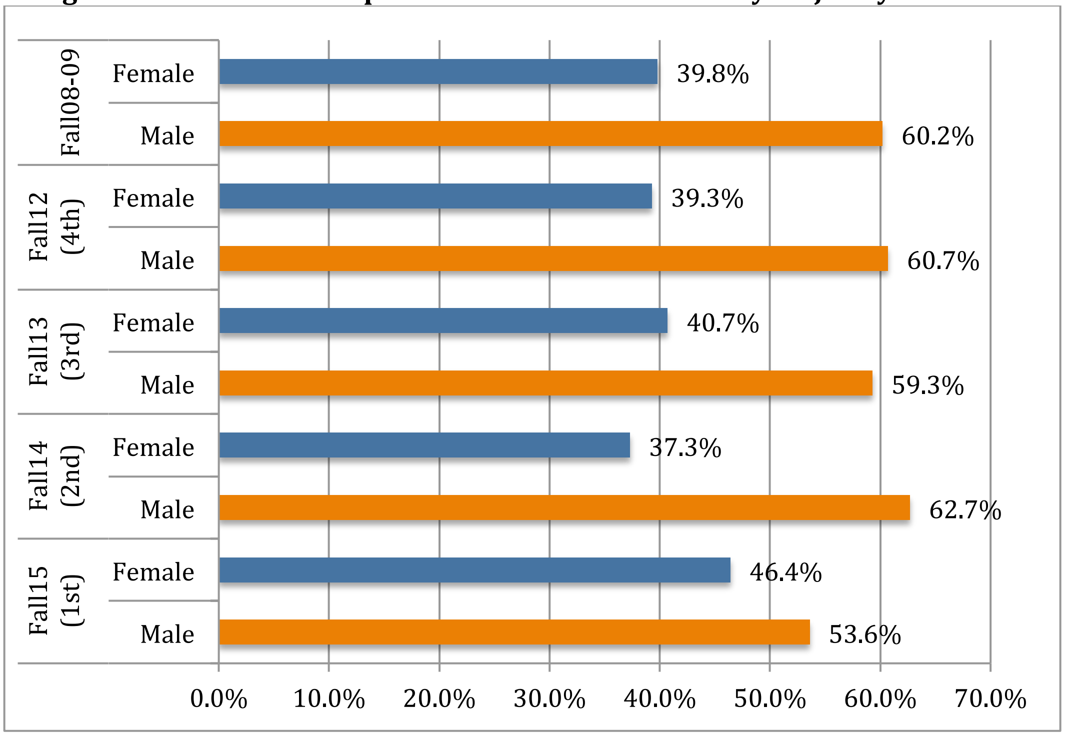
The 4th year students also showed similar retention rate outcomes as the graduated students for the following: attended a rural high school (a low 25.0% for both), first generation (34.1% for graduated; 34.6% for 4th year), started in Chemistry 102 General Chemistry I (37.3% for graduated; 36.4% for 4th year), started in Chemistry 202 Accelerated Chemistry I (48.4% for graduated; 44.7% for 4th year), and started in Math 241 Calculus III (54.5% for graduated; 57.1% for 4th year). However, some retention rates varied widely by year such as students that attended suburban high schools, urban high schools, and microurban high schools. There was also variability by starting math courses like Math 115 Precalculus, Math 220/221 Calculus I, and Math 231 Calculus II. Finally, the retention rates were variable by gender as well and a trend was not apparent. See Figure 6. (For a full report of trending comparisons, consult Appendix N.)

Figure 6. Retention Rates of Initially Declared Chemistry Majors by Gender



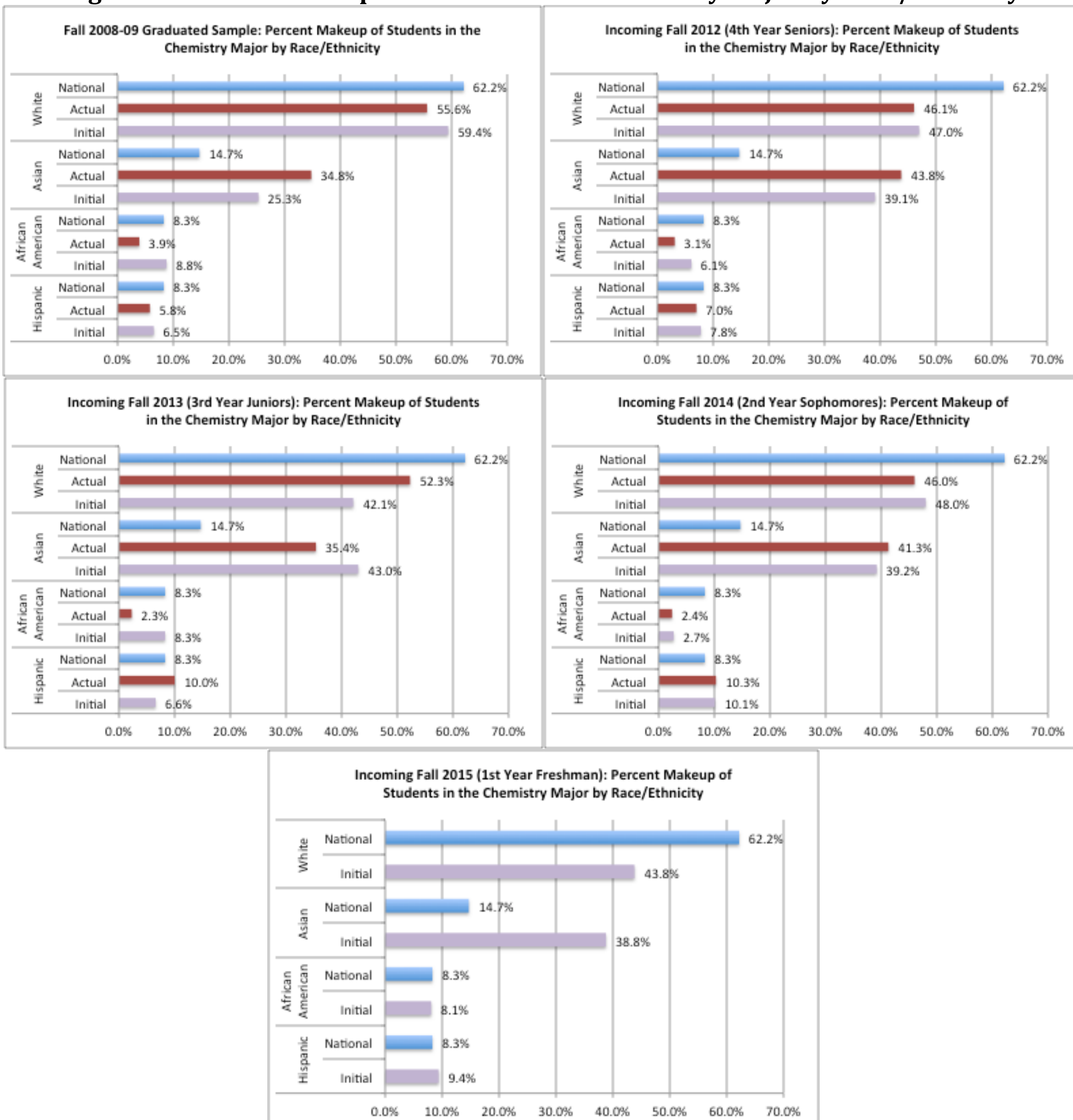
Although a trend was not apparent for the retention rate based on gender, one does appear when analyzing the percent makeup of students that declare the chemistry major (persisters and those that switched into the major). The 4^{th} year students showed similar outcomes as the graduated students based on gender. See Figure 7. Furthermore, for every class of declared chemistry majors, females were underrepresented. Initially declared females come into the chemistry program underrepresented and that trend continues each subsequent year through graduation.

Figure 7. Percent Makeup of Students in the Chemistry Major by Gender



When analyzing the percent makeup of students based on race/ethnicity, again, similar trends continue, with African-American students well below the national trends and Asian students well above; similar outcomes as the Part One graduated students. See Figure 8. "National" shows the national percent makeup of chemistry degrees awarded[1], "Actual" shows the percent makeup of students that are currently declared in chemistry by class standing, and "Initial" shows the percent makeup of students that entered the university initially declared chemistry.

Figure 8. Percent Makeup of Students in the Chemistry Major by Race/Ethnicity



Other similar trends between the current chemistry majors and graduated students include the largest percentage of students coming from suburban high schools, the majority of chemistry majors starting in Chemistry 102 and 202 (although neither course is consistently in the majority over the other), and the majority of chemistry majors starting in Math 220/221 Calculus I. (For a more detailed report of trending comparisons, consult Appendix O.) The majority of students are in the Sciences & Letters Curriculum (consistently between 70-80% of the students each year) versus the Specialized Curriculum. In addition, about a third of chemistry majors participate in undergraduate research for credit by their senior year (31% for graduated; 33% for 4th year). The percent of underrepresented students participating in research for credit has steadily rose in recent years, with only 9% of the total from the graduated sample to 20% of the total for current sophomores (9% for graduated sample; 10% for 4th Year; 14% for 3rd Year; 20% for 2nd Year). This increase most likely results from the concerted efforts by the department to recruit more underrepresented students into research and awarding summer research scholarships. By gender, the participation in undergraduate research by females has also improved with only 37% of the total in the graduated sample to 44-50% in the 2nd - 4th Year samples.

Finally, a regression analysis of the 4th year students (current seniors) was conducted to assess how it compared to the graduated students from Part One. Only the 4th year students were used in this analysis since these students are the furthest along in their degree programs and closest to graduating. A Spearman correlation matrix revealed similar variables were correlated with each other and with declaring the chemistry major. The results of the "MAXR" regression analysis showed the *same* results as in Part One; that the best model to use was the 4-variable model with predictor variables: termination of math course, participation in undergraduate research, starting math course, and first-semester GPA. See Table 11. This model resulted in R^2 = 0.4248 (Part One resulted in R^2 = 0.4328) with a bit more variability in the p-values in the 4th Year sample.

Table 11. Best 4-Variable Model for 4th Year Student Sample (N = 144)

Analysis of Variance					
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	4	13.86479	3.46620	25.66	< .0001
Error	139	18.77410	0.13507		
Corrected Total	143	32.63889			

Variable	**Parameter Estimate**	**Standard Error**	**Type II SS**	**F Value**	**Pr > F**
Intercept	-0.53253	0.19916	0.96566	7.15	0.0084
FIRSTGPA	0.14445	0.06029	0.77533	5.74	0.0179
MATHCRSE	0.04134	0.02452	0.38399	2.84	0.0940
RESEARCH	0.28148	0.07586	1.85956	13.77	0.0003
ONEMATH	0.63523	0.09170	6.48101	47.98	< .0001

Even though some variability exists in these comparisons, the current students show many similarities to the graduated student sample in Part One and are trending towards similar outcomes. Thus, the conclusions drawn from Part One can be applied to the current sample of students and the factors investigated from Part One (e.g., math experiences, chemistry experiences, high school preparation, academic performance) were valid and appropriate to explore with the current students in the survey and interviews.

Current Student Population Compared to Survey Sample. Of the 623 current chemistry majors, 209 students took the survey (33.5% response rate). For the former chemistry majors, 44 out of 165 students took the survey (26.7% response rate). Another 46 students (current and former majors) opened the survey, but did not take it. Table 12 shows a side-by-side comparison of the student population percent totals versus the survey sample percent totals. Survey sample identifiers were self-reported by the participants, whereas the student population identifiers came from the university database delivered by ATLAS.

Table 12. Student Population vs. Survey Sample Comparisons for Current and Former Chemistry Majors

Current Student Population: Chemistry Majors
N=623

Identifer	# Students	Percent of Total
Female	257	41%
Male	366	59%
	623	100%
Asian/Pacific Islander	132	21%
Black Non-Hispanic	17	3%
Hispanic	59	9%
International	118	19%
White Non-Hispanic	220	35%
Other	58	9%
None Specified	19	3%
	623	100%
Freshman	140	22%
Sophomore	135	22%
Junior	151	24%
Senior	197	32%
	623	100%

SURVEY Sample: Chemistry Majors
N=209

Identifer	# Students	Percent of Total
Female	104	50%
Male	98	47%
Not Specified	7	3%
	209	100%
Asian/Pacific Islander	37	17%
Black Non-Hispanic	11	5%
Hispanic	26	12%
International	37	17%
White Non-Hispanic	99	45%
Other	2	1%
None Specified	7	3%
American Indian/Alaskan I	2	1%
	221	100%
Freshman	55	26%
Sophomore	40	19%
Junior	62	30%
Senior	52	25%
	209	100%

Current Student Population: Former Majors
N=165

Identifer	# Students	Percent of Total
Female	79	48%
Male	86	52%
	165	100%
Asian/Pacific Islander	29	18%
Black Non-Hispanic	9	5%
Hispanic	12	7%
International	30	18%
American Indian/Alaskan I	1	1%
White Non-Hispanic	68	41%
Other	10	6%
None Specified	6	4%
	165	100%
Freshman	3	2%
Sophomore	24	15%
Junior	50	30%
Senior	88	53%
	165	100%

SURVEY Sample: Former Majors
N=44

Identifer	# Students	Percent of Total
Female	29	66%
Male	14	32%
Not Specified	1	2%
	44	100%
Asian/Pacific Islander	5	11%
Black Non-Hispanic	5	11%
Hispanic	3	7%
International	6	14%
American Indian/Alaskan I	0	0%
White Non-Hispanic	23	52%
Other	1	2%
None Specified	1	2%
	44	100%
Freshman	0	0%
Sophomore	6	14%
Junior	11	25%
Senior	27	61%
	44	100%

*Note: For race/ethnicity, students could select more than one category on the survey.

For the current chemistry majors, the percent makeup between the actual population and survey sample were fairly representative by class standing. Race/ethnicity was also fairly representative, although there was an oversampling of African-American, Hispanic, and White students (however "Other" was a higher percentage in the actual population and the survey participants could have actually reported their race/ethnicity). When identified by gender, there was also an oversampling of females. For the former majors, again class standing was fairly representative with the exception of oversampling of the seniors. Race/ethnicity was more variable, again with oversampling of African-American and White students. There was also a noticeable oversampling of females, more so than with the current majors. The differences between the two populations (actual vs. survey samples) were accounted for by weighting the survey responses to reflect the actual population when reporting overall survey results for the close-ended items. However, when disaggregating the results by various factors, the results were not weighted because the oversampling of females and African Americans was advantageous since these two populations are underrepresented in the chemistry major. Their perspectives are critical to understanding what contributes to their persistence and recruitment into the major.

Current Student Population Compared to Student Interview Sample. In total, 67 students were interviewed, 45 current chemistry majors and 22 former majors. Of those students that switched into the chemistry major and participated in an interview, 75% (12 out of 16 students) also completed the online survey. Of those students that persisted in the chemistry major and participated in an interview, 75% (21 out of 28 students) also completed the online survey. However, of the interview participants that left the chemistry major, only 61% (14 out of 23 students) completed the online survey. Thus, conducting interviews was important for all three groups, but most important for those who left the major to obtain their additional and insightful perspectives. When considering a comparison between the actual student population and the interview sample, it was not my goal to interview a representative sample of the population, but to gather the most insight from those groups that are underrepresented in the major. See Table 13. That goal was accomplished. There was an oversampling of females and underrepresented minorities for both the current and former majors. It was also more insightful to oversample the juniors and seniors, as they provided a richer perspective due to their longer experience as university students.

Table 13. Student Population vs. Interview Sample Comparisons for Current and Former Chemistry Majors

Current Student Population: Chemistry Majors
N=623

Identifer	# Students	Percent of Total
Female	257	41%
Male	366	59%
	623	100%
Asian/Pacific Islander	132	21%
Black Non-Hispanic	17	3%
Hispanic	59	9%
International	118	19%
White Non-Hispanic	220	35%
Other	58	9%
None Specified	19	3%
	623	100%
Freshman	140	22%
Sophomore	135	22%
Junior	151	24%
Senior	197	32%
	623	100%

INTERVIEW Sample: Chemistry Majors
N=45

Identifer	# Students	Percent of Total
Female	22	49%
Male	23	51%
	45	100%
Asian/Pacific Islander	9	20%
Black Non-Hispanic	6	13%
Hispanic	8	18%
International	4	9%
White Non-Hispanic	16	36%
Other	2	4%
	45	100%
Freshman	4	9%
Sophomore	4	9%
Junior	15	33%
Senior	22	49%
	45	100%

Current Student Population: Former Majors
N=165

Identifer	# Students	Percent of Total
Female	79	48%
Male	86	52%
	165	100%
Asian/Pacific Islander	29	18%
Black Non-Hispanic	9	5%
Hispanic	12	7%
International	30	18%
American Indian/Alaskan]	1	1%
White Non-Hispanic	68	41%
Other	10	6%
None Specified	6	4%
	165	100%
Freshman	3	2%
Sophomore	24	15%
Junior	50	30%
Senior	88	53%
	165	100%

INTERVIEW Sample: Former Majors
N=22

Identifer	# Students	Percent of Total
Female	16	73%
Male	6	27%
	22	100%
Asian/Pacific Islander	1	5%
Black Non-Hispanic	4	18%
Hispanic	2	9%
International	2	9%
American Indian/Alaskan]	0	0%
White Non-Hispanic	11	50%
Other	0	0%
None Specified	2	9%
	22	100%
Freshman	0	0%
Sophomore	3	14%
Junior	11	50%
Senior	8	36%
	22	100%

SURVEY RESULTS: CLOSE-ENDED ITEMS

Overall Trends. The results of the weighted sampling showed that students feel pretty confident in succeeding in their intended major. Students also reported that their high schools prepared them the *least* for their university chemistry lab courses, study skills needed to be a successful college student, and time management. (To see a full copy of the survey protocol, consult Appendix J.) They reported the highest mean in high school preparation for their lecture-based chemistry courses. See Table 14.

Table 14. Weighted Trends on Confidence to Succeed in Major and High School Preparation

Variable Measures (1-5 scale)	Mean	Standard Error of Mean (SE)
Confidence to succeed in current major; N=249	4.10	0.054
How do you feel your high school has prepared you for:		
Chem classes at UIUC; N=248	3.94	0.061
Chem labs at UIUC; N=249	3.29	0.071
Math classes at UIUC; N=249	3.81	0.064
Other general classes at UIUC; N=249	3.89	0.056
Study skills needed; N=249	3.50	0.069
Time management needed; N=249	3.48	0.066
Confidence needed to succeed in college; N=248	3.72	0.063

Variable Measure Scale for Confidence: 1 = Not at all confident to 5 = Very confident
Variable Measure Scale for HS Preparation: 1 = Not at all to 5 = A great deal

When asked about what played a role in remaining in their initial major or changing majors, students reported the highest means for their interest in chemistry, alignment with career goals, sense of belonging in chemistry, and sense of succeeding in chemistry. Students reported the lowest means for participating in a study group, having a mentor, and level of competition in mathematics courses. Only interest in chemistry and alignment with career goals had means higher than “Somewhat” on what played a role in remaining in their initial major or changing majors. See Table 15.

Table 15. Weighted Trends on What Played a Role in Remaining in Initial Major or Changing Majors

Variable Measures (1-5 scale)	Mean	Standard Error of Mean (SE)
Quality of instruction in chem lecture(s); N=245	3.63	0.066
Quality of instruction in chem lab(s); N=244	3.22	0.066
Quality of instruction in chem discussion(s); N=245	3.25	0.068
Chem topics taught; N=245	3.72	0.061
Level of competition in chem courses; N=243	3.23	0.066
First chem class; N=244	3.32	0.075
Ability to learn chem concepts quickly; N=245	3.69	0.065
Grade performance in chem; N=245	3.51	0.066
My sense of whether I can succeed in chem; N=243	3.83	0.066
My sense of belonging in chem; N=244	3.89	0.065
My interest in chem; N=244	4.17	0.060
Alignment with career goals; N=243	4.13	0.052
Support from Chem Dept; N=244	3.16	0.069
Support from chem instructors; N=243	3.27	0.068
Support from peers; N=244	3.13	0.065
Support from family; N=243	3.66	0.057
Involvement with extracurricular activities; N=244	2.79	0.066
Participating in a study group; N=243	2.46	0.066
Participating in undergrad research; N=242	2.68	0.079
Having a mentor; N=243	2.47	0.073
Quality of instruction in math courses; N=242	2.67	0.068
Level of competition in math courses; N=242	2.53	0.065
Ability to learn math concepts quickly; N=243	3.00	0.071
Grade performance in math; N=243	3.04	0.071

Variable Measure Scale: 1 = Not at all to 5 = A great deal

Leavers, Persisters, and Switchers. To explore differences among students that leave the major (Leavers), remain in the major (Persisters), or switch into the major (Switchers), ANOVA and Chi-square analyses were conducted. There was a significant difference (p = 0.0028) between the groups on high school preparation for university chemistry classes, with the Persisters reporting the highest mean (4.13 out of 5.0 scale) and the Leavers reporting the lowest mean (3.53 out of 5.0 scale). See Table 16. Leavers also reported the lowest mean (3.14) on how their high school prepared them for time management needed to be successful in college. In fact this mean was significantly different (*p* = 0.0465) from the other two groups, which ranked time management higher (3.57). Overall, Leavers reported the highest mean (3.78) on high school preparation for other general university classes and the lowest mean (3.14) for time management needed. Persisters reported the highest mean (4.13) on high school preparation for university chemistry classes and the lowest mean (3.37) on preparation for university chemistry labs. Switchers reported the highest mean (3.91) on high school preparation for other general university classes and the lowest mean (3.23) on preparation for university chemistry labs.

Table 16. ANOVA Survey Results for Leavers, Persisters, and Switchers: High School Preparation

	Mean Values (SD)					
Variable Measures (1-5 scale)	**Leavers***	**Persisters+**	**Switchers#**	***F*-Test Values**	***p*-values**	**Effect Size (η_p^2)**
How do you feel your high school has prepared you for:						
Chem classes at UIUC; N = 72, 120, and 56	3.53 (1.23)	4.13 (1.07)	3.86 (1.23)	F(2,245) = 6.03	*p* = .0028	η_p^2 = 0.0469
Chem labs at UIUC; N = 73, 120, and 56	3.18 (1.28)	3.37 (1.33)	3.23 (1.33)	F(2,246) = 0.52	*p* = .5979	η_p^2 = 0.0042
Math classes at UIUC; N = 73, 120, and 56	3.66 (1.33)	3.86 (1.19)	3.82 (1.15)	F(2,246) = 0.64	*p* = .5307	η_p^2 = 0.0051
Other general classes at UIUC; N = 73, 120, and 56	3.78 (1.13)	3.92 (1.03)	3.91 (1.07)	F(2,246) = 0.41	*p* = .6661	η_p^2 = 0.0033
Study skills needed; N = 73, 120, and 56	3.40 (1.26)	3.55 (1.26)	3.48 (1.35)	F(2,246) = 0.32	*p* = .7233	η_p^2 = 0.0026
Time management needed; N = 73, 120, and 56	3.14 (1.27)	3.57 (1.21)	3.57 (1.28)	F(2,246) = 3.11	*p* = .0465	η_p^2 = 0.0246
Confidence needed to succeed in college; N = 73, 119, and 56	3.67 (1.09)	3.76 (1.18)	3.70 (1.19)	F(2,245) = 0.13	*p* = .8741	η_p^2 = 0.0011

***Leavers: Students that were chemistry majors but switched out of chemistry (or indicated that they are switching out).**
+Persisters: Students that were admitted as chemistry majors and are remaining in chemistry.
#Switchers: Students that were not admitted as chemistry majors but switched into chemistry.
Note: Not all variable fields were available for all students.

When asked "to what extent has the following played a role in your decision to remain in your initial major or change majors," there were significant differences between groups in several areas. The most significant differences (*p* < 0.0001) occurred for chemistry topics taught (Switchers reported the highest mean of 4.11), interest in chemistry (Switchers and Persisters reported the highest means of 4.38 and 4.31 respectively, and Leavers reported the lowest mean of 3.55), and support from family (again Switchers and Persisters reported the highest means of 3.71 and 3.95 respectively, and Leavers reported the lowest mean of 2.89). There were also significant differences on quality of instruction in chemistry lectures ($p = 0.0077$), ability to learn chemistry concepts quickly ($p = 0.0030$), and support from peers ($p = 0.0277$); with the Switchers consistently reporting the highest means and Leavers consistently reporting the lowest means. There was also a significant difference ($p = 0.0276$) for alignment with careers goals, with Persisters reporting the highest mean (4.24) and Leavers reporting the lowest mean (3.83). Significant differences were apparent for participating in undergraduate research ($p = 0.0283$) and level of competition in mathematics courses ($p = 0.0302$), however the overall means were quite low (between "Very Little" to "Neutral"). Overall, the highest means reported for Persisters and Switchers were interest in chemistry (4.31 and 4.38, respectively) and the lowest means reported were participating in a study group and level of competition in mathematics courses (2.54 and 2.16, respectively). However, the highest mean reported for Leavers was alignment with career goals, but only at an average of 3.83 (SD 1.26), with the lowest mean for having a mentor (2.18). Thus, of the options listed in the survey, interest in chemistry and alignment with career goals played a role for Persisters remaining in their major (with means in between "Somewhat" and "A Great Deal"). For Switchers, interest in chemistry, alignment with career goals, and chemistry topics taught played a role in switching into the chemistry major (again with means in between "Somewhat" and "A Great Deal"). However for Leavers, alignment with career goals and sense of belonging in chemistry ranked the highest (but only with means in between "Neutral" and "Somewhat"). Thus from this ANOVA test, it's unclear what played the most significant role in their decision to leave the major. (For a full report of results, consult Appendix P.)

The results of the Chi-square analysis showed a few differences between the three groups (Leavers, Persisters, and Switchers). However, there was no significant relationship with type of high school attended, first math class taken, gender, and underrepresented minority. There were significant differences between the three groups and class standing (X^2 (8,251) = 44.5809, $p < 0.0001$), first chemistry class taken (X^2 (12,250) = 34.8699, $p = 0.0005$), and participation in undergraduate research (X^2 (2,249) = 12.3840, $p = 0.0020$). It was expected that a significant difference would emerge with class standing since most students cannot switch into the chemistry major during their freshman year (and even sophomore year), thus most Switchers that took the survey were third year students and above (51 out of 56 students). In addition, also expected, there was a small number of freshman Leavers as compared to freshman Persisters (14 versus 40 students), although it should be noted that 18.92% of the Leavers that took the survey reported a first year standing, thus already indicating that they planned to leave the major in the first semester of their freshman year. Regarding the first chemistry class taken, a greater percentage of Switchers reported starting in Chemistry 101 Introductory Chemistry and Chemistry 102 General Chemistry I (73.21%) as compared to Leavers and Persisters (40.54% and 44.17% respectively). Furthermore, a larger percentage of Leavers and Persisters started in Chem 202 Accelerated Chemistry I or higher (48.65% and 55.01% respectively versus 25.00% for Switchers). Regarding undergraduate research, as expected, a greater percentage of Persisters and Switchers reported participating in research versus the Leavers (25.83%, 34.55%, versus 9.46% respectively).

Gender Differences. Cross tabulations were completed by gender to further explore differences, including between Leavers, Persisters, and Switchers. Cross tabs revealed that a larger percentage of females (59%) reported starting in Chemistry 101 and 102 versus males (40%). Thus, a larger percentage of males reported starting in Chemistry 202 and higher (58% versus 37% for females). These outcomes are similar to the actual population where a greater percentage of females did start in Chemistry 101 and 102 (64%) versus males (45%), and a larger percentage of males did start in Chemistry 202 and higher (50% versus 30%). Regarding mathematics, a greater percentage of females reported starting in lower-level math courses versus males. For example, 62% of females reported starting in Math 112, Math 115, or Math 220/221. Only 46% of males reported starting in those same math classes. Instead, 49% of males reported starting in Math 231, Math 241, or higher-level math courses, whereas only 33% of females reported starting in these same higher-level courses. Again, these outcomes are similar to the actual population where a greater percentage of females did start in lower-level math classes (58%) versus males (46%), and a larger percentage of males did start in higher-level math classes (48% versus 30%). Finally, a larger percentage of males (28%) reported participating in undergraduate research versus females (20%), and from those participating, 46% of the total consisted of females (which matches the actual population of students participating in research for credit).

For the close-ended survey items with variable measures (1-5 Likert scales), several significant differences were apparent between males and females. First, males were significantly more confident that they will succeed in their intended major versus females. For all students combined, males reported an overall mean of 4.28, whereas females reported an overall mean of 3.98 (significant at the $p < 0.05$ level). This difference was even more substantial for the Persisters, where males rated their confidence with an overall mean of 4.25 and females rated their confidence with a mean of 3.78 (again, significant at the $p < 0.05$ level). Male Switchers also reported higher means than females (4.46 versus 4.10), but these differences were not significant. Leavers, on the other hand, showed no difference in means between males and females with a mean of 4.20, thus signaling much more confidence in females once they leave the chemistry major. Next, in reporting what played a role in the decision to leave the chemistry major, female Leavers reported significant differences from male Leavers in: support from chemistry instructors (or lack thereof), with means of 3.20 versus 2.53 ($p < 0.05$); and support from the Chemistry Department (or lack thereof), with means of 3.15 versus 2.57 ($p < 0.10$). Some additional differences were also observed at the $p < 0.10$ level in:

- high school preparation for university chemistry classes, with male Switchers reporting a higher mean of 4.21 versus 3.59 for female Switchers; and
- high school preparation for university mathematics classes, with male Leavers reporting a higher mean of 4.00 versus 3.46 for female Leavers.

Overall for female Leavers, alignment with career goals (3.98), sense of succeeding in chemistry (3.80), and sense of belonging in chemistry (3.80) had the highest means for what played a role in leaving the chemistry major. For male Leavers, alignment with career goals (3.62), interest in chemistry (3.57), and sense of belonging in chemistry (3.40) had the highest means, although they reported lower overall means than the females (but not significantly lower). Overall for Persisters, males and females reported the highest means for interest in chemistry, alignment with career goals, sense of belonging in chemistry, sense of succeeding in chemistry, and support from family. Females reported lower overall means than males (but not significantly lower). Overall for male Switchers, interest in chemistry (4.29), alignment with career goals (4.25), and chemistry topics taught (4.25) had the highest means for what played a role in changing their major to chemistry. However for female Switchers, more influences played a role. Females reported the highest means for interest in chemistry (4.44), sense of succeeding in chemistry (4.09), sense of belonging in chemistry (4.44), alignment with career goals (4.06), and chemistry topics taught (4.00). Sense of succeeding in chemistry and sense of belonging in chemistry are aligned with female reports of lower confidence to succeed in the chemistry major than males, thus these additional influences are also deemed as important for females.

Race/Ethnicity Differences. Cross tabulations were also completed by race/ethnicity to further explore differences, including between Leavers, Persisters, and Switchers. However because of the small sample sizes for some populations, students were grouped into two categories: underrepresented minority students, URMs (African American, Hispanic, and Native American) and majority students (White and Asian). Cross tabs revealed that a larger percentage of underrepresented minorities (67%) reported starting in Chemistry 101 and 102 versus majority students (46%). Thus, a larger percentage of majority students reported starting in Chemistry 202 and higher (50% versus 32% for URMs). These outcomes are similar to the actual population where a greater percentage of underrepresented minorities did start in Chemistry 101 and 102 (68%) versus majority students (51%), and a larger percentage of majority students did start in Chemistry 202 and higher (44% versus 30%). Regarding mathematics, a greater percentage of underrepresented minorities reported starting in lower-level math courses versus the majority students. For example, 75% of URMs reported starting in Math 112, Math 115, or Math 220/221. Only 50% of majority students reported starting in those same math classes. Instead, 43% of majority students reported starting in Math 231, Math 241, or higher-level math courses, whereas only 25% of URMs reported starting in these same higher-level courses. Again, these outcomes are similar to the actual population where a greater percentage of URMs did start in lower-level math classes (71%) versus the majority students (48%), and a larger percentage of majority students did start in higher-level math classes (45% versus 17%). Finally, a larger percentage of majority students (24%) reported participating in undergraduate research versus URMs (18%), and from those participating, 14% of the total consisted of URMs (which closely matches the actual population of URM students participating in research for credit at 13%).

For the close-ended survey items with variable measures (1-5 Likert scales), some significant differences were apparent between the majority students and underrepresented minority students. For all students combined, URMs reported that their high schools prepared them better for other university classes versus the majority students (means of 4.13 versus 3.82, $p < 0.10$). This is especially true for URM Persisters, with a mean of 4.38 versus 3.80 for majority Persister students ($p < 0.05$). URM Persisters also reported that their high schools gave them a greater confidence to succeed as a student, with a mean of 4.26 versus 3.64 ($p < 0.05$). However, URM Leavers had the lowest means for high school preparation in study skills needed to be a successful student (2.93) and time management (2.80). Next, in reporting what played a role to decide to leave the chemistry major, URM Leavers reported the highest means for alignment with career goals (4.27) and sense of belonging in chemistry (4.13). For majority student Leavers, no means were above 4.0 (“Somewhat”). The highest mean (3.72) was for alignment with career goals. For URM Persisters, several aspects played a role in deciding to remain in the chemistry major including interest in chemistry (4.57), alignment with career goals (4.52), sense of succeeding in chemistry (4.09), sense of belonging in chemistry (4.09), ability to learn chemistry concepts quickly (4.00), and support from family (4.00). For majority student Persisters, only interest in chemistry (4.25) and alignment with career goals (4.17) had means above 4.0 (“Somewhat”). For URM Switchers, only alignment with career goals had a mean of 4.00, with significant differences with majority student Switchers on chemistry topics taught (URM mean of 3.33 versus 4.20, $p < 0.05$) and interest in chemistry (URM mean of 3.67 versus 4.46, $p < 0.10$). Majority student Switchers reported several factors with a mean above 4.0 including interest in chemistry (4.46), chemistry topics taught (4.20), alignment with career goals (4.16), sense of belonging in chemistry (4.06), and sense of succeeding in chemistry (4.00).

SURVEY RESULTS: OPEN-ENDED ITEMS

Overall Trends. Based on the coding system used, the most frequently cited reasons why students chose chemistry as their initial major was their high school chemistry experience and/or connection with chemistry. Several students mentioned positive experiences in their high school chemistry classes and with their chemistry teachers, and/or being “good” at chemistry in high school. Students also mentioned connecting with chemistry, meaning they found chemistry interesting, had a passion for chemistry, liked that it is application-based, and enjoyed the challenge. Two students commented:

> “I chose this major for the love of what chemistry studies and involves. In my opinion it's the best science as it applies mathematical skills and not simply remote memorization like biology. It also involves many conceptual problems that need to be understood before solving a problem (similar to physics also but not as abstract thankfully) and is heavily involved in experiments and laboratory work. I also feel comfortable with my major since I was privileged enough to take 2 years of chemistry in high school. Honors Chem my junior year and AP

> Chem my senior to finish off strong. A strong science and math background will serve me well and will develop and refine my abilities to perform research and experiments that help promote change and facilitate progress."

> "Throughout high school, chemistry was my favorite subject. I've always had a passion for almost every subject of science, but what tipped the scale to chemistry was the teacher I had in my high school career. She was so passionate about the subject and that ultimately influenced me on choosing chemistry."

However, students cited other reasons for initially choosing chemistry as their major as well, with a few differences between those who left the major and those who persisted in the major. See Table 17. Specifically, more students who left the major indicated that chemistry was not their first choice and were redirected by some other program such as chemical engineering or computer science. Leavers also cited social pressures, such as from family.

Table 17. Open-Ended Survey Results: "Describe Your Reasoning for Your Initial Major."

Emerged Categories	# Times Cited by Respondents: Leavers	# Times Cited by Respondents: Persisters	# Times Cited by Respondents: TOTAL
High School Chemistry Experience	**21**	**47**	**68 (29.7%)**
Chemistry "Connection"	**17**	**47**	**64 (27.9%)**
Career Options & Prospects	15	17	32 (14.0%)
Chemistry Major NOT First Choice	15	3	18 (7.9%)
Health Career Goals	9	27	36 (15.7%)
Research & Lab Experiences	4	5	9 (3.9%)
Social Pressures	2	0	2 (0.9%)

For those students that switched into the chemistry major, the main reasons cited for choosing their initial major was because they were undecided, interested in that major coming into the university, their initial major aligned well with their career options and goals, they were admitted into the university as undeclared (e.g., redirected from engineering), had a positive high school experience in that field, and/or social pressures. (To see a full report of the open-ended survey results including Emerged Category definitions, consult Appendix Q.) When those same students that switched into the chemistry major were asked to describe all of the reasons why they switched into the chemistry major, the most frequently cited reason was because of a connection with chemistry. Two students commented:

"I found once i started organic chemistry that I really liked it. It fascinated me that chemistry is involved with everything in our day to day lives and could be applied anywhere. This versatility made me choose chemistry because no matter what I decided to do career-wise, I would be knowledgeable about a very important topic."

"I am fascinated by science and how things work and feel chemistry is the basic building blocks of everything. I also really enjoy learning about space and I feel that this has also encouraged me to pick chemistry because chemistry plays a big role in space exploration and I like to be able to understand information I read about it. I also feel, that even though chemistry is one of the first sciences studied, I believe there is still much to be learned and explored in the field. I would like to take part in being one of the first people to discover or work on something. I feel like chemistry can offer me that."

Other cited reasons included alignment with career goals, positive experiences with professors, research and lab experiences, could not succeed in another major such as chemical engineering, and some were in transition and planned to transfer to chemical engineering once the requirements were met. See Table 18.

Table 18. Open-Ended Survey Results: "Describe All of the Reasons Why You Decided to Switch Majors."

Emerged Categories	**# Times Cited by Respondents: Switchers**
Chemistry "Connection"	**30 (49.2%)**
Career Options & Prospects	11 (18.0%)
Professors/Teachers	7 (11.5%)
Health Career Goals	4 (6.6%)
Research & Lab Experiences	3 (4.9%)
Could Not Succeed in Other Major	3 (4.9%)
"In Transition"	3 (4.9%)

When Leavers were asked to describe all of the reasons why they left the chemistry major, the two most frequently cited reasons were because they didn't find the chemistry degree a "useful" degree to earn and they became interested in another major. Students commented:

"I still enjoy chemistry, but the major was very math and physics based. I felt that I was gaining general knowledge on several subjects and felt lost in what I wanted to do as a career. The food science major still includes chemical aspects and feels more specific and inclusive to its students. The food science advisers were much more supportive and helpful and I felt like I knew what kind of careers I could have while still enjoying chemistry."

"Human Nutrition is much more focused, and I realized it is a more useful degree to have."

"I think chemical Engineering is more practical. I figured out that graduating as a chemical Engineering will give me more opportunities than chemistry. I still like chemistry. In fact, I enjoy my chemistry classes more than my chemical engineering one's."

"I feel Chemical Engineering is a more marketable major, and the amount of work and dedication that is needed for it gives a more comprehensive feel of Chemistry for me, as well as carries a higher prestige."

Other cited reasons included that the other major was more relevant to future career goals, they were redirected from another major (and desire to return to that original major), issues with supporting coursework such as calculus or physics, poor first semester experience, not connecting with chemistry, poor grade performance in chemistry, overwhelmed with the course load, feeling socially isolated, and poor advising with the academic advisors. See Table 19.

Table 19. Open-Ended Survey Results: "Describe All of the Reasons Why You Decided to Switch Out of the Chemistry Major."

Emerged Categories	# Times Cited by Respondents
Engagement/Interest in Other Major	**21 (18.8%)**
Usefulness of BS Chemistry Degree	**21 (18.8%)**
Other Major More Relevant to Future Career Goals	12 (10.7%)
Redirect	9 (8.0%)
Issues with Supporting Coursework	9 (8.0%)
First Semester Experience	8 (7.1%)
Not Connecting with Chemistry	8 (7.1%)
Chemistry Grade Performance	7 (6.3%)
Overwhelmed with Course Load	6 (5.4%)
Social Isolation	6 (5.4%)
Chemistry Advising	5 (4.5%)

Students wrote:

> "Chemistry at UIUC was considered a weed out course for me. The structure was difficult and I wasn't engaged. The professor was also not very helpful. No matter how hard I tried, I always seemed to fail and it took a toll on me. Why would I continually hurt myself like this with something I'm not even passionate about?"

> "I think that there are several factors that impaired my ability to succeed in the chemistry major. First of all, the large group setting for instruction was new and inconsistent to how I had always learned in the past. The fear of not knowing who to ask for help was also very strong my freshman year. Finally, the grades I received in math and science courses at the U of I were so much different from my grades in high school that I felt very discouraged."

> "I hated my chemistry class and I wanted to not be miserable for four years. My classes were isolating."

> "I switched to geology and I am still doing the secondary education minor. I decided to switch because the initial course load (my freshman year) was overwhelming and I was not prepared for the level and pace at which the classes were moving at."

> "[Professor X] made me really uncomfortable. He was unapproachable, and when I actually tried to approach him to introduce myself he was standoffish and really impolite. It made me feel like he didn't actually care about his students and just wanted to get on with his life after class was over. I realized Chemistry is still a male dominated STEM field and I didn't want to continue feeling inferior."

> "I knew after the first week at the University of Illinois that I wanted to change my major. In the first week of chem102, I felt very overwhelmed and realized that college chemistry was going to be very different from what I had experienced in high school. I had a gut feeling it just was not for me and knew I would spend too much time struggling. I debated switching to biology, but after taking a kinesiology course, I knew I had found the right fit. Not only did I have no desire to continue on as a chemistry major, I also no longer wanted to be a teacher. Prior

to deciding on chemistry education, I had considered athletic training and later learned about physical therapy. I felt kinesiology would allow me to develop skills specifically for this field."

"I took a class with a professor who didn't teach us general chemistry and taught quantum mechanics which was things that our graduate student TAs had not learned yet. I didn't enjoy it and the labs were a lot more than I could handle. I loved to cook and so food science was a perfect fit."

"I decided to switch to be honest because I felt terribly unwelcomed in any chemistry advising office every time I tried to visit. I was quickly rushed out and didn't get thorough answers to any questions I had regarding the major. When I signed up for classes as an incoming freshman, my advisor forgot to put me into a lab which was Chem 103 at the time. Being a clueless freshman I went through alms it a month of classes before realizing I was supposed to be in a lab. When I went to the chemistry advisors for guidance they blamed it on me and told me I should have registered myself for it. Also I had a very careless Chem 102 TA. He did not explain things at all to us and left me really struggling in what was my first chemistry class at u of I."

"As previously stated, the advisers in the food science department made the school seem very small and inclusive. I was told about research opportunities and invited to info nights and clubs. After planning my courses with an adviser, I felt that I knew what to do and where to go toward getting a job and starting my career, where as in the chemistry department my education felt very general and I felt that I was not important enough to get accepted to research or internship positions."

"Calculus is ridiculous here. Professors are much more focussed on showing off their knowledge then actually teaching when it comes to Math."

"It was all just a one big combination of my personal interests in other subjects, lack of substantial/effective/passionate teaching, courses designed to basically try to accumulate as many points as possible rather than test adequate knowledge of the given subject, not being clearly aware of student interest/confusion/ability/etc, and/or having obscure grading policies that are subjected towards unfair bias or consequences (i.e- not curving an exam if the class average is around a 40% or having too much/too little weight to a given category (such as having a commutative final exam only account for 10% of the final grade or having 2 or 3 exams that are worth 50%-90% of one's overall total grade)), and just the sheer apathetic nature researcher-based lecturers have when teaching the class. The unenthusiastic, uninspired, and seemingly bored professors really do take a huge toll on student performance and how they go about adapting the course by other means (if that is such a case). These factors also played a major role for me as well. I guess this isn't so much a problem for the students who may plan on going into research themselves as it is for pre-health students respectively."

"Another thing that played a role in my switch was my advisor at the time. I do not think she was supportive and she did not provide me with essential information needed to make my decision."

When Leavers were asked what major they intended to pursue, the most frequently selected major was chemical engineering (21 out of the 75 responses). Multiple selected responses also included molecular & cellular biology (7), integrative biology (4), computer science (4), food science (3), community health (3), geology (2), kinesiology (2), mathematics (2), and psychology (2). Several other majors were selected once and are included in Appendix Q.

All students were also openly asked to describe their career goals to get a sense of what they hoped to do in the future. The most frequently cited plans included becoming a researcher, working in industry, becoming a medical doctor, and going to graduate school. Among Leavers, the most frequently cited career goal was to work for industry. Among those who switched into chemistry, the most frequently cited career goals were to work for industry or become a medical doctor. Among Persisters, the most frequently cited career goal was to become a researcher. Overall, a wide variety of career goals were cited among all three groups and can be found in Appendix Q.

The survey also asked students to provide general feedback about their experiences in the UIUC Chemistry Department. Although these responses cannot be specifically linked to retention or recruitment, they are very helpful in understanding the climate in which students experience the chemistry major. When asked what were the most positive aspects of interacting with the Department of Chemistry, students most frequently cited the chemistry professors and chemistry classes. See Table 20. Other frequently cited aspects included the academic advisors, overall staff experience in the department, learning a lot, and undergraduate research.

Table 20. Open-Ended Survey Results: "What Have Been the Most Positive Aspects of Interacting with the Department of Chemistry?"

Emerged Categories	# Times Cited by Respondents: Leavers	# Times Cited by Respondents: Switchers	# Times Cited by Respondents: Persisters	# Times Cited by Respondents: TOTAL
Chemistry Professor(s)/Classes	**17**	**20**	**28**	**65**
Chemistry Scholarships	0	0	4	4
Learned A Lot	**5**	**4**	**7**	**16**
Advisor(s)	**17**	**7**	**7**	**31**
Outside Help	0	1	3	4
SCS Career Services	2	2	4	8
Undergraduate Research	**2**	**3**	**10**	**15**
Mentoring	0	2	5	7
Overall Staff Experience	**7**	**7**	**15**	**29**
TAs	4	0	2	6
Chemistry Clubs	0	0	1	1
Being a TA	0	1	2	3
Merit Program	1	3	3	7
Support from/Community of Chemistry Peers	0	0	7	7
Overall Not a Positive Experience	5	1	0	6

When asked to write suggestions for improving the undergraduate student experience in the Department of Chemistry, students most frequently cited issues with academic advisors, improving the first-year chemistry class experience, and the need for a peer community in the chemistry major. See Table 21. Other frequently cited improvements included issues with the online Chemistry 232 organic chemistry I course, accessibility of undergraduate research, and issues with teaching assistants (TAs).

Table 21. Open-Ended Survey Results: "Please Write Any Suggestions You Have for Improving the Undergraduate Student Experience in the Department of Chemistry."

Emerged Categories	# Times Cited by Respondents: Leavers	# Times Cited by Respondents: Switchers	# Times Cited by Respondents: Persisters	# Times Cited by Respondents: TOTAL
Smaller Class Sizes	2	1	1	4
First Year Chemistry Class Experience	**6**	**0**	**6**	**12**
Community Needed	**1**	**3**	**6**	**10**
Cost	1	1	3	5
Online Chem 232 Course	**1**	**5**	**3**	**9**
Undergraduate Research	**1**	**2**	**6**	**9**
More Variety within Major	3	1	3	7
Issues with Lab Experience	2	1	4	7
Issues with TA(s)	4	1	3	8
Issues with Professor(s)	1	1	3	5
Issues with Advisor(s)	**5**	**5**	**6**	**16**
Issues with Career Advising	1	2	4	7
Mentoring	2	0	4	6
Everything is Fine	4	1	2	7
Other (e.g. improve 100 Noyes Lab, not require calc 3)	2	3	4	9

Many students provided constructive feedback on these improvements. Some are highlighted below (with more included in Appendix Q):

> "Build more of a community where students have the opportunity to interact with one another at social events. Perhaps even have t-shirts to bring everyone together."
>
> "Reach out to students for personal or small group meeting with professors. Don't make group emails. Some will naturally be able to connect and network, but others struggle with trying to do that and need more help. Maybe in the students sophomore year, reach out to the ones that have not gotten to know more of the staff."
>
> "I would have set groups of people who are willing to study together so no one is left behind."
>
> "I wish the Chemistry department would take the time to focus on people who are just chemistry majors. There is so much emphasis on Chemical Engineering, that people who are just Chemistry majors feel brushed to the side."

"From the point of view of an innocent little high school graduate, coming to CHEM 202 right after a long summer vacation can be a frightening experience. The difficulty level of the questions we get asked, the amount of questions we are asked to solve in an unfairly small amount of time, combined with a 4-hour lab in which we have to stand and work with hazardous chemicals like hydrofluoric acid (it dissolves bone...that's scary stuff for 18-year olds) - for a mere 2 credit hours, all gives a collective impression of Chemistry being a highly difficult field to pursue. While these things were exactly what attracted me to ChemE (I knew right from Day 1 what I was getting myself into), they are also the most commonly cited reasons given by dropouts. Such a competitive environment makes it difficult to get a good starting grade in Freshman Semester 1, which makes the students re-evaluate whether they have the aptitude to pursue the field. My suggestion would be to make the curriculum gradually increase in difficulty, so that you don't scare away students so quickly. It's like getting the frog in warm water, and gradually getting the water boiling."

"I think its important to look at the student individually. If one thinks a student is not prepared for a class, they probably are not. The adviser asked my if I wanted to take physics in the spring and I said yes but in reality she should have looked at my grades from the fall and should have offered an alternative path even if it took longer."

"I do not know if it's in anyone's power but I would say the main course that made me really think about whether or not I wanted to remain in chemistry was Orgo I, because that class is not something that should be taught online."

"I mean we all basically hate the lab courses. We never know what exactly is expected of us and that makes learning and satisfying requirements really hard."

"I've thought about this a lot and I coming up with suggestions is exceptionally hard. I think one way that I could have had a better experience is if I had built up the confidence to do chemical research in undergrad, or just confidence in my ability to do chemistry at a higher level, at all. My suggestion would then be to do more to introduce undergrads to research. The process is so student-initiated right now that anyone with self-efficacy issues is likely to never get involved. Perhaps there could be an independent study with the goal of having students define their interests in chemical research that simultaneously puts chemistry into real-world contexts and is an introduction to the world of academic chemical research."

"I feel that the higher level courses vary too much when taught by different professors. In some cases the topics covered are completely different than another section, which makes me feel like I am either missing crucial information or learning things that are not important."

"I think that the advisors should make it more clear to the incoming students, what the difference between specialized chemistry and chemistry science and letters is. When I got here I had no idea what I was signed up for and I also didn't know what other options I have. I think every student should know their options when they come into school."

Gender Differences. Open-ended responses were disaggregated by gender to further explore retention and recruitment differences between males and females. Overall, for both males and females, the top reasons cited for choosing the initial chemistry major was their high school chemistry experiences and connection with chemistry. However, differences emerged between female Leavers and male Leavers. Consult Table 22. The top reasons cited among female Leavers included high school chemistry experiences and career options and prospects for the future. For male Leavers, the top reasons cited were a connection with chemistry and that chemistry was not their first major choice (redirected from some other major). Thus, a greater number of males signified that they were never intending to major in chemistry in the first place.

Table 22. Open-Ended Survey Results Disaggregated by Gender: "Describe Your Reasoning for Your Initial Major."

Emerged Categories	**# Times Cited by Respondents: Leavers**		**# Times Cited by Respondents: Persisters**		**# Times Cited by Respondents: TOTAL**	
	Female	Male	Female	Male	Female	Male
High School Chemistry Experience	**14**	5	**23**	**23**	**37**	**28**
Chemistry "Connection"	8	**8**	**23**	**24**	**31**	**32**
Career Options & Prospects	**12**	3	9	8	21	11
Chemistry Major NOT First Choice	5	**8**	1	1	6	9
Health Career Goals	6	3	16	11	22	14
Research & Lab Experiences	2	2	2	3	4	5
Social Pressures	1	1	0	0	1	1

For those students who switched into the chemistry major, females were mostly undecided when they entered the university, whereas males indicated more varied responses, especially based on interest, feeling undecided, and suggesting more social pressures to pursue their original major. (To see a more detailed report of the open-ended survey results disaggregated by gender, consult Appendix R.) However, both males and females cited a connection with chemistry as the main reason why they switched to the chemistry major.

The largest difference between males and females emerged for students that left the chemistry major. See Table 23. Male Leavers cited the usefulness of the chemistry degree and interest in another major as the main reasons for leaving, with a smaller emphasis on being redirected from another major, the other major more relevant to career goals, not connecting with chemistry, and issues with supporting coursework. However for female Leavers, their reasons for leaving were much more varied. They also cited the same reasons as males, but also placed emphasis on a poor first semester experience, overwhelmed with their course load, chemistry grade performance, social isolation, and poor academic advising. Furthermore, 93%

of the male Leavers indicated they were still pursuing a STEM degree versus only 71% for female Leavers.

Table 23. Open-Ended Survey Results Disaggregated by Gender: "Describe All of the Reasons Why You Decided to Switch Out of the Chemistry Major."

Emerged Categories	# Times Cited by Respondents	
	Female	Male
Engagement/Interest in Other Major	**11 (15.7%)**	10 (25.6%)
Usefulness of BS Chemistry Degree	10 (14.3%)	**11 (28.2%)**
Other Major More Relevant to Future Career Goals	6 (8.6%)	5 (12.8%)
Redirect	2 (2.9%)	6 (15.4%)
First Semester Experience	8 (11.4%)	0
Issues with Supporting Coursework	6 (8.6%)	2 (5.1%)
Not Connecting with Chemistry	5 (7.1%)	3 (7.7%)
Overwhelmed with Course Load	5 (7.1%)	1 (2.6%)
Chemistry Grade Performance	6 (8.6%)	1 (2.6%)
Social Isolation	6 (8.6%)	0
Chemistry Advising	5 (7.1%)	0

Regarding future career goals, the most frequently cited goal for females was to work in industry, followed by becoming a medical doctor. For males, the most frequently cited goal was to become a researcher, followed by going to graduate school (16% of males cited they intended to go to graduate school versus only 8% for females). Again, a wide variety of career goals were cited among both males and females and can be found in Appendix R.

When asked to provide general feedback about their experiences in the UIUC Chemistry Department, both males and females cited the chemistry professors and classes, academic advisors, and overall staff experience as the most positive aspects of interacting with the Department of Chemistry. However, female Persisters made additional mentions of having a community of chemistry peers and utilizing the SCS Career Services Office. For improvements, females most frequently cited better first-year chemistry class experiences, the need for a chemistry community, and issues with advisors. Males most frequently cited issues with undergraduate research (accessibility and number of credits for lab work done).

Race/Ethnicity Differences. Open-ended responses were also disaggregated by race/ethnicity. Overall, connection with chemistry was highly cited by all groups as a reason for initially choosing chemistry as a major, although health career goals was also highly cited by African Americans and high school chemistry experiences were highly cited by White, Asian, and Hispanic students. Because of the small sample sizes, the responses were not disaggregated further into Leavers and Persisters for this survey question. All groups of Switchers most frequently cited connection with chemistry as a reason for switching into the chemistry major. For the Leavers, there were no prominent differences between groups when citing reasons for leaving the chemistry major. All groups cited the usefulness of the chemistry degree and interest in another major most frequently.

Regarding career goals, there were differences between groups. African-American students most frequently cited business field/health administration positions as future goals. Hispanic and Asian students most frequently cited that they wanted to become researchers. White students most frequently cited that they wanted to work for industry. However, to see the wide variety of career goals cited among the groups, consult Appendix S.

When asked to provide general feedback about their positive experiences in the Chemistry Department, both African-American and Hispanic students most frequently cited the overall staff experience with the Department. Asian students most frequently cited the academic advisors specifically. The White students most often mentioned their chemistry professors and classes as the most positive aspects. For improvements, the results were widespread, even within groups (consult Appendix S for further details). Overall, African-American, White, and Hispanic students frequently cited issues with advisors. Asian students frequently cited issues with career advising, issues with their lab experiences, and more variety of courses needed within the major.

INTERVIEW RESULTS

To display the interview results, I used a meta-matrices display format, which are master charts assembling descriptive data from each interview conducted into a standard format.[120] Then, I partitioned the data into the three groups: Leavers, Switchers, and Persisters. I was then able to cluster the data that fell together and coded them into emerged categories.[120] Summarized master charts are located in Appendix T. The results below show these emerged categories and the individual students displayed represent distinct perspectives on the emerged categories of interest.

Leavers. In total, 23 students were interviewed that left or were intending to leave the chemistry major. Of those 23, 17 were female and 7 students identified as underrepresented minorities. From these interviews, the most frequently cited reasons for leaving the chemistry major were due to issues with chemistry coursework and issues with supporting coursework. See Table 24. Other cited reasons included more interest in another major, having a peer group in another major, overwhelmed with coursework while not having the appropriate study skills, usefulness of the chemistry degree, and issues with the large class sizes.

Table 24. Interview Results: Reasons for Switching Out of the Chemistry Major

Emerged Categories (for switching out of the major)	# Times Cited by Respondents
Issues with Chemistry Coursework	19
Issues with Supporting Coursework	16
More Interested in Other Major	12
Peer Group in Other Major	10
Overwhelmed/Study Skills	10
Usefulness of the Chemistry Degree	7
Issue with Class Size	3

Below are some distinct perspectives from students on why they switched out of the chemistry major, along with why they initially chose chemistry upon entering the university.

Table 25. Interview Results: Case-Level Display for Select Students That Left the Chemistry Major

Student ID	***Why did you initially decide to choose a chemistry major?***	***Why did you switch out of the chemistry major and choose your current major?***	***Emerged Categories (for switching out of the major)***	***Current Major***
10 (female)	"I was close with my chemistry teacher in high school and I like science."	"[My chemistry major] was very difficult and got to the point where I wasn't excited about it (didn't want to do it for 3 more years); Math classes were not review for me and I felt unsure as to how to succeed; I had no advanced, AP, or honors courses available to take in high school; I did not have good experiences in Math 220 (lecture involved constant writing with a ton of information and no time to ask questions); It was math 220 that I realized chemistry was not going to be for me; GRADES were huge to my retention in chemistry; I also was not sure what I could do with my chemistry degree afterwards; It was hard for students to relate the labs to the material in the course…not sure why I was doing the lab; I had no idea how to manage time and study; I was very overwhelmed (took 18 hours both semesters freshman year); In my current major classes, the class sizes are small (versus a large lecture) so that everyone has to contribute and discuss and ask questions"	Issues with Supporting Coursework, Issues with Chemistry Coursework, Usefulness of the Chemistry Degree Overwhelmed/Study Skills, Class Size an Issue	Anthropology
24 (female)	"I really like chemistry and computer science; I took a community college chem course over the summer."	"I love chemistry, I'm just not that good at it; My dad told me I have to pick a balance of what I like versus what I'm good at; I was interested in pharmaceuticals but chemistry is a struggle for me; I have to reread it over and over and I'm still not getting it (don't like that feeling); The online quizzes don't really assess what I know (paper quizzes are a better gauge); I love computer science (logic and problem solving); I love math; I'm taking statistics 100 and I got a 100 on my last exam (I'm very excited); I'll take calc 3 next semester (got AP credit for calc 1 and 2); I participate in women & computer science (WCS) - makes it okay if you don't know what you want to do – they say to just join; I tried attending a chemical engineering club but I felt like it wasn't good if you don't know what you want to do…like I didn't fit in because I was unsure and didn't know what I wanted"	Issues with Chemistry Coursework, More Interested in Other Major, Peer Group in Other Major	Computer Science + Math

Table 25 (cont.)

26 (male) (interntl)	(did not answer this question)	"The chem 203 lab class really drained me and I thought I can't do this all of college; I thought it would be all of my college life at the time; I struggled in Chem 203 because I had no former lab experience; I struggled with the difficulty of lab and writing 20-30 page lab reports; They didn't explain how to use the equipment; I really struggled and it was draining; I didn't think I could do much with a chemistry degree at the time (just experiments and applications); I thought engineering was "fancy" so I chose that instead; I am interested in finance; I had an internship on investment banking (get to do analysis and research and meet clients); I use a similar methodology that's needed for chemistry"	Overwhelmed/Study Skills, Issues with Chemistry Coursework, Usefulness of the Chemistry Degree	Electrical Engineering
29 (female)	"I really liked my high school chemistry teachers and AP chem."	"In chem 203, there was no help with lab report writing; TAs would not help even if I brought a rough draft in advance…said it wasn't fair…yet nothing was clarified ahead of when it was due; There was no structure from the TA so there was so much guessing and little instruction; I did NOT like the lab - Chem 203 took so much time so that I had no free time; I just wanted 1 hour in my day; It was too rigorous for what I wanted in college that I didn't even join clubs until sophomore year; Chem 202 was not gen chem to me…the professor did not teach general chemistry (topics were quantum mechanics and physics); I started in calc 3 but I did not like 3 dimensions and didn't understand it and the professor said if I don't get it, then I should just drop the class (plus I was rushing a sorority); I switched to calc 2 after 2 weeks and this was much better because I already knew a lot of it from AP; I never went on to calc 3 because I had decided to switch to a major that didn't require it; Physics 100 class was also difficult because it was hard to understand the professor and the TA got annoyed; I wasn't learning in lecture and the TA wasn't helpful; Time management was a transition and what to expect in college in terms of structure; Within one month, I was not getting enough sleep and couldn't finish assignments so that I understood them; I was fed up with it and didn't like the chem classes I was taking; Not knowing anything was a big shock and I had prep but it wasn't similar at all which threw me off; I was told that there were a lot of opportunities in food science and also had an internship; I liked the food science application and I got to talk to others in the company (liked the social aspect); I previously shadowed at Honeywell and decided I didn't like the oil industry...so I thought what else can I do with a chemistry degree?"	Issues with Chemistry Coursework, Issues with Supporting Coursework, Overwhelmed/Study Skills, Usefulness of the Chemistry Degree	Food Science

Table 25 (cont.)

30 (female)	"I enjoyed chemistry and wanted to learn about it."	"I had to switch out of chemistry because I was on probation; Calculus classes were awful; I took calc 2 twice and failed both times; I struggled so hard in math that I didn't have the time I wanted to give to chemistry classes; Groups in math classes were terrible…discussions were brutal - if I asked for help, the students ignored me or talked down to me; It was really difficult; A smart person didn't want to give me the time of day; I was in class with sexist engineers and quiet international students and then a group of "lost" people; It would be me with three other guys that discussed the problem without me and I was completely ignored; When they found out I was "just" a chemistry major, they put me down especially because I was also a woman; I went to tutoring to try and get help but I didn't click with the TAs because they expected me to get it right away; Professor's methods and TA's methods didn't match so it caused confusion for me; TAs were really bad; I was not able to balance chemistry and calculus at the same time; In high school I didn't have to do much outside of the classroom and then a brick wall hit me when I got here because I have to do so much self teaching and budget my time; I mostly studied on my own; I found it hard to mesh with people here because I'm from a small town; I need one-on-one time here so that I can talk it through with someone but people would look at me like I'm stupid, especially boys in the class; I felt like they looked down upon me because I was a woman in science; Even races were clicky with each other; Because English is a more female dominated major, it's easier to work in groups; however it was easier to click with people in chemistry too because there are more girls and a better mix - but I was outweighed in calc classes"	Issues with Chemistry Coursework, Issues with Supporting Coursework, Overwhelmed/Study Skills, Peer Group in Other Major	English
31 (male)	(did not answer this question)	"I always loved food and cooking; I found out about the food science major from a friend about a month into starting the chemistry program (didn't know this major existed); Food science major was a better fit for me; I didn't align with the other chem major's aspirations; I felt out of place; FSHN is together…professors are tight with each other and accessible; I was not loving chemistry and struggling; I dropped the Chem 223 lab because it was unorganized and the TAs did not know what they were doing; The professor just dropped in and out; I started in calc 2 but dropped it because I decided to change majors; It was hard to pay attention and get it because the professor seemed disinterested; The online HW didn't accept formatting of answers and the exams were not related to the material"	More Interested in Other Major, Peer Group in Other Major, Issues with Chemistry Coursework, Issues with Supporting Coursework	Food Science
33 (female)	"I loved chem in high school; I took AP chem and loved it; The chemistry major is a very broad major and could transfer to other majors easily; I was not sure about nutrition at the time; I also toured the UIUC chem dept."	"Chemistry is a narrow path; I figure that if I don't get into medical school, then I have a backup and can have a career in nutrition, but what can I do with a chemistry degree? I have job security with this major; I really disliked my chem 102 teacher and I advise others to choose other professors instead; Chem 102 was my roughest chemistry class along with the combination of being a freshman and taking calculus at the same time - hadn't developed study adjustment yet; I was overwhelmed; I really hated calc 221; It was really difficult my freshman year…very fast paced and no time for reviewing; I had a cool TA though; I don't think I'm very good at calculus…although I got an A in high school; I'm not a numbers person; I really like the College of ACES; My advisor is great and lays out my plan for me; I really disliked my chemistry advisor…didn't give me a 4-year plan; The FSHN culture is great - smaller classes and professors know us"	Usefulness of the Chemistry Degree, Issues with Chemistry Coursework, Issues with Supporting Coursework, Overwhelmed/Study Skills, More Interested in Other Major	Food Science

Table 25 (cont.)

39 (female)	"I am pre-pharmacy; I really liked chemistry in high school; Chemistry was interesting and I was good at it."	"The main reason for switching was because of frustrations with chem 104; I started in chem 104; It was not a consistent experience from 104 professor to 104 professor; My professor went through the motions; [My professor] got off topic with examples; The clickers were weird; The exams were different than lecture and discussion worksheets; I was overwhelmed at first - UIUC is a major leaguer; I got a C on my first test; I studied a lot with other people - with my boyfriend and friends who were MCB majors; In my MCB 150 class, the professor made it interesting and made me want to learn more…big deal for my first semester; I looked at the advanced courses in MCB and chemistry and MCB looked more interesting"	Issues with Chemistry Coursework, More Interested in Other Major, Overwhelmed/Study Skills, Peer Group in Other Major	Molecular & Cellular Biology
40 (male) (URM)	"I'm a fan of science fiction; I'm gadget and gizmo oriented; I was good at chemistry in high school; I taught others in chemistry and physics in high school; I stood out in high school."	"The main reasons why I left are: not feeling like I could succeed - that it wasn't possible no matter what I did and that the major was also time consuming; After lots of effort, I didn't get the result I wanted so I felt like I couldn't do it; I started in chem 202/203 but moved to 104/105; Chem 203 was done sloppily; The lecture was not helpful; They didn't give us a way to know how to write the lab reports - what's the structure?; If you don't know, you're less fortunate; It took awhile for lab reports to get back to me so I would continue to make the same mistakes; In Chem 202, I couldn't make it to a lot of office hours because of my class schedule which was not fun; In Chem 202, you're in there by yourself; I was the only African American kid; I was uneasy; There was one other African American, but he quickly switched to Chem 102 (said 202 is not for me); Made me feel like it wasn't for me…not really my place; Math 220 taught why in this class; The professor was helpful even though it was hard; In Math 231 I did not have a helpful professor; The discussion was not very helpful - no explanation of why from the TA; Calc 2 was my most difficult class"	Issues with Chemistry Coursework, Issues with Supporting Coursework	Economics and Creative Writing
67 (female) (URM)	"I took AP chemistry in high school; I loved it and had a great time; My teacher was really encouraging and helped me; I liked her class; I was premed"	"One significant factor was that I was not doing as well as I wanted in the chemistry major; The classes were challenging and I studied weeks in advance but the exams still didn't go well; I still like helping others in chemistry; I like explaining; I loved chemistry in high school and I still enjoy the classes now; One reason why I left chemistry was that I was scared of taking physics and it's required for the major; I took it in high school and other students (not even from this college) scared me about taking it; I was interested in becoming a nursing major and an advisor in the College of Nursing encouraged me to switch to Community Health because they go more hand in hand for the requirements"	Issues with Chemistry Coursework, Issues with Supporting Coursework, Usefulness of the Chemistry Degree	Community Health

Switchers. In total, 16 students were interviewed that switched into the chemistry major. Of those 16, 8 were female and 4 students identified as underrepresented minorities. From these interviews, the most frequently cited reason for switching was due to engagement with the chemistry major. See Table 26. Other cited reasons included the flexibility of the chemistry major, alignment with career goals, and disinterested in their original major.

Table 26. Interview Results: Reasons for Switching Into the Chemistry Major

Emerged Categories (for switching into the major)	# Times Cited by Respondents
Engagement with Chemistry Major	12
Flexibility of the Major	5
Aligns with Career Goals	4
Disinterest in Other Major	4

Below are some distinct perspectives from students on why they switched into the chemistry major, along with their original major upon entering the university.

Table 27. Interview Results: Case-Level Display for Select Students That Switched Into the Chemistry Major

Student ID	*Can you please share the reasons you decided to choose chemistry as a major?*	*Emerged Categories*	*First Major*	*Current Major*
3 (male) (URM)	"I was in FSHN but it's very focused. I wanted flexibility so I'm majoring in chem and minoring in FSHN; I'm interested in food science and food chemistry. I want to go to graduate school and do research"	Flexibility of the Major, Aligns with Career Goals	Psychology, then FSHN	Chemistry (S&L)
13 (female)	"I was MCB for 1 year but it's not my thing – I first wanted to be a pediatrician; I didn't like bio; I felt like MCB 150 and IB 150 were weed out classes; I realized that chemistry labs are hands on and liked them; A lot of my coursework already transferred to the chemistry major and I felt pressure to finish in 4 years; I want to go into the pharmaceutical industry – I had an internship over the summer"	Disinterest in other major, Engagement with Chemistry Major, Flexibility of the Major, Aligns with Career Goals	MCB	Chemistry (S&L)
17 (male)	"I liked the ease of being able to do the chemistry major because it overlaps with my MCB requirements; I enjoy chemistry; I could have done another science with MCB but I enjoy chem"	Flexibility of the Major, Engagement with Chemistry Major	MCB	Double Major: MCB Honors/ Chemistry (S&L)
21 (male)	"I started as an animal science major because my dad is a vet but I found that I like the cellular level more and biology is chemistry; A friend told me to double major because it's doable with Sciences & Letters; My high school chemistry teacher was good and the 100-level chemistry lectures here were really good so they reinforced my enjoyment of chemistry and I like it"	Disinterest in other major, Flexibility of the Major, Engagement with Chemistry Major	Animal Sciences	Double Major: MCB/ Chemistry (S&L)
23 (male)	"Originally I wanted to do chemical engineering but I couldn't handle the courses; I really liked chemistry so I didn't want to leave chemistry; I couldn't work in a lab because I wouldn't be happy (did for one summer and I didn't really like it); I decided on PA school or pharmacy (and ultimately PA school); My aunt is a chemical engineer and I thought what she did was cool; I like how chemistry applies to everything"	Engagement with Chemistry Major	Undeclared	Chemistry (S&L)
25 (male) (URM)	"I took IB 150 and MCB 150 and hated them!; I really liked AP chem in high school; I saw that the requirements weren't too hard and I liked the material; Liking the material is the main reason I'm a chemistry major"	Engagement with Chemistry Major, Disinterest in Other Major	Biology	Chemistry (S&L)
44 (female) (URM)	"I was undeclared and on an engineering track and then I found out engineering was a lot of desk job type of work - a lot of computer modeling and integration; I was like oh my god no I can't do this so then I switched into geology and that was fun for awhile but I realized that I kept adding chemistry classes; At some point I had a geology department meeting and I wanted to incorporate all of these chemistry classes for my technical electives for my geology degree and they told me that maybe I should switch majors because if I want to switch every geology class to something chemistry related then maybe chemistry is a better fit for me; What has significantly kept me in chemistry - professors, teachers, the department, [my mentor] - it makes a huge impact because I've jumped from department to department and I've mingled with a lot of people and their ability to reason with you and talk with you is very different; The chemistry department is just very open, warm, and friendly; You have to reach out to the chemistry department but you have to reach out to any department"	Engagement with Chemistry Major, Disinterest in Other Major	Undeclared	Chemistry (S&L)

Table 27 (cont.)

47 (female) (URM)	"I was undeclared and at the time I was going to major in biology but I had to take chemistry courses and I didn't remember anything from high school so I took chem 101; I really liked the professors; They did cool demos and my TA was super knowledgeable and very enthusiastic; I thought it was fun and I'm not super bad at it so I might want to do this in the future; The most significant contribution to staying in chemistry is definitely the professors - every course I've taken, the professor is always enthusiastic and makes the material fun and makes me want to learn and apply it to the future"	Engagement with Chemistry Major	Undeclared	Chemistry (S&L)
52 (male)	"A good friend and former boss from back home is a chemistry grad student in Arizona right now; I knew I wanted to do something in STEM, science related; The appeal of chemistry is that it just makes sense; It makes perfect sense and they can explain it - unlike physics where they just talk about perfect worlds; You see things happen in real life and you can explain exactly what's going on"	Engagement with Chemistry Major	MCB	Chemistry (S&L)
56 (male)	"I liked chemistry and it was around organic chemistry that I realized I wanted to continue chemistry because that's when it basically ends for MCB majors; I realized it was only adding on a couple of calculus classes and p-chem so it wasn't too bad; The material itself is very interesting and the logic used to solve chemistry problems is a lot how I think; It's very diagnostic...it's very logical; Being a chemistry major opens up a lot of doors for academia, government, research, industry; There are all sorts of opportunities for chemistry"	Engagement with Chemistry Major, Aligns with Career Goals	MCB	Double Major: MCB/ Chemistry (S&L)
57 (male)	"When I was trying to become an engineer, I enjoyed my science classes a lot better than my engineering courses; I leaned towards chemistry because I enjoyed my chemistry classes the most of the classes I took; Chemistry is the most applicable to going into a big range of industries like going into materials science or food science or actual chemistry; There's a lot more you can do with chemistry versus some of the other sciences; I like knowing how things work and most people don't know"	Engagement with Chemistry Major	Undeclared	Chemistry (S&L)
58 (female)	"The whole application process of chemistry and not just memorizing information definitely geared me towards chemistry; I loved orgo I and working through it and not just memorizing facts"	Engagement with Chemistry Major	Undeclared	Double Major: MCB/ Chemistry (S&L)
59 (female)	"I took orgo 236 because it was in the IB Honors curriculum and 236 is what made me want to do chemistry; I got in an orgo research lab and now I want to go to grad school; I like the research environment here - esp. since U of I is so highly ranked; It's ridiculous that we can be in these labs doing a senior thesis with a project in these labs that are so high level"	Engagement with Chemistry Major	IB	Double Major: IB Honors/ Chemistry (S & L)
61 (female) (interntl)	"I started as engineering undeclared and at the end of my freshman year I decided I wanted to transfer into chemical engineering but to do that I need some other coursework first; So the spec chemistry major is just an interim major for me right now; Chemistry is great but chemical engineering applies math with it in the application"	Aligns with Career Goals	Engineering Undeclared	Chemistry (Specialized)

Persisters. In total, 28 students were interviewed that persisted in the chemistry major. Of those 28, 13 were female and 10 students identified as underrepresented minorities. From these interviews, the most frequently cited reasons for remaining in the chemistry major were its alignment with their career goals and engagement with the major. See Table 28. Other cited reasons included a sense of belonging and mentorship in chemistry and flexibility of the major.

Table 28. Interview Results: Reasons for Remaining In the Chemistry Major

Emerged Categories (for remaining in the major)	# Times Cited by Respondents
Aligns with Career Goals	17
Engagement with Chemistry Major	14
Sense of Belonging/Mentorship/Community	9
Flexibility of the Major	2

Below are some distinct perspectives from students on what significantly contributed to remaining in the chemistry major, along with why they initially chose chemistry upon entering the university.

Table 29. Interview Results: Case-Level Display for Select Students That Remained in the Chemistry Major

Student ID	*Why did you initially decide to choose a chemistry major?*	*What has significantly contributed to you remaining in the chemistry major?*	*Emerged Categories (for remaining in the major)*	*Current Major*
1 (male)	"I was always interested in science - both of my parents are scientists"	"Chemistry is the most interesting - it's the central science; I love lab!; I want to do basic research - expand the knowledge of the human race"	Engagement with Chemistry Major, Aligns with Career Goals	Chemistry (Specialized)
4 (female) (interntl)	"In South Korean schools, you have to choose early - I chose the science/math track"	"I was more confident that I belonged in chemistry; I feel I belong here; All of my experiences have been good - with people, research, and especially classes; I want a research career; Organic chemistry is very interesting and has its own unique language"	Sense of Belonging/Mentorship/ Community, Aligns with Career Goals, Engagement with Chemistry Major	Chemistry (Specialized)
5 (female) (URM)	"I like how my high school teacher taught chemistry and I took organic chemistry in high school"	"I like this major because I can be free; There is a lot of wiggle room in the major and most schools don't have that; I was going to be biochemistry but the 30 hours of chemistry won me over because I could put in other classes that I like; Chemistry is a promising degree; I love chemistry! I'm good at it and I get it; Chemistry challenges me"	Flexibility of the Major, Aligns with Career Goals, Engagement with Chemistry Major	Chemistry (S&L)
16 (male)	"I got interested in honors chemistry in high school – it was the right medium between application and theory and how nature works; I knew I could find a job in the field"	"It's the drive for discovery; I want to invent and create something - research is a way to do that"	Engagement with Chemistry Major	Chemistry (Specialized)
19 (male)	"Chemistry was harder for me in high school - the greatest challenge to me; A lot comes easy to me; I chose this because I understood it the least; It's also practical if I don't go to medical school because then I can go to grad school"	"I like how well chemistry now explains everything; It's practical if I don't go to medical school because then I can go to grad school"	Engagement with Chemistry Major, Aligns with Career Goals	Chemistry (Specialized)
27 (female)	"Chemistry was the one thing in high school that clicked; I wanted to be in that class all day; I like knowing why something works and the why behind everyday things"	"I like learning the reasons why; The main reason why I've stayed is because of my peer mentor, faculty mentor, and the Merit TAs; I hear that it's okay to fail - we think a C is the end of the world; they teach me how to look at things differently; My Merit TA reminds me that failing isn't the end of everything; The upperclassmen majors help to get me excited especially the way they talk about the major - they're excited; I work in the demo room with other chemistry majors"	Engagement with Chemistry Major, Sense of Belonging/Mentorship/ Community	Chemistry (Specialized)

Table 29 (cont.)

43 (female) (URM)	"I wanted to do science or math; No good reason for chemistry but a few friends chose chemistry so I chose it too, but it's not really a passion"	"I know I'll have a bright future with a chemistry background"	Aligns with Career Goals	Chemistry (S&L)
51 (male) (URM)	"I had a good experience with chemistry in the past before college; It was the one subject that always worked out"	"It's the the science that's most applicable to life and most useful in research; There is top of the line research and it's most applicable - a very useful science"	Engagement with Chemistry Major	Chemistry (Specialized)
53 (male)	"My high school chemistry teacher was my honors chem teacher and AP chem teacher; That's what inspired me to go into chemistry because she was so passionate about what she did; Compared to the other AP teachers we had, she was so experienced and overqualified because she knew so many things"	"My high school chemistry teacher set me up with a tour of Argonne; There are many opportunities in the long run to do research especially with astrochemistry"	Aligns with Career Goals	Chemistry (S&L)
62 (female)	"I took a gamble when I chose chemistry for my college application; I was trying to figure out if I should click bio or chemistry and I literally just clicked chemistry"	"I really enjoy chemistry so far because it has a wide variety of applications in many sciences and because you can take chemistry from pharmaceuticals to materials to organic to inorganic; I think that's why I really appreciate chemistry; Biology is too centralized…it's just biology; I've definitely developed stronger critical thinking skills because of chemistry"	Engagement with Chemistry Major	Chemistry (S&L)

Gender Differences. From conducting these interviews, both individual and focus group, one key difference emerged by gender. Females overall put a greater emphasis on peer groups and a sense of belonging to a community. For example, of the 10 Leavers that discussed having a peer group in another major, 9 out of the 10 of them were female. Furthermore, when Switchers were asked if they used chemistry study groups or had a chemistry peer community in their classes, all 8 females reported that they did versus only 3 of 7 for the male Switchers. However, the majority of *both* female Persisters (9 out of 11) and male Persisters (10 out of 12) indicated that they used a chemistry study group or belonged to a chemistry community in their classes, whereas only 4 out of 17 female Leavers and 3 out of 6 male Leavers indicated that they participated in a chemistry group. One female Switcher commented that the most positive aspect of her chemistry major was "getting to know people in my courses…I made friends and study partners…I connected with teachers."

Race/Ethnicity Differences. Because of the small sample sizes, students were grouped into underrepresented minority students, URMs (African-American, Hispanic, and Native American students) and majority students, non-URMs (Asian and White students). When grouped in this way, differences emerged from the interviews, particularly between Leavers, Switchers, and Persisters. For example, URM Leavers reported lower rates of participating in chemistry study groups or having a chemistry peer community in their classes (only 1 out of 7 URM students versus 6 out of 16 non-URM students). For the Switchers, non-URM students reported much higher rates of having a chemistry community and study group (9 out of 11 students) versus URM students (2 out of 4 students). But for the Persisters, URM students reported higher rates of working in groups (8 out of 8 students) versus non-URM students (11 out of 15 students). What's most distinct is how students discussed the importance of their chemistry communities and how it impacted their retention. As an example, when asked what most significantly contributed to remaining in the chemistry major, one underrepresented student commented "I really enjoy lab and that's a plus for me and I joined a research group which is the main reason I'm still a chemistry major. I have a lot of fun. The research - I can really see myself doing this after. I like the support from everyone chemistry related." Another underrepresented student said "What most significantly contributed was Merit - extra exposure where you have to work with people. Some of the people I met in Merit are my best friends to this day so it was just really comfortable plus we take pretty much the same classes so I get the same study group." Another student said "The professors - I've been in office hours so many times and if wasn't for that I wouldn't have done so well on the exams. I would also say that I have a pretty good study group also - a group of friends that I can study with and are reliable and can help you on your homework and study for exams." A separate URM student described "[My mentor] most significantly contributed - I remember when I was struggling in my classes my sophomore year I came to my mentor and she put her arm around me and told me to put in more effort and go to office hours and I'll get the grade in the class that I want and that helped a lot for me. A lot of students in classes as a whole want to help each other and they make a lot of Facebook groups so they create an atmosphere in general that makes it easy to make friends and study groups." A chemistry community for these underrepresented students described a community of professors, graduate students, and peers that provide support in the chemistry major, their studies, and socially outside of the classroom. For those majority students that reported a chemistry community as important as well, many of their descriptions were a bit different in nature - describing a sense of belonging from the department and that others serve as role models. These descriptions were also in the context of other factors significantly contributing to their retention, such as alignment with career goals and engagement with the chemistry major. For example, one non-URM student said "I was more confident that I belonged in chemistry. I feel I belong here. All of my experiences have been good - with people, research, and especially classes. I want a research career. Organic chemistry is very interesting and has its own unique language." Another student commented "I see many chemistry majors go to grad school or get an MD/PhD. I see a grad student and I think, I can do this." Another said "I like chemistry and feel like the department is there to back me up. I'm premed." While having a chemistry community was described as important by both underrepresented and majority students, underrepresented students more often cited their community as the sole reason for remaining in the major.

Important Considerations. As in the survey, the interviews also asked students to provide general feedback about their experiences in the UIUC Chemistry Department. Although these responses cannot be specifically linked to retention or recruitment, they are very helpful in understanding the climate in which students experience the chemistry major and provides valuable feedback. Thus, some of the students comments are highlighted below, although consult Appendix T for a lot more details. When asked what were the most positive aspects of interacting with the Department of Chemistry, students described positive experiences with professors, classes, advisors, peers, the Chemistry Learning Center, research labs, departmental scholarships, career services, and the prestige of the department. See Table 30.

Table 30. Interview Results: Case-Level Display for Select Students That Provided Feedback on What the Chemistry Department Has Done Well to Contribute to a Positive Learning Experience

Student ID	**What has the Chemistry Department done well to contribute to a positive learning experience for students?**
14 (female) (URM)	"Willingness to help - everyone including professors, TAs, and counselors which is good because I get intimidated"
26 (male) (interntl)	"The greatest legacy of chemistry for me was Chem 202 – the way of thinking and how to approach the material; It taught me to divide the problem, analyze it, and then recombine it; I will keep applying this to my life and use this for investment banking and research in economics"
17 (male)	"Lots of collaboration between peers that help each other; It's more laid back and not as much stress - more distrust between students in MCB"
44 (female) (URM)	"I've jumped a couple of majors and one thing that I can say is that the professors in this department here are absolutely phenomenal; For example, in engineering when you're trying for engineering, a lot of professors look at you as someone who's competing to get into their program so they have a very stand off-ish attitude and they're like okay, prove it to me, what do you got, what are you telling me and everything is like an interview or an interrogation; Whereas with the chemistry department teachers…it was a genuine effort; I have these questions, can we talk about this? Professors would work out problems on the board and would show you the way or what you're missing so that you understand those gaps in your knowledge; A lot of other departments don't do that and I've switched majors three times"
58 (female)	"I did the Merit Program and I found it very helpful; It prepared me especially for my first semester of chemistry; It allowed me to collaborate with people and get ideas"
63 (female)	"One thing I like - how much these classes facilitate forming study groups; So you can study independently but some of my best experiences were in a group setting and learning from and discussing a mock exam together"
64 (female)	"It's nice that we have such amazing professors here; We forget and then you overhear their conversation at a coffee shop and they are talking about all of this high level stuff and we have so many resources here"
4 (female) (interntl)	"Exposure to a research group for 2 years; Talking to graduate students has been most important because they've given me great advice including life attitudes; I learn how a research project works - writing and communicating"
7 (female)	"Help is there; The resources available; Homework has tutors and office hours"
8 (male) (interntl)	"The ranking of the chemistry department; Generous with scholarships (surprised that international students can get them); Patricia Simpson helped with resume lots of times and told me to network (but international students don't really know that)"
19 (male)	"The overall feeling that we want us to do well and understand - even if it's hard and pushing us within reason; I have a good community - chemistry and chemical engineers; By select nature we are bonded"
46 (male) (URM)	"I kind of like the fact that when I tell people I'm a chemistry major they have a face like "WHAT?" - really like their expression; happens so often; so sort of a superficial reason"
50 (male) (URM)	"The research lab - you think you're working by yourself on your own project but if you need help you ask your partner; You ask if they ran into that problem before or how they go about it so it's a lot more interaction than I thought at first; I really enjoy lab; Sometimes I don't really understand it at first but as I learn more chemistry and they are really friendly and explain how they do it and ask if I get it; So I actually really enjoy that about lab"

When asked what the Chemistry Department can do to improve experiences, students frequently described improving Chemistry 232 (organic chemistry I), better advising, creating a chemistry community including mentors, better instructors and TAs, improving the chemistry curriculum (especially lab courses), better career services, and improved math experiences for chemistry majors. See Table 31 (but consult Appendix T for a lot more details).

Table 31. Interview Results: Case-Level Display for Select Students That Provided Feedback on What the Chemistry Department Can Do To Improve Experiences

Student ID	***What can the Chemistry Department do to improve the learning experience for students?***
26 (male)	"More information on the differences between specialized chem, chem engineering, and sciences & letters; If I knew about Chem 102/103, I may not have switched majors; It's hard to drop down from Chem 202/203 to 102/103 once you start"
30 (female)	"More resources for math help; It's hard for women in science to find others like them; Address the scariness of the difficulty of the major - taking calc and chem together; TAs should be hand picked better"
32 (female)	"Advising could have helped me better; I would have liked a mentor (junior to be paired with) - paired with someone doing the same thing to share advice about classes and go about the major, help prepare for the future, and someone to study with; Smaller classes because the larger environment makes it hard to ask questions because people judge you and want to get out of class and it's hard to get to know professors because they're intimidating; Students need to be aware of the different paths you can take in the major - I thought there was just one path; LAS 101 had a lot of potential but I didn't learn much because there were so many different majors"
41 (female)	"Chem 232 is TERRIBLE – I'm watching you tube videos of someone I don't know; The professor is at discussions but doesn't teach them, the TAs do; It feels like UIUC randomly found these you tube videos; I pay a lot of money so 232 should be put in a classroom; I want a live teacher; Most people in the class are confused; Also tell profs not to scare us, it's just intimidating!"
3 (male) (URM)	"Having the right prerequisites for classes (e.g. 102/104 to 236/436); There isn't a diversity of classes to take for chemistry majors - typically hard core; I want more applied classes…even Dr. Mitchell's class they have over in vet med already"
13 (female)	"More advertising of career services; I hear more from the College of LAS than the Chemistry Department; If there are get togethers, then I'm not hearing about them; I would like more events to get to know peers more"
57 (male)	"Applying for jobs - a lot of times the chemical engineers overpower us when applying; and a lot of times people just don't understand the importance of being a chemist - there are so many things you can do being a chemist (sometimes companies or other students don't really understand the importance)"
1 (male)	"1) MORE SUPPORT for students going to PhD programs (help with applications because there are a lot of nuances like letters of recommendation); we need guidance and information to help with the process 2) MORE COMMUNITY in the specialized chem major (I only know 2 people in my specific major) and 3) this is minor but free printing"
5 (female) (URM)	"More representation of the demographics in classes!; Break down material in lectures; Chem 232 online is bad - worst thing the department has done because it shows we don't care; Organic chem is the reason I became a chemistry major from high school but this class turned me away; Other colleges on campus make their students feel special - we need that!; We need more people of color - there is no one to look up to because they switch to other majors"
11 (female) (interntl)	"I don't really like experimental; Chem 420 - not really science to me (just memorize a ton of things); Others have said it's the worst class they've ever taken (class itself, not really the professor)"
19 (male)	"LABS are so frustrating – in Chem 203/205 a lot is expected but we don't know what we're doing; I have to write a lab report and we don't know what to write for completeness; This year in Chem 237 more is outlined on what's expected in reports but the lab lecture doesn't correspond to lab (the lecture is off)… work out the kinks; Labs themselves are fun but the structure of the class is frustrating""
27 (female)	"After 2-3 weeks into my calc courses, I feel like courses are geared towards engineering majors - but they think differently and yes, they're bright, but what about us?; The way the instructors even speak about the "engineers out there…"; Calc is so abstract; Why not calc for the rest of us that aren't in business or engineering? How does this apply to chemistry? How do these classes affect females? I feel alone because it's mostly males; ugh...calculus, why can't this math be offered through the chemistry department?"
45 (male) (URM)	"I agree with the peer tutoring service because you have someone there that has already taken the class and someone to give you advice, especially on future classes; If you have someone there, they can really help you a lot but also to help themselves because they can put it on their resumes/application; I think people would volunteer to do this"
46 (male) (URM)	"If the exam average is higher for the first exam, why do professors make the second exam really hard to bring the average down? Isn't that what you want? A higher average? If someone could break it down and explain it to me, that would be appreciated; The reasons are unknown to us"
49 (female) (URM)	"What I notice is that the math class here is combined with the engineers so that just makes it 10 times harder…it's just frustrating and scary; I think the average GPA for the engineering school is like a 3.1 and most of us are premeds and pre-healths so we don't want a 3.1; The fact that you try and try and try and go to TA office hours; One time I went to my professor's office hours and he could not solve the problem and he called himself stupid but if he's calling himself stupid, how am I supposed to feel? It was not a pleasant experience"

Table 31 (cont.)

55 (male)	"Every single course I've taken in chemistry I've liked except for one - that's online orgo I; I consider it just advanced arrow drawing; I didn't learn anything; The setup was God awful and I didn't learn anything in that course; I just studied for exams and relied on the curve to get the grade I wanted in that class; In orgo 2 you actually understand the way things went and it prepared me; In orgo I I was just guessing and hoping I'd get it right"
62 (female)	"Instrumentation classes should be required for LAS majors; It would be cool if the department required group projects because I have no experience with that other than my ATMOS classes; Inorganic should be spread over two courses like organic, p-chem, etc."
65 (female) (interntl)	"Having two chemistry programs is very confusing and there's a huge discrepancy between the two - specialized is so rigorous and the other one is so lenient; You can graduate in LAS without instrumentation or tough classes; I think analytical classes are so important for industry, research, pretty much everything; Advising was not good - as a freshman, they put me in Chem 232, 233, and math 231; Regardless of my high school background, I'm coming from far away and you need a group to work with for online chem 232 and I didn't know anyone; That kicked off college really bad for me; Chemistry majors should not have the same LAS 101 as the other majors - it's a huge issue when you're with all sorts of other majors and chemical engineers take their own 101 - chemistry majors need to be given important information like joining a research lab or whatever advice about what you want to do with your future career wise which is different than other humanities majors - STEM majors should have LAS sciences or something; I had to get the proper advice through joining AXE; this class for chemistry majors can learn about organizations this way too"

CHAPTER 5: DISCUSSION, LIMITATIONS, IMPLICATIONS, AND FUTURE DIRECTION[1]

Discussion

The goal of this research study was to determine the factors that lead to retention and recruitment of chemistry majors at a large, top-tier, research I university and highly ranked chemistry program. The purpose of Part One was to determine the extent to which the quantitative variables available for students predict the attainment of a chemistry degree. In addition, the results from Part One helped *shape* the types of questions investigated in Part Two of the study.

The Part One results indicated agreement with research literature suggesting that quantitative variables such as first-semester college GPA (p = 0.0484), high school math preparation (p = 0.0003), and participation in undergraduate research (p = 0.0003) contributed to attaining the chemistry degree. Which math course students enrolled in (precalculus, calculus I, etc.) was in indication of high school course offerings and rigor that students had prior to entering the university. However, a more in-depth analysis with detailed quantitative variables indicated that the largest amount of variance was accounted for when students *stopped* taking math or avoided taking a math class altogether (R^2 = 0.3560). This could have been a signal that students were done pursuing the chemistry major and already thinking of pursing a different one, even though many continued to take subsequent chemistry courses (29 out of the 50 students continued taking chemistry courses). Although there was also an association between degree attainment and undergraduate research, most students

---

[1] A research article on the Chemistry Merit Program, including its successes, appeared in its entirety in the Journal of Chemical Education. Adams, G.; Lisy, J. M.; The Chemistry Merit Program: Reaching, Teaching, and Retaining Students in the Chemical Sciences. *J. Chem. Educ*. **2007**, *84*, 721-726. A portion of this article is reprinted with the permission of the publisher and is available at http://jchemed.chem.wisc.edu/.

participated in undergraduate research in their third and fourth years, so these students may have already made the decision to remain/pursue this major because those who left the major primarily did so in the second year.

The purpose of Part One was to also investigate any predictor differences by gender, race, or ethnicity. From the descriptive statistics, the percent total of degrees awarded was below the national average for female, African-American, and Hispanic students. Regarding gender, slightly different factors emerged in the regression analysis. For females, greater variance (R^2 = 0.4724) was accounted for by their math preparation, discontinuing math, and undergraduate research. For males, a smaller amount of variance (R^2 = 0.4220) was accounted for that was also influenced by discontinuing math and participating in research, but instead included what type of high school attended (suburb versus non-suburb) and first-semester GPA. These differences by gender were thus investigated in Part Two of the study. Although a negative correlation existed between underrepresented students and degree attainment (r_s = -.03), the sample size was just too small to run a regression analysis with any statistical significance. Factors surrounding underrepresented groups based on race/ethnicity were explored in Part Two of the study.

From the regression analysis, up to 47% of the variance was accounted for based on quantitative predictor variables. However, a lot of variance was still unaccounted for. Part Two of the study sought to strengthen the validity of the data from Part One and deepen our understanding of why students choose to remain in the major, leave the major, or pursue the major. From the sample group comparisons, it appears that the current students are trending towards similar outcomes as past students including retention in the chemistry major (~39%), an overall net positive gain in chemistry majors over time (i.e., gained more majors than lost), similar regression outcomes of predictor variables (specifically discontinuing math courses, participating in undergraduate research, starting math course, and first-semester GPA), and many students that leave the major still choose an alternative STEM major. Disaggregated data also show that females continue to be underrepresented in the major and below the national average. African-American students continue to show lower retention and recruitment rates in chemistry (and below the national trend). Hispanic students also show lower rates, although there are some improvements for 1st through 3rd Year students, where right now Hispanic chemistry majors are slightly above the national trend.

The research literature supports that high school preparation is related to STEM persistence. From the survey and interviews, the overall trend showed that students did not feel that their high schools prepared them strongly for their coursework at the University of Illinois. The students reported overall means in between "Neutral" (3) to "Somewhat" (4), with no area above a score of 4. The lowest means were given to preparation associated with student independence, rather than academic courses. They reported the least preparation for university chemistry labs, which are hands-on, require a lot of independence, and detail-oriented writing. They also reported a lower preparation for study skills needed and time management needed to be a successful college student. These skills are needed for a new level of independence and critical-thinking, particularly in our university science and math classes (beyond high school Advanced Placement courses). These are harder skills to teach in high school where there is a greater variance of student maturity levels, abilities, and priorities.

Also supported by the research literature, an interest in and connection to chemistry, along with STEM-related professional goals, were significant reasons why students initially chose the chemistry major or switched into it. Whether this interest was generated in high school, which was most highly cited by students initially declared chemistry, or generated at UIUC, a connection with chemistry and/or how it related to their future career goals were important.

That same concept of interest and engagement applied to those who left the major. Survey respondents highly cited that they became interested in another major over chemistry, which was one reason why they switched. (In fact, a small group of students were redirected from another major and never intended to pursue chemistry in the first place.) Another highly cited reason, which was *not expected* because the research literature did not discuss this, was that students did not think that earning a chemistry degree was *useful*. Many students did not understand their career options and had misconceptions (e.g., chemistry majors must go to graduate school, all chemistry majors are premed) and other majors seemed more promising to their future. One reason for this view could be that the University of Illinois is a highly ranked STEM university overall so students have a lot of options in choosing a top major. Another more obvious reason is a lack of career knowledge about what they can do with a chemistry degree.

Aligned with both the research literature and the outcomes of Part One, both survey respondents and interviewed students cited issues with chemistry grade performance and math grade performance as reasons for switching out of the major. Some students also mentioned the combination of taking both courses at the same time, especially the first semester, affected their overall grade performance (and thus their first-semester GPA).

The lack of high school preparation that was more experiential in nature and related to independence was also related to retention in the chemistry major. It was expected that the students who left the major would report less high school preparation for their university chemistry classes, however some students in both the surveys and interviews also reported feeling overwhelmed with the course load because of time management and study skill issues, along with frustrations and inexperience with the university chemistry labs.

The students that left the chemistry major described several reasons that were directly associated with psychological predictors, as described by the literature. Students described feeling discouraged and like they could not succeed (related to self-confidence, self-esteem, ability, and self-worth), not enjoying the chemistry and feeling miserable (related to interest and motivation), not sure what chemists do and the major seems too general (related to identity and self-efficacy), afraid to take future math and physics classes (related to self-doubt, performance-avoidance orientation), and feeling like they just were not good at chemistry or math (fixed intelligence). Once a student felt dissatisfied and the investment needed to be successful in the chemistry major was too large, the other major seemed like a better alternative and the students left. Subjective task value also emerged in the students' descriptions. For some students, the utility value of the chemistry major was not worthwhile because it did not align with their future goals anymore. For others, there was not enough intrinsic value; the students did not enjoy it. For still others, it did not align with their student identity, especially if they were not knowledgeable on what careers were possible with a chemistry degree. And finally, for some, it was not worth the cost – the time needed to be successful was not worth missing out on other activities.

Lastly, many students who left the major did not report engagement with the chemistry major and courses. Very few reported participating in chemistry undergraduate research, having a chemistry study group, and feeling a sense of belonging in the chemistry major. Some Leavers reported that the chemistry major was socially isolating and they found a peer group in another major.

On the other hand, for those students who switched into the chemistry major (Switchers), engagement with the major and a connection with chemistry were keys to recruitment. Of those that reported participating in undergraduate research, the largest percentage (34.55%) were from those that switched into the major. Students also cited their research and lab experiences as a reason for switching. They also mentioned support from peers as important. Switchers reported positive experiences with professors and chemistry lectures. Since most of the students that switched into chemistry (73%) started in Chemistry 101 Introductory Chemistry and Chemistry 102 General Chemistry I, these courses play a key role in recruiting majors, even though they are not intentionally designed for students pursuing a chemistry degree (like Chemistry 202 Accelerated Chemistry I). This is also why flexibility in meeting degree requirements is important (e.g. LAS major as an option) so that it is easier for students to switch. Students specifically mentioned the flexibility of our major as a reason for switching. Overall, students that switched into chemistry expressed a genuine interest in the field, enjoyed the topics taught, and understood how earning a chemistry degree aligned with their career goals.

The quantitative and qualitative data provided by the Switchers aligned with psychological predictors associated with retention. Of the three groups, Switchers reported the highest mean (4.25 out of 5.0) in confidence to succeed in their chemistry major. This average, along with descriptions from the surveys and interviews, related to their strong self-confidence, self-esteem, and self-worth. They expressed great interest, enjoyment, and connection with chemistry (which was related to interest, motivation, and intrinsic value). They found utility value in their major because it aligned with their career goals and was associated with their self-identity.

Like the Switchers, students who initially declared the chemistry major and are still pursuing it (Persisters) cited their interest in chemistry and alignment with career goals as the main reasons for remaining in the major. As the literature supports, most Persisters initially chose the chemistry major because of positive high school experiences and a connection with the subject. They also felt the most academically prepared by their high schools for their chemistry and math coursework as compared to Leavers and Switchers, thus grade performance was not cited as an issue for this group. As with the other two groups, they cited a lack of preparation for university chemistry labs, although their connection with chemistry was reported as quite strong, thus it may have been enough to overcome this deficiency. Persisters also described active engagement with the major through participation in undergraduate research and having a sense of belonging in chemistry through peer groups and/or mentoring. Most of these students were also knowledgeable about the value of their chemistry degree and how it aligned with their career goals. And finally, they described positive experiences with most of their chemistry professors, classes, and the departmental staff overall such as advisors and career services.

Because women have a history of underrepresentation in chemistry and *continue* to be underrepresented at the University of Illinois, issues surrounding retention and recruitment by gender were also deeply explored. It was important to understand the experiences of UIUC chemistry majors by gender because nationally, a very minimal gap exists. First, the UIUC Chemistry Department does not recruit females into the chemistry major at the same rate as males, thus females start the chemistry major in the minority. One minor reason for this, as indicated in the survey, is that males are redirected to the chemistry major from some other major at a higher rate than females (survey reported 9 males were redirected versus 6 females). Then, this gap continues each subsequent year through graduation. Although the actual retention of chemistry majors varies each year by gender, the department recruits more males than females into the major so the gap widens and is well below the national trend by graduation. In fact, the percent makeup of female *graduate* students in chemistry has closely matched the percent makeup of female *undergraduate* students for the past three years (~38%).[8] The UIUC Chemistry Department is not the only campus unit with this issue, as Physics and Math/Statistics also have substantial gaps (~9% below the national trend for physics; ~10% below the national trend for math/statistics).[7,8] However other top-ranked science units such as biology and the agricultural sciences recruit and retain females that match the national trends (59% for biology; 54% for agricultural sciences)[7,8], thus demonstrating it is possible to meet national trend outcomes at this large, top-ranked, research I institution. Broadly speaking, it is difficult to compare UIUC Chemistry Department trends to peer institutions because most degree and enrollment data by campus unit are very difficult to obtain publicly. However, UIUC Chemistry appears to have a higher percentage of degrees awarded to females as compared to the University of Wisconsin-Madison (~30% awarded to females).[121] The University of Michigan-Ann Arbor shows similar trends in chemistry major enrollment at ~38% for females.[122]

Aligned with both the regression analysis from Part One and the research literature, more women started in lower-level STEM courses at the university versus men. Initial math course placement is determined by the ALEKS® placement test. Women had a lower overall mean on this test and subsequently enrolled in Math 112 (College Algebra), Math 115 (Precalculus), and Math 220/221 (Calculus I) at a higher rate than males (58% versus 46%). In addition, initial chemistry course placement is primarily determined by a combination of Math ACT and a chemistry placement exam, of which women again have lower overall means on both counts. The regression analysis for females showed that which math course a student initially enrolls in accounts for a significant amount of variance in predicting retention (the higher the course, the better). Placing into higher courses signals better high school preparation, which is supported by the research literature in predicting STEM retention.

The regression analysis and research literature also showed that participating in undergraduate research was linked to retention in chemistry for both males and females. Fortunately, both groups are exposed to this opportunity, with females currently accounting for 46% of those reporting research for credit. However, only about a third of declared chemistry majors actually participate in research. Since a smaller percentage of females indicated they wanted to attend graduate school in the future, involving more students in undergraduate research, especially females, is important so that they can make a more informed decision on what graduate school entails.

Overall, the results of the survey and interviews showed that females are less confident than males in believing they will succeed in their intended major, as supported by the research literature. This is especially true of the women currently persisting in the major, and even those who switched into the major. This lack of confidence aligned with females' emphasis on peer groups and sense of belonging to a community as important to their retention in their major. Having a support system helps build confidence and comraderie.[31]

Females that left the major cited issues with supporting coursework as one reason for leaving, which aligned with the regression analysis on females discontinuing math course enrollment as a significant factor contributing to retention. However, female Leavers also cited reasons that were beyond the regression analysis linked to math. They described many additional factors that were linked to the research literature on psychological predictors. Women Leavers cited reasons such as a lack of support from chemistry instructors, lack of support from the Chemistry Department such as poor advising, social isolation, and not having a sense of belonging in a chemistry community; all of which are important when self-confidence is weak. The literature also described women as more sensitive to the pressures of introductory "weed out" courses,[74,81,82] more sensitive to grades received,[84,85] and higher test anxiety.[87,88] This aligned with reported reasons for leaving including issues with chemistry coursework, a poor first semester experience, overwhelmed with course load, dissatisfaction with chemistry grade performance, not having a sense of being able to succeed in chemistry, and large class sizes. At the University of Illinois, freshman STEM classes are large, can be perceived as "weed out" courses, and grades are primarily determined by test performance. Females also described experiences related to stereotype threat including comments like "I realized Chemistry is still a male dominated STEM field and I didn't want to continue feeling inferior," "I need one-on-one time here so that I can talk it through with someone but people would look at me like I'm stupid, especially boys in the class…I felt like they looked down upon me because I was a women in science," "more resources for math help…it's hard for women in science to find others like them," and "How does [calculus] apply to chemistry? How do these classes affect females? I feel alone because it's mostly males." Whether this stereotype threat was real or perceived, it affected these women and their retention in the chemistry major. Women also described a lower self-assessment of their STEM skills and more fixed intelligence views than males with comments such as "I love chemistry…I'm just not that good at it," "calculus didn't click with my brain," and "I don't think I'm very good at calculus." And finally, common reasons for leaving the major which aligned with male Leavers were usefulness of the chemistry degree (utility value), alignment with career goals (chemistry career no longer aligned with their self-identity), and no longer feeling interested in chemistry (lack of intrinsic value and motivation). Female Leavers reported a lower rate of pursuing a STEM major, 71% versus 93% for males. For male Leavers, the primary reasons for leaving also included alignment with career goals, a lack of interest in chemistry, and not having a sense of belonging in chemistry. However, they also reported a high rate of not finding the chemistry degree useful and interest in another major. They also placed a smaller emphasis on issues with supporting coursework like math, which aligned with the regression analysis in Part One. On the other hand, in Part Two there was no relationship between male Leavers and type of high school attended (e.g., suburban high school versus others), which appeared in the regression for males in Part One.

Female and male Switchers shared many similar reasons for switching into the chemistry major such as finding chemistry interesting, aligning with career goals, connecting with chemistry as a subject, and enjoying the chemistry topics taught. However, female Switchers also described that having a sense that they could succeed in chemistry and belonged in the chemistry major also played roles in their decision. The female Leavers, on the other hand, described these components as lacking in their chemistry experiences. This aligned with the psychological predictor that self-confidence is important to retention and these two factors are important to boosting confidence. Female Switchers also reported that their high schools prepared them less for their university chemistry classes versus males, however their sense of feeling they could succeed in chemistry was enough to overcome this perception.

Female and male Persisters shared many of the same reasons for remaining in the chemistry major – interest in chemistry, alignment with career goals, sense of belonging in chemistry, sense of succeeding in chemistry, and support from family. However females also put greater emphasis on having a chemistry community of peers and use of the Career Services office (which contributes to greater professional role confidence and self-efficacy). Again, these factors are strongly tied to those psychological predictors that are linked to retention. When asked about how the department can improve experiences for students, female Persisters most often cited a better first-year experience, the need for a chemistry community, and better advising. These are all issues female Leavers mentioned as reasons for leaving the major. Thus, these issues are critical to improving since they are significant enough to cause females to leave the major. The female Persisters overcame these issues to remain in the major, but not all do and these improvements can be implemented in the department. Male Persisters most frequently cited improvements to the undergraduate research process including how to find a lab, mechanisms for more students to participate, and a standardization of research credit hours for time spent in lab.

Like females, underrepresented minority students (URMs) have a long-standing history of underrepresentation in the UIUC Chemistry Department. This underrepresentation is especially alarming for African-American students with a percent makeup of total degrees and chemistry majors well below the national trend every year. Initially, the recruitment of African-American and Hispanic chemistry majors vary from year to year; sometimes the percent total of URMs initially starting as chemistry majors matched the national trend and sometimes it was below. However, the retention rates of URMs in chemistry substantially dropped as compared to majority students, trending towards 42% for majority students versus 23% for underrepresented students. In addition, recruiting URMs into the chemistry major has also been lacking, specifically for African-American students. Thus, it was extremely important to the research study to explore retention and recruitment factors that were specifically linked to URMs.

As with females, underrepresented minority students placed into and started in lower-level STEM courses as compared to majority students. For example, a larger percentage of URMs started in Chemistry 101 Introductory Chemistry and Chemistry 102 General Chemistry I (68% versus 51% for majority students) and in Math 112 College Algebra, Math 115 Precalculus, and Math 220/221 Calculus I (71% versus 48% for majority students). This showed less high school STEM preparation among URMs, but may also be tied to the research literature on motivation and performance vulnerability in the face of lower expectations, through starting in these lower-level courses. In addition, URMs reported that their high schools prepared them better for other university classes (outside of chemistry and math) as compared to majority students. Thus, URMs indicated that academically they were prepared for non-STEM type courses, which would support them in moving out of a STEM field. From all of the URM Leavers surveyed and interviewed, 61% indicated that they were still pursuing a STEM degree versus 86% for majority students.

The research literature also includes discrimination as a factor for keeping underrepresented students from persisting in STEM.[99] However, both African-American and Hispanic students described their overall staff experiences as the most positive aspects of interacting with the UIUC Department of Chemistry. Overall staff experiences included interaction with professors, teaching assistants, and advisors. In both the survey and interviews, none of the URMs cited discrimination as a reason for leaving the major or described discriminatory acts occurring in their chemistry experiences overall.

For those that left the chemistry major, all groups cited the usefulness of the chemistry degree, alignment with career goals, and lack of interest in chemistry as the most common reasons for leaving. However, underrepresented students also cited that they did not have a sense of belonging in chemistry, which contributed to them leaving as well. Furthermore, URMs had lower rates of participating in chemistry study groups or having a chemistry peer community in their classes versus majority student Leavers. One URM Leaver commented, "In Chem 202, you're in there by yourself. I was the only African American kid. I was uneasy. There was one other African American, but he quickly switched to Chem 102 (said 202 is not for me). Made me feel like it wasn't for me…not really my place." This aligned with the research literature showing that academic and cultural isolation are two factors that keep URMs from persisting in STEM.[99] URM Leavers also reported the lowest means among *all groups* for high school preparation in study skills and time management needed to be a successful college student. This makes the transition to college and academic performance particularly vulnerable for this group.

Underrepresented student Persisters showed sharp contrasts with the underrepresented student Leavers in their experiences with chemistry, signaling factors that led to their persistence in the major. First, URM Persisters reported that their high school prepared them better in several areas including university chemistry classes, university math classes, other university classes, study skills needed, time management, and thus a greater confidence to succeed as a student. They also cited several reasons that contributed to remaining in the major such as their interest in chemistry, alignment with career goals, sense of succeeding in chemistry, ability to learn chemistry concepts quickly, sense of belonging in chemistry, and support from family. The URM Leavers also cited alignment with career goals and a sense of belonging in chemistry (a lack thereof) as reasons for leaving. These reasons cited by the URM Persisters are also much more varied as compared to non-URM Persisters, which only frequently cited interest in chemistry and alignment with career goals as reasons for remaining in the major.

URM Persisters also had much higher rates of working in chemistry study groups and sensing that they were a part of a chemistry community, especially among those interviewed. These students described their community as the main reason for staying in the major. Moreover, some of the URM Persisters suggested the creation of a peer mentoring system as one significant improvement the UIUC Chemistry Department can make moving forward. Some of the URM Persisters interviewed were actively doing undergraduate research in faculty labs, which has been shown in the literature to increase STEM persistence and improve performance goals over time in their coursework.[36] The UIUC Chemistry Department has made a concerted effort in the last few years to involve more URM chemistry majors in research as evidenced by the increasing percentage of URMs now participating and currently matching the actual percentage of URMs in the chemistry major. Some of the URM Persisters interviewed described the importance of faculty interaction in their classes as critical to their retention, which again is supported by the research literature.[36] Finally, some URM Persisters discussed their involvement in the Chemistry Merit Program for Emerging Scholars and/or the Merit Fellows Scholarship Program as most significant to remaining in the chemistry major.

The Chemistry Merit Program for Emerging Scholars has a long history of success at the University of Illinois, particularly in improving academic performance, STEM retention/recruitment, and peer collaboration.[2] The Merit Program implements Uri Treisman's model of collaborative–cooperative instruction methods developed at the University of California, Berkeley during the 1970s. A highly trained facilitator stimulates student–student interactions by providing a challenging worksheet or activity for the students, then circulates around the classroom to give constructive feedback as the students work together in small groups. At UIUC, we implement this program by having Merit participants attend the same lectures and labs as other students in the course and take the same exams, and—in addition—they meet weekly for Merit workshops lasting two hours. Each workshop contains about 22 students. These workshops replace the regular recitation sections. Although workshop questions are based on material covered in lectures, they are designed to stretch each

[2] A research article on the Chemistry Merit Program, including its successes, appeared in its entirety in the Journal of Chemical Education. Adams, G.; Lisy, J. M.; The Chemistry Merit Program: Reaching, Teaching, and Retaining Students in the Chemical Sciences. *J. Chem. Educ*. **2007**, *84*, 721-726. A portion of this article is reprinted with the permission of the publisher and is available at http://jchemed.chem.wisc.edu/.

student's abilities to the fullest extent. The facilitator gives "few answers on the mechanics of problem solving, but rather encourages the students to think out loud, giving everyone in the group a chance to interact and react to each student's thoughts". Having different groups of students compare their answers further encourages student–student interaction. This peer teaching can expose student misconceptions and promotes a more conceptual understanding of the material. The Merit Program provides a setting in which they can see that many other students also struggle with the material and that by working hard, staying motivated, and asking questions, they too can be successful science students in college. In summary, "the students help each other with difficult course problems, develop friendships based on common academic interests, and inspire each other to maintain a high level of commitment to excellence in an atmosphere of trust and respect". In addition, many of our facilitators are former Merit students themselves or plan to pursue teaching careers in the future. As a result, they often mentor the current Merit students on how to be successful in college. The students in our program also receive additional advising support from the Merit Program director, extending all the way to graduation. The Chemistry Merit Program is modeled after other programs cited in the literature demonstrating that active learning in introductory STEM courses, along with support and motivation, increases STEM persistence and performance.[31]

However, a further refinement of this program led to the Merit Fellows Scholarship Program, which additionally adds on early research experiences, membership in a chemistry learning community, and more active mentoring and advising, specifically to underrepresented chemistry majors.[3] The Merit Fellows Program is for a select group of Merit students majoring in chemistry, integrative biology, or mathematics. It is partially funded by an S-STEM grant (Award #1154189) sponsored by the National Science Foundation. Students are selected in the middle of their freshman year after a rigorous application process, interview, and demonstration of financial need. The goal of this program is to increase the number of underrepresented students graduating with degrees in chemistry, integrative biology, and mathematics. In addition to participating in Merit sections, these students receive additional services that include renewable scholarships, mentoring, research opportunities, and community-building activities in both social and professional settings. To date, there are 16 Chemistry Merit Fellows and all 16 of them are on track and continuing their path towards a chemistry degree (100% retention rate). One student even graduated a year early and is now participating in an internship for the National Institutes of Health (NIH), while currently applying to MD/PhD programs.

Although not specifically linked to retention in the chemistry major, much as the literature also supports, a few URM Persisters mentioned that they desired a better representation of same-race peers in their upper-level chemistry classes. One URM student commented that s/he would like "more representation of the demographics in classes…we need more people of color – there is no one to look up to because they switch to other majors." Another student said "in higher level classes there are less minorities and it's discouraging in a sense...seeing other people that look like me and push me from similar backgrounds that I can

[3] A paper was presented on the Merit Fellows Scholarship Program at the National Science Teachers Association National Meeting. Adams, G.; McNeilly, J. The Merit Model and Recruitment/Retention of STEM Majors: How It Works and How We Know. **2015**. Presented at the Society for College Science Teachers portion of the National Science Teachers Association National Meeting.

relate to." Thus, underrepresented minority chemistry majors are truly *underrepresented*, so a better URM recruitment effort by the UIUC Chemistry Department, peer groups in courses, mentoring, and an inclusive chemistry community are pivotal to their success throughout their *entire* undergraduate experience at this university.

Limitations

The results of this research study must be considered in light of several limitations regarding the data and generalizability of the findings. First and foremost, the student survey response rates were fairly low, especially for former chemistry majors. Greater response rates were desired and perhaps offering a monetary incentive would have boosted those rates. Next, although the students that switched into chemistry and earned the degree (or declared the major) could be tracked, those students that did not initially declare and wanted to switch into chemistry or did switch and then move out again were not tracked. Thus, I have no data or feedback on those students that intended to pursue the chemistry degree from some other major (such as undeclared) but were unsuccessful or changed their mind. Third, this study used samples from a single, large, top-tier, research I university and highly ranked chemistry program, not from multiple institutions with the same background. It is not certain if the same trends would exist, however the same methodology can be used to check for a similar representation of students and results. Additionally, another way to approach Part Two of the study could have been to initially survey and interview declared chemistry majors as incoming freshman and then incrementally survey and interview them again at different points of their undergraduate career (e.g. freshman year, sophomore year, etc.). That way changes in attitudes, feelings, psychological predictors, and perspectives could have been evaluated versus gathering information at one point in time that depended on their current state and remembering past experiences. This would have also allowed an initial, in-depth understanding of why students initially chose the chemistry major. For example, when a student stated that they chose chemistry because they were “interested in chemistry” or “enjoyed chemistry,” what exactly did they mean? Was it that they were intrigued by the scientific approach, the topics, or that they earned high grades in high school in this subject and felt “good at it”? Due to the other questions that needed to be asked on the survey and in the interviews, a lot of time was not spent probing this issue, especially because it required remembering past decisions. However, that initial reason for choosing chemistry could be directly linked to why they remained in the major or left. Overall, this longitudinal approach was not feasible due to the time frame required to complete it (up to 4-6 years for one incoming class). And finally, some of the sample sizes were small (e.g., underrepresented minority students, rural students, microurban students, etc.), so generalizability was challenging when performing statistical analyses. However to compensate for that issue, oversampling of certain populations occurred such as with underrepresented minority students, especially for the interviews.

Implications and Future Direction

The purpose of this two-part research study was to determine the factors that lead to retention and recruitment of chemistry majors at a large, top-tier, research I university and highly ranked chemistry program. These results will inform instructors and departmental administrators so that they can understand what programmatic and curricular changes need to take place, including for those students that are underrepresented. Furthermore, understanding why students switch into chemistry can lead to a more robust recruiting effort on behalf of the department and instructors.

This study gives valuable future direction for the UIUC Chemistry Department and top-tier, research I chemistry programs across the nation. Based on the results and analyses, the following changes are recommended:

- Semester-long course solely for new chemistry majors and those interested in the chemistry major to create an academic learning community centered just around the major. This course would incorporate study skills and time management, career services so that students understand their career possibilities with a chemistry degree, how to get involved in undergraduate research, academic resources, and most importantly – foster the creation of a chemistry community and chemistry study groups.
- Creation of an organized and highly promoted mentoring program consisting of faculty, graduate students, and undergraduate students. This program would facilitate mentoring between faculty-undergraduate students, graduate-undergraduate students, and upperclassman-lowerclassman students.
- Increased academic advising requirements for first-year students such as meeting every two weeks to address math coursework progress, chemistry coursework progress, course load management, student satisfaction and well being, and resources for those students that are struggling in certain courses.
- Curricular changes to chemistry courses that address the frustrations and inexperience with chemistry labs, in addition to brainstorming chemistry content and pedagogy that will engage and interest chemistry majors. Furthermore, additional curricular revisions are needed that connect the required math coursework to chemistry concepts

experienced early in a major's career, instead of waiting for advanced-level chemistry coursework for students to make this connection. Finally, improvements are needed with the online Chemistry 232 (organic chemistry I) course, as students expressed the most frustration with this class.

- Recruitment efforts to attract more females and underrepresented minorities to the chemistry major, both at the pre-college and college levels. In addition, organized outreach with K-12 teachers, especially at the high school level, to provide mentoring and collaboration on how to better prepare students for the transition to a large, top-ranking chemistry program.
- Organized opportunities for females and underrepresented students to connect with same-sex and same-race/ethnic people that are also interested in chemistry. This could include faculty, graduate students, industrial scientists, medical personnel with chemistry degrees, club organizations, and/or other peers. It could also include an expansion of the Merit Fellows Scholarship Program, which provides these opportunities, in addition to financial, academic, and social support.

If these changes are implemented, it would be extremely valuable to continue mixed-methods studies to analyze whether these recommended changes improve retention and recruitment of chemistry majors, especially among underrepresented groups. However, given the large number of chemistry majors at an institution like the University of Illinois, the scalability of these interventions need to be explored as well.

Conclusion

The University of Illinois Chemistry Program and other top-tier chemistry programs across the country have the opportunity to answer President Obama's call to increase the number of high quality STEM majors graduating specifically with a chemistry degree. A program such as this one gives students the opportunity to do world-class research and learn from top-notch faculty that are experts in their field. However, given the size and emphasis on research as a priority, it does present some challenges. Some of these challenges have become the reasons why students have left the major including a lack of career knowledge, issues with the high-level chemistry coursework, issues with the high-level math and physics coursework, range of high school preparation, lack of a chemistry community, poor recruitment of underrepresented groups, and a lack of effective mentoring/advising. These issues can be appropriately addressed and tested to measure improvements in retaining and recruiting students in the chemistry major. In addition, a special emphasis to address the needs of females and underrepresented minorities must take place in order to close the gap and improve retention for these subpopulations of students. From this study, top-tier institutions like the University of Illinois can use this information to become the leader of chemistry retention and recruitment and produce top-quality graduates that make significant differences for our society in the years to come.

BIBLIOGRAPHY

1. National Science Board. *Science and Engineering Indicators 2016*. Arlington, VA: National Science Foundation. NSB-2016-1. 2016. http://www.nsf.gov/statistics/2016/nsb20161/#/report (accessed Feb 2016).

2. Feder, M. *One Decade, One Million more STEM Graduates.* Office of Science and Technology Policy 2012. https://www.whitehouse.gov/blog/2012/12/18/one-decade-one-million-more-stem-graduates (accessed Feb 2016).

3. President's Council of Advisors on Science and Technology (PCAST) in a report to the President. *Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics.* Executive Office of the President. 2012.

4. Berliner, D.C.; Glass, G.V.; et. al *50 Myths & Lies That Threaten America's Public Schools: The Real Crisis in Education*; Teachers College Press: New York, NY, 2014, pp 203-208.

5. Physical sciences include astronomy, chemistry, physics, earth, atmospheric, and ocean sciences and physical sciences, n.e.c. (not elsewhere classified). Social sciences include anthropology, area/ethnic studies, economics, history of science, linguistics, political science/public administration, sociology, and other social sciences.

6. Morse, R.; Tolis, D. Top-ranked Universities that Grant the Most STEM Degrees. *U.S. News & World Report*, 2013. http://www.usnews.com/education/blogs/college-rankings-blog/2013/06/18/top-ranked-universities-that-grant-the-most-stem-degrees (accessed Jan 2016).

7. Flanigan, S.; Morse, R. Best Grad Schools Rankings. *U.S. News & World Report*. 2014. http://grad-schools.usnews.rankingsandreviews.com/best-graduate-schools/top-science-schools/chemistry-rankings (accessed Jan 2016).

8. Division of Management Information. 2014-2015 Campus Profile. *University of Illinois at Urbana-Champaign*. 2015. http://dmi.illinois.edu/cp/ (accessed Feb 2016).

9. 2014 ACT National and State Scores. ACT, Inc. 2016. http://www.act.org/newsroom/data/2014/states.html (accessed Jan 2016).

10. Scott, T. P.; Tolson, H. H. T. Y. Predicting Retention of Mathematics and Science Majors at a Research One Institution and Suggested Advising Tools. *Journal of College Admission*. **2008**.

11. Abdel-Salam, T.; Kauffmann, P.; Williamson, K. A Case Study: Do High School GPA/SAT Scores Predict the Performance of Freshmen Engineering Students? **2005**. Presented at the Frontiers in Education 2005 35th Annual Conference.

12. Levin, J.; Wyckoff, J. Predicting Persistence and Success in Baccalaureate Engineering. *Education.* **1991**, *111*, 461−468.

13. Mendez, G.; Buskirk, T. D.; Lohr, S.; Haag, S. Factors Associated With Persistence in Science and Engineering Majors: An Exploratory Study Using Classification Trees and Random Forests. *J. Eng. Educ*. **2008**, *97*, 57−70.

14. Haemmerlie, F. M.; Montgomery, R. L. Gender Differences in the Academic Performance and Retention of Undergraduate Engineering Majors. *College Student Journal*, **2012**, *46*(1), 40.

15. Spencer, H. E. Mathematical SAT Test Scores and College Chemistry Grades. *J. Chem. Educ*. **1996**, *73*, 1150.

16. Zhang, G.; Anderson, T. J.; Ohland, M. W.; Thorndyke, B. R. Identifying Factors Influencing Engineering Student Graduation: A Longitudinal and Cross-Institutional Study. *J. Eng. Educ*. **2004**, *93*, 313−320.

17. Hazari, Z.; Tai, R. H.; Sadler, P. M. Gender Differences in Introductory University Physics Performance: The Influence of High School Physics Preparation and Affective Factors. *Sci. Educ*. **2007**, 91, 847−876.

18. Lee, J.; Judy, J. Choosing a STEM Path: Course-Sequencing in High School and Postsecondary Outcomes. *Society for Research on Educational Effectiveness*. **2010**.

19. Riegle-Crumb, C.; Moore, C; Ramos-Wada, A. Who Wants to Have a Career in Science or Math?: Exploring Adolescents' Future Aspirations by Gender and Race/Ethnicity. *Science Education*. **2011**, 95(3), 458–476.

20. Mau, W. C. Factors That Influence Persistence in Science and Engineering Career Aspirations. *Career Dev. Q*. **2003**, *51*, 234−243.

21. Maltese, A. V., & Tai, R. H.; Pipeline persistence: Examining the association of educational experiences with earned degrees in STEM among U.S. students. *Science Education*. **2011**, *95*(5), 877–907. doi:10.1002/sce.20441

22. Csikszentmihalyi, M.; Schneider, B. *Becoming Adult: How Teenagers Prepare for the World of Work*. Basic Books: New York, NY, 2000.

23. Schneider, B.; Stevenson. D. *The Ambitious Generation: America's Teenagers, Motivated but Directionless*. Yale University Press: New Haven, CT, 1999.

24. Schneider, B. *Forming a College-Going Community in U.S. Public High Schools*. Bill & Melinda Gates Foundation: Seattle, WA, 2007.

25. Schneider, B. Inspiring Youth to Careers in Science and Medicine: Lessons from the Sloan Study of Youth and Social Development. **2008**. Presented at the Social Science Perspectives on Workforce Policy Conference, Center for Disease Control. Atlanta, GA.

26. Felder, R. M.; Mohr, P. H.; Dietz, E. J.; Baker Ward, L. A Longitudinal Study of Engineering Student Performance and Retention II. Rural/Urban Student Differences. *Journal of Engineering Education*. **1994**, *83*(3), 209–217. doi:10.1002/j.2168-9830.1994.tb01106.x

27. Jensen, J.; Neeley, S.; Hatch, J.; Piorczynski, T. Learning Scientific Reasoning Skills May Be Key to Retention in Science, Technology, Engineering, and Mathematics. *Journal of College Student Retention: Research, Theory & Practice*. **2015**, *0*, 1–19. doi: 10.1177/1521025115611616

28. Heilbronner, N. N. Stepping Onto the STEM Pathway: Factors Affecting Talented Students' Declaration of STEM Majors in College. *Journal for the Education of the Gifted*. **2011**, 1–24. doi:10.1177/0162353211425100

29. Sadler, P. M.; Tai, R. H. High School Chemistry Instructional Practices and Their Association with College Chemistry Grades. *J. Chem. Educ*. **2007**, *84*, 1040.

30. Tai, R. H.; Ward, R. B.; Sadler, P. M. High School Chemistry Content Background of Introductory College Chemistry Students and Its Association with College Chemistry Grades. *J. Chem. Educ*. **2006**, *83*, 1703.

31. Graham, M. J.; Frederick, J.; Byars-Winston, A.; Hunter, A. B.; Handelsman, J. Increasing Persistence of College Students in STEM. *Science*. **2013**, *341*(6153), 1455–1456. doi:10.1126/science.1240487

32. Seymour, E.; Hewitt, N. M. *Talking About Leaving: Why Undergraduates Leave the Sciences*. Westview Press: Boulder, CO, 1997.

33. Astin, A.W. *What Matters in College? Four Critical Years Revisited*. Jossey-Bass: San Francisco, CA, 1993.

34. Kuh, G.D.; Hu, S. The Effects of Student-Faculty Interaction in the 1990s. *Rev. Higher Educ*. **2001**, *24*(3), 309–332.

35. Pascarella, E.T.; Terenzini, P.T. *How College Affects Students, Vol. 2, A Third Decade of Research*. Jossey-Bass: San Francisco, CA, 2005.

36. Newman, C. Engineering Success: The Role of Faculty Relationships with African American Undergraduates. *Journal of Women and Minorities in Science and Engineering*. **2011**, *17*(3), 193–207. doi:10.1615/JWomenMinorScienEng.2011001737

37. Packard, B. W. Mentoring and Retention in College Science: Reflections on the Sophomore Year. *Journal of College Student Retention: Research, Theory and Practice*. **2004**, *6*(3), 289–300. doi:10.2190/RUKP-XGVY-8LG0-75VH

38. Kapraun, E. D., Jr; Coldren, D. W. Academic Advising to Facilitate Student Retention. *NACADA Journal*. **1982**.

39. Felder, R. M.; Felder, G. N.; Dietz, E. J. A Longitudinal Study of Engineering Student Performance and Retention. V. Comparisons with Traditionally-Taught Students. *Journal of Engineering Education*. **1998**, *87*(4), 469–480. doi:10.1002/j.2168-9830.1998.tb00381.x

40. Dawson, P.; van der Meer, J.; Skalicky, J.; Cowley, K. On the Effectiveness of Supplemental Instruction: A Systematic Review of Supplemental Instruction and Peer-Assisted Study Sessions Literature Between 2001 and 2010. *Review of Educational Research*. **2014**, *84*(4), 609–639. doi:10.3102/0034654314540007

41. Gosser,D.K.; Roth, V. The Workshop Chemistry Project: Peer-led Team Learning. *Journal of Chemical Education*. **1998**, *75*, 185.

42. Gosser, D.K.; Cracolice, M.; Kampmeier, J.A.; Roth, V.; Strozak, V.S.; Varma-Nelson, P. *Peer-led Team Learning: A Guidebook*. Prentice Hall: Upper Saddle River, NJ, 2001.

43. Lewis, S; Lewis, J.E. Departing from Lectures: A Peer-led Guided Inquiry Alternative. *J. Chem. Educ*. **2005**, 82, 135–139.

44. Hockings, S.C.; DeAngelis, K.J.; Frey, R.F. Peer-led Team Learning in General Chemistry: Implementation and Evaluation. *J. Chem. Educ*. **2008**, 85, 990–996.

45. Wamser, C.C. Peer-led Team Learning in Organic Chemistry: Effects on Student Performance, Success, and Persistence in the Course. *J. Chem. Educ*. **2006**, 83, 1562–1566.

46. Lyon, D.C.; Lagowski, J.J. Effectiveness of Small-Group Learning in a Large Lecture Class. *J. Chem. Educ*. **2008**, 85, 1571–1576.

47. Preszler, R.W. Replacing Lecture with Peer-led Workshops Improves Student Learning. *CBE-Life Sciences Education*. **2009**, 8, 182–192.

48. Horwitz, S.; Rodger, S.H. Using Peer-Led Team Learning to Increase Participation and Success of Underrepresented Groups in Introductory Computer Science. *SIGCSE*, 2009.

49. Loui, M.C.; Robbins, B.A. Work in Progress - Assessment of Peer-led Team Learning in an Engineering Course for Freshman. **2008**. Presented at the Frontiers in Education 2008 38th Annual Conference.

50. Becvar, J.; Two Plus Two Equals More: Modifying the Chemistry Curriculum at UTEP. *Progressions*. **2004**.

51. Richardson, J.; Dantzler, J. Effect of a Freshman Engineering Program on Retention and Academic Performance. *Conference on Frontiers in Education*. 2002, *3*(3). doi:10.1109/FIE.2002.1158656

52. Cooley, W. L.; Prucz, M. Live and Learn: Program for Recruitment/Retention. *Frontiers in Education 1997 27th Annual Conference. Teaching and Learning in an Era of Change*. 1997, *1*(1), 80–82. doi:10.1109/FIE.1997.644815

53. deProphetis Driscoll, W.; Gelabert, M.; Richardson, N. Efficacy of Using Learning Communities To Improve Core Chemistry Education and Increase Student Interest and Retention in Chemistry. *J. Chem. Educ*. **2010**, *87*(1), 49–53. doi:10.1021/ed800021f

54. Pence, L. E.; Workman, H. J.; Haruta, M. E. A General Chemistry and Precalculus First-Year Interest Group (FIG): Effect on Retention, Skills, and Attitudes. *J. Chem. Educ*. **2005**, *82*(1), 65. doi:10.1021/ed082p65

55. Bowling, B.; Bullen, H.; Doyle, M.; Filaseta, J. Retention of STEM Majors Using Early Undergraduate Research Experiences. *Proceeding of the 44th ACM Technical Symposium*. New York, New York, USA: ACM. 2013, 171–176. doi:10.1145/2445196.2445249

56. Seymour, E.; Hunter, A.; Laursen, S.L.; Deantoni, T. Establishing the Benefits of Research Experiences for Undergraduates in the Sciences: First Findings From a Three-year Study. *Science Education*. **2004**, 88, 493–534.

57. Schowen, B. Value and Impact of Undergraduate Research in Chemistry: Lessons Gained From 45 Years of Experience at the University of Kansas. *ConfChem Conference on Undergraduate Research,* 2002.

58. Summers, M. F.; Hrabowski III, F.A. Preparing Minority Scientists and Engineers. *Science.* **2006**, *311*(5769), 1870–1871.

59. Besterfield-Sacre, M.; Atman, C. J.; Shuman, L. J. Characteristics of Freshman Engineering Students: Models for Determining Student Attrition in Engineering. *J. Eng. Educ*. **1997**, *86*, 139–149.

60. Bauer, C. F. Beyond ''Student Attitudes'': Chemistry Self-Concept Inventory for Assessment of the Affective Component of Student Learning. *J. Chem. Educ*. **2005**, *82*, 1864.

61. Reardon, R. F.; Traverse, M. A.; Feakes, D. A.; Gibbs, K. A.; Rohde, R. E. Discovering the Determinants of Chemistry Course Perceptions in Undergraduate Students. *J. Chem. Educ*. **2010**, *87*(6), 643–646. doi:10.1021/ed100198r

62. Crocker, J.; Luhtanen, R. K.; Cooper, M. L.; Bouvrette, A. Contingencies of Self-Worth in College Students: Theory and Measurement. *J. Pers. Soc. Psychol*. **2003**, *85*, 894−908.

63. Ackerman, P. L.; Kanfer, R.; Beier, M. E. Trait Complex, Cognitive Ability, and Domain Knowledge Predictors of Baccalaureate Success, STEM Persistence, and Gender Differences. *J. Educ. Psychol*. **2013**, *105*, 911−927.

64. Shedlosky-Shoemaker, R.; Fautch, J. M. Who Leaves, Who Stays? Psychological Predictors of Undergraduate Chemistry Students' Persistence. *J. Chem. Educ*. **2015**, *92*(3), 408–414. doi:10.1021/ed500571j

65. Rusbult, C. E.; Martz, J. M.; Agnew, C. R. The Investment Model Scale: Measuring Commitment Level, Satisfaction Level, Quality of Alternatives, and Investment Size. *Pers. Relat*. **1998**, *5*, 357−387.

66. Andersen, L.; Ward, T. J. Expectancy-Value Models for the STEM Persistence Plans of Ninth-Grade, High-Ability Students: A Comparison Between Black, Hispanic, and White Students. *Sci. Educ*. **2014**, *98*, 216−242.

67. Marra, R. M.; Rodgers, K. A.; Shen, D.; Bogue, B. Women Engineering Students and Self-Efficacy: A Multi-Year, Multi-Institution Study of Women Engineering Student Self-Efficacy. *J. Eng. Educ*. **2009**, *98*, 27−38.

68. Perez, T.; Cromley, J. G.; Kaplan, A. The Role of Identity Development, Values, and Costs in College STEM Retention. *J. Educ. Psychol*. **2014**, *106*, 315−329.

69. Oleson, K. C.; Poehlmann, K. M.; Yost, J. H.; Lynch, M. E.; Arkin, R. M. Subjective Overachievement: Individual Differences in Self-Doubt and Concern With Performance. *J. Pers*. **2000**, *68*, 491−524.

70. Dweck, C. S.; Chiu, C.; Hong, Y. Implicit Theories and Their Role in Judgments and Reactions: A Word From Two Perspectives. *Psychol. Inq*. **1995**, *6*, 267−285.

71. Elliot, A. J.; Church, M. A. A Hierarchical Model of Approach and Avoidance Achievement Motivation. *J. Pers. Soc. Psychol*. **1997**, *72*, 218−232.

72. Cacioppo, J. T.; Petty, R. E.; Feng Kao, C. The Efficient Assessment of Need for Cognition. *J. Pers. Assess*. **1984**, *48*, 306−307.

73. Ryan, R. M. Control and Information in the Intrapersonal Sphere: An Extension of Cognitive Evaluation Theory. *J. Pers. Soc. Psychol*. **1982**, *43*, 450−461.

74. Brandt, R. *Why do Undergraduate Women Persist as Stem Majors? A Study at Two Technological Universities*. Seton Hall University Dissertations and Theses. 2014.

75. Griffith, A. L. Persistence of Women and Minorities in STEM Field Majors: Is It the School that Matters? *Econ. Educ. Rev*. **2010**, *29*, 911− 922.

76. Halpern, D.F.; A Different Answer to the Question, "Do Sex-related Differences in Spatial Abilities Exist?" *American Psychologist*, **1986**, *41*(9), 1014–1015.

77. Fennema, E.; Peterson, P. *Classroom Processes, Sex Differences, and Autonomous Learning Behaviors in Mathematics*. University of Wisconsin-Madison: Madison, WI, 1984.

78. Modi, K.; Schoenerg, J.; Salmond, K. *Generation STEM: What Girls Say About Science, Technology, Engineering, and Math*. Girl Scout Research Institute. 2012.

79. Lubinski, D.; Persson Benbow, C. *Sex Differences in Personal Attributes for the Development of Scientific Expertise*. In S. Ceci & W. Williams (Eds.), Why Aren't More Women in Science?, 2nd ed., 79–100). American Psychological Association: Washington, D.C., 2007.

80. Kimmel, L. G.; Miller, J. D.; Eccles, J. S. Do the Paths to STEMM Professions Differ by Gender? *Peabody J. Educ*. **2012**, *87*, 92−113.

81. Bettinger, E.; Long, B. Female Role Models for Female College Students. *American Economic Review Papers and Proceedings*. **2005**, *95*(2), 152–157.

82. Hughes, W. J. Perceived Gender Interaction and Course Confidence Among Undergraduate Science, Mathematics, and Technology Majors. *J. Women Minor. Sci. Eng*. **2000**, *6*, 14.

83. Diekman, A. B.; Brown, E. R.; Johnston, A. M.; Clark, E. K. Seeking Congruity Between Goals and Roles: A New Look at Why Women Opt Out of Science, Technology, Engineering, and Mathematics Careers. *Psychol. Sci*. **2010**, 21, 1051−1057.

84. Ost, B. The Role of Peers and Grades in Determining Major Persistence in the Sciences. *Economics of Education Review*. **2010**, *29*, 923–934.

85. Miyake, A.; Kost-Smith, L. E.; Finkelstein, N. D.; Pollock, S. J.; Cohen, G. L.; Ito, T. A. Reducing the Gender Achievement Gap in College Science: A Classroom Study of Values Affirmation.

Science. **2010**, *330*, 1234−1237. doi:10.1126/science.1195996

86. Brainard, S.G.; Carlin, L. A Six-year Longitudinal Study of Undergraduate Women in Engineering and Science. *Journal of Engineering Education*. **1998**, *87*(4), 369–375.

87. Lynch, D.J. Confronting Challenges: Motivational Beliefs and Learning Strategies in Difficult College Courses. *College Student Journal*. **2008**, *42*(2) , 416-421.

88. Lynch, D.J. Motivational Beliefs and Learning Strategies as Predictors of Academic Performance in College Physics. *College Student Journal*. **2010**, *44*(4) , 920-927.

89. Stout, J. G.; Dasgupta, N.; Hunsinger, M.; McManus, M. A. STEMing the Tide: Using Ingroup Experts to Inoculate Women's Self-Concept in Science, Technology, Engineering, and Mathematics (STEM). *J. Pers. Soc. Psychol*. **2011**, *100*, 255−270.

90. Hill, C.; Corbett, C.; St. Rose, A. *Why So Few? Women in Science, Technology Engineering and Mathematics*. AAUW: Washington, D.C., 2010.

91. Cromley, J. G.; Perez, T.; Wills, T. W.; Tanaka, J. C.; Horvat, E. M.; Agbenyega, E. T.-B. Changes in Race and Sex Stereotype Threat Among Diverse STEM Students: Relation to Grades and Retention in the Majors. *Contemporary Educational Psychology*. **2013**, *38*(3), 247–258. doi:10.1016/j.cedpsych.2013.04.003

92. Cech, E.; Rubineau, B.; Silbey, S.; Seron, C. Professional Role Confidence and Gendered Persistence in Engineering. *American Sociological Review*. **2011**, *76*, 641–666.

93. Wilson, D. M.; Bates, R.; Scott, E. P.; Painter, S. M.; Shaffer, J. Differences in Self-Efficacy Among Women and Minorities in STEM. *Journal of Women and Minorities in Science and Engineering*. **2015**, *21*(1). doi:10.1615/JWomenMinorScienEng.2014005111

94. Ceci, S. J.; Williams, W. M.; Barnett, S. M. Women's Underrepresentation in Science: Sociocultural and Biological Considerations. *Psychol. Bull*. **2009**, *135*, 218−261.

95. Muller, C. B.; Pavone, M. L. Retaining Undergraduate Women in Science, Math, and Engineering: A Model Program. **1997**, *1*, 130–133. Presented at the Frontiers in Education 1997 27th Annual Conference. Teaching and Learning in an Era of Change, Stipes Publishing. doi:10.1109/FIE.1997.644825

96. Marra, R.A.; Edmister, W.B.; Watford, B.B.; Bogue, B.C.; Tsai, C.L.A.; Gooden, F.B. Peer Mentoring: Impact on Mentees and Comparison with Non-participants. **2010**. Presented at the ASEE Annual Conference and Exposition, Louisville, KY.

97. Garrison, H.H.; *Minorities: Their Underrepresentation and Career Differentials in Science and Engineering*, L. S. Dix, Ed. National Academy Press: Washington, DC, 1987.

98. Nettles, M.T.; *Toward Black Undergraduate Student Equality in American Higher Education*. Greenwood Press: New York, 1988.

99. Allen, W.R.; The Color of Success: African-American College Student Outcomes at Predominantly White and Historically Black Public Colleges and Universities. *Harvard Ed. Rev*. **1992**, *62*, 26.

100. Steele, C.M.; Aronson, J. Stereotype Threat and the Intellectual Test Performance of African Americans. *Personality Soc. Psych*. **1995**, *69*, 797.

101. Gandara, P.; Maxwell-Jolly, J. *Priming the Pump: A Review of Programs That Aim to Increase the Achievement of Underrepresented Minority Undergraduates*. College Board: New York, 1999.

102. American Council on Education. *Minorities in Higher Education 2003–2004: Twenty-First Annual Status Report*. Washington, DC: American Council on Education. 2005.

103. Hernandez, P.; Schultz, P. W.; Estrada, M.; Woodcock, A.; Chance, R. C.; Sustaining Optimal Motivation: A Longitudinal Analysis of Interventions to Broaden Participation of Underrepresented Students in STEM. *Journal of Educational Psychology*. **2013**, 1–20. doi:10.1037/a0029691.supp

104. Matsui, J.; Liu, R.; Kane, C.M. Evaluating a Science Diversity Program at UC Berkeley: More Questions Than Answers. *Cell Biol. Educ*. **2003**, *2*, 117–121.

105. Weston, T. *LA-STEM Student Outcome Report*. 2009. https://sites01.lsu.edu/wp/osi/files/2014/09/Dr-Tim-Westons-LA-STEM-Propensity-Report2.pdf (accessed Feb 2016)

106. Shavelson, R.; Towne, L. Eds. *Scientific Research in Education*. Washington, DC: National Academy Press. 2002.

107. Westat, J. The 2010 User-Friendly Handbook for Project Evaluation. *National Science Foundation*. 2010. https://www.purdue.edu/research/docs/pdf/2010NSFuser-friendlyhandbookforprojectevaluation.pdf (accessed Feb 2016).

108. Bamberger, M. Introduction to Mixed Methods in Impact Evaluation. *InterAction Impact Evaluation Guidance Notes*. 2012, 1. http://www.interaction.org/document/guidance-note-3-introduction-mixed-methods-impact-evaluation (accessed Feb 2016).

109. Greene, J.C. *Mixed Methods in Social Inquiry*. Jossey-Bass: San Francisco, CA, 2007.

110. Kane, M.; Trochim, W. *Concept Mapping for Planning and Evaluation*. Sage Publications: Thousand Oaks, CA, 2007.

111. Greene, J.C.; DeStefano, L.; Burgon, H., et. al. New Directions for Evaluation. **2006**, *109*, 53-71.

112. High school GPA and high school class ranking were not used as predictor variables because these are self-reported by the students. The validity of these variables is not reliable due to the inconsistency of how these are determined by high schools.

113. Statistical Analyses Using SAS. Institute for Digital Research and Education. *UCLA*. 2015. http://www.ats.ucla.edu/stat/sas/whatstat/whatstat.htm (accessed Feb 2016).

114. Jolliffe, I. *Principal Component Analysis. Wiley StatsRef: Statistics Reference Online*. 2014.

115. SAS/STAT(R) 9.22 User's Guide. SAS Institute Inc. 2015. http://support.sas.com/documentation/cdl/en/statug/63347/HTML/default/viewer.htm#statug_reg_sect030.htm (accessed Feb 2016).

116. Strauss, A.; Corbin, J.; Denzin, N.K.; Lincoln, Y.S. *Grounded Theory Methodology: An Overview*. Handbook of Qualitative Research. Sage Publications: Thousand Oaks, CA, 1994.

117. Strauss, A. *Qualitative Analysis for Social Scientists*. Cambridge University Press: New York, NY, 1987.

118. Allan, G. A Critique of Using Grounded Theory as a Research Method. *Electronic Journal of Business Research Methods*. **2003**, *2*(1), 1–10.

119. Thomas, G.; James, D. Reinventing Grounded Theory: Some Questions about Theory, Ground and Discovery. *British Educational Research Journal*. **2006**, *32*(6), 767–795.

120. Miles, M.B.; Huberman, A.M. *An Expanded Sourcebook: Qualitative Data Analysis*. 2nd Ed. Sage Publications: Thousand Oaks, CA, 1994.

121. Office of the Registrar. Degrees by Diversity and Degree Level within Major and Term. *University of Wisconsin-Madison*. 2015. https://registrar.wisc.edu/documents/Stats_DegCntsbyDiversityandDegLvlwnMajorandTerm-2015.pdf (accessed Mar 2016).

122. Office of the Registrar. Undergraduate Enrollment by School or College, Field of Specialization, Class Level, and Gender. *University of Michigan-Ann Arbor*. 2015. http://ro.umich.edu/enrollment/enrollment.php (accessed Mar 2016).

APPENDIX A: POTENTIAL PREDICTOR VARIABLES

Potential Predictor Variables Included in Data Set

1st semester GPA	Participation in undergraduate research	Reported AP chemistry score	ACT Composite score	Starting chemistry course
2nd semester GPA	Chicago Public High School Graduate	Reported AP calculus score	ACT Math score	Starting math course
3rd semester GPA	Ethnicity/race; URM identification; Gender identification	Reported AP scores; not chemistry or math	ACT Science Reasoning score	Termination of math course enrollment
4th semester GPA	First generation college student	Total number of reported AP courses	Chemistry placement exam score	Termination of chem course enrollment
Last recorded GPA	James Scholar participant	High school type	Math ALEKS® placement test score	Merit Program participant

Potential Predictor Variable Definitions

Predictor Variable	Definition
First-semester GPA	First term UIUC grade point average
Second-semester GPA	Second term UIUC grade point average
Third-semester GPA	Third term UIUC grade point average
Fourth-semester GPA	Fourth term UIUC grade point average
Last recorded GPA	Last recorded UIUC grade point average
Participation in undergraduate research	Participation in undergraduate research with a chemistry faculty member (denoted by enrollment in undergraduate research credit courses)
Chicago Public High School Graduate	Graduated from a Chicago Public High School
Merit Program participant	Participation in at least one Chemistry or Math Merit class (www.merit.illinois.edu)
First generation college student	First generation college student as defined by UIUC
James Scholar participant	James Scholar student as defined by UIUC (based on high school GPA, ACT score, and Student Academic Index)
Reported AP chemistry score	Reported Advanced Placement Chemistry exam score to UIUC
Reported AP calculus score	Reported Advanced Placement Calculus exam score to UIUC
Reported AP scores; not chemistry or math	Reported Advanced Placement exam scores to UIUC, other than chemistry and math exam scores
Total number of reported AP courses	Total number of Advanced Placement courses reported to UIUC
High school type	Urban - major city (e.g. Chicago, IL; Peoria, IL) Microurban - smaller city; not surrounding a major city; ethnically more diverse than suburb and various income; According to the Illinois Interactive Report Card, greater than 30% low-income students (percentage of students eligible to receive free or reduced-price lunches, live in substitute care, or whose families receive public aid); http://iirc.niu.edu/Classic/Default.aspx Suburban - near a major city; According to the Illinois Interactive Report Card, less than 30% low-income students; higher than average on "college readiness"; http://iirc.niu.edu/Classic/Default.aspx Rural - small population; not ethnically diverse; designated by UIUC as "low sending/rural" to the university
ACT Composite score	ACT composite score

Potential Predictor Variable Definitions (cont.)

ACT Math score	ACT math score
ACT Science Reasoning score	ACT science reasoning score
Chemistry placement exam score	Chemistry placement exam score (incoming students take before first registration)
Math ALEKS® placement test score	Math ALEKS® placement test score summer before first semester courses
Starting chemistry course	Starting chemistry course – no chemistry, Chemistry 101 (Introductory Chemistry), Chemistry 102-104 (General Chemistry I/II), Chemistry 202 (Accelerated Chemistry I)
Starting math course	Starting math course – no math, Math 115 (Pre-calculus), Math 220 (Calculus), Math 221 (Calculus I), Math 231 (Calculus II), Math 241 (Calculus III), higher-level math (such as matrix theory or differential equations)
Termination of math course enrollment	Took no math or stopped enrollment after taking 1 math class (and had more to take)
Termination of chemistry course enrollment	Took no chemistry or stopped enrollment after taking 1 chemistry class (and had more to take)
Ethnicity/race; URM identification	Identified as African American, Hispanic, and/or Native American
Gender identification	Identified as male or female

APPENDIX B: RETENTION OF STUDENTS IN THE CHEMISTRY MAJOR

Incoming Freshman Classes Fall 2008 and Fall 2009 Combined (Initially Declared Chemistry)

	Initial No. of Students	Students That Graduated with a Chemistry Degree	Retention Rate
Overall	192	74	38.5%
Asian	43	25	58.1%
African American	15	3	20.0%
Hispanic	11	3	27.3%
White	101	36	35.6%
International	18	4	22.2%
Other	4	3	75.0%
Male	101	42	41.6%
Female	91	32	35.2%
Suburban Student	121	56	46.3%
Urban Student	19	6	31.6%
Microurban Student	19	5	26.3%
Rural Student	16	4	25.0%
Chicago Public School Student	11	4	36.4%
First Generation Student	41	14	34.1%
James Scholar Student	46	26	56.5%
Merit Program Student	43	17	39.5%
Started in Chem 101	24	4	16.7%
Started in Chem 102	67	25	37.3%
Started in Chem 202	91	44	48.4%
Started in Chem 103/105 (labs only)	4	1	25.0%
Started in Chem 222	1	0	0.0%
No Chem	5	0	0.0%
Started in Math 115	31	6	19.4%
Started in Math 220/221	86	31	36.0%
Started in Math 231	40	23	57.5%
Started in Math 241	22	12	54.5%
Started in Math 225 or 285	2	2	100.0%
No Math	11	0	0.0%

Note: Not all variable fields were available for all students.

APPENDIX C: CHEMISTRY DEGREES AWARDED

Incoming Freshman Classes Fall 2008 and Fall 2009 Combined (Initially Declared Chemistry and Not Initially Declared Chemistry)

	Total Number of Degrees Awarded	Percent of Total	National Trend (as of 2013)[1]
Overall	226	100%	100%
African American and American Indian/Alaska Native	8	3.5%	8.3%
Asian	72	31.9%	14.7%
Hispanic	12	5.3%	8.3%
White	115	50.9%	62.2%
Other or International	19	8.4%	6.5%
Male	136	60.2%	52.1%
Female	90	39.8%	47.9%

	Total Number of Degrees Awarded	Percent of Total
Suburban Student	166	73.5%
Urban Student	18	8.0%
Microurban Student	11	4.9%
Rural Student	13	5.8%
"Other" (not able to be identified)	18	8.0%
Chicago Public School (CPS) Student	12	5.3%
First Generation Student	48	21.2%
James Scholar Student	71	31.4%
Merit Program Student	52	23.0%
Started in Chem 101	23	10.2%
Started in Chem 102	87	38.5%
Started in Chem 202	99	43.8%
Started in Chem 103/105 or Chem 236	17	7.5%
Started in Math 115	11	4.9%
Started in Math 220/221	94	41.6%
Started in Math 231	68	30.1%
Started in Math 241	48	21.2%
Started in Math 225 or 285	5	2.2%

Note: Not all variable fields were available for all students.

APPENDIX D: COMPARISON OF LEAVERS, PERSISTERS, AND SWITCHERS

Leavers: Students that were admitted as chemistry majors but did not graduate with a chemistry degree.
Persisters: Students that were admitted as chemistry majors and graduated with a chemistry degree.
Switchers: Students that were not admitted as chemistry majors but graduated with a chemistry degree.

	Mean Values (SD)			**ANOVA Results**		
Predictor Variable Measures	**Leavers**	**Persisters**	**Switchers**	***F*-Test Values**	***p*-values**	**Effect Size (η_p^2)**
First-Semester GPA out of 4.0; N = 118, 74, and 152	2.97 (0.65)	3.29 (0.54)	3.28 (0.47)	$F(2,341) = 12.22$	$p < .0001$	$\eta_p^2 = 0.0669$
Second-Semester GPA out of 4.0; N = 117, 74, and 151	2.97 (0.74)	3.20 (0.57)	3.19 (0.55)	$F(2,339) = 4.82$	$p = .0087$	$\eta_p^2 = 0.0276$
Third-Semester GPA out of 4.0; N = 114, 73, and 150	2.89 (0.81)	3.09 (0.58)	3.16 (0.66)	$F(2,334) = 4.82$	$p = .0086$	$\eta_p^2 = 0.0281$
Fourth-Semester GPA out of 4.0; N = 113, 72, and 151	2.93 (0.88)	3.26 (0.55)	3.24 (0.62)	$F(2,333) = 7.26$	$p = .0008$	$\eta_p^2 = 0.0418$
Last Recorded GPA out of 4.0; N = 118, 73, and 152	3.01 (0.63)	3.30 (0.44)	3.24 (0.45)	$F(2,340) = 9.78$	$p < .0001$	$\eta_p^2 = 0.0544$
Total Number of Reported AP Courses; N = 111, 71, and 148	2.45 (2.46)	4.07 (2.44)	3.86 (2.65)	$F(2,327) = 12.54$	$p < .0001$	$\eta_p^2 = 0.0712$
ACT Composite Score out of 36; N = 115, 73, and 152	27.94 (3.13)	29.07 (3.19)	29.47 (3.04)	$F(2,337) = 8.12$	$p = .0004$	$\eta_p^2 = 0.0460$
ACT Math Score out of 36; N = 115, 73, and 152	29.23 (4.14)	31.37 (3.19)	31.91 (3.13)	$F(2,337) = 19.70$	$p < .0001$	$\eta_p^2 = 0.1047$
ACT Science Reasoning Score out of 36; N = 103, 66, and 139	26.82 (3.64)	28.68 (3.95)	29.12 (3.74)	$F(2,305) = 11.59$	$p < .0001$	$\eta_p^2 = 0.0706$
Chemistry Placement Exam Score out of 30; N = 111, 71, and 140	19.13 (7.34)	23.15 (5.82)	20.79 (7.08)	$F(2,319) = 7.28$	$p = .0008$	$\eta_p^2 = 0.0437$
Math ALEKS® Placement Test Score out of 100; N = 115, 70, and 147	79.20 (15.66)	86.17 (9.99)	84.37 (10.76)	$F(2,329) = 8.32$	$p = .0003$	$\eta_p^2 = 0.0482$

Note: Not all variable fields were available for all students.

Comparison of Leavers, Persisters, and Switchers (cont.)

	Number of Students		
Predictor (Categorical) Variables	***Leavers*** (N=118)	***Persisters*** (N=74)	***Switchers*** (N=152)
Participation in Undergraduate Research	3	31	39
First Generation College Student	27	14	34
James Scholar Participant	20	26	45
Chicago Public High School Graduate	7	4	8
Merit Program Participant	26	17	35
Reported AP Chemistry Course	43	49	69
Reported AP Calculus Course	48	53	104
Reported AP Courses (not chemistry or calculus)	64	57	119
Underrepresented Minority	20	6	14

	Female	*Male*	*Female*	*Male*	*Female*	*Male*
Gender: Female|Male	59	59	32	42	58	94

	None	*101*	*102*	*202*	*None*	*101*	*102*	*202*	*None*	*101*	*102*	*202*
Started in: No Chem|Chem 101|Chem 102-103|Chem 202 on up	5	20	42	51	0	4	25	45	0	19	62	71

	None	*115*	*220 221*	*231*	*241*	*None*	*115*	*220 221*	*231*	*241*	*None*	*115*	*220 221*	*231*	*241*
Started in: No Math|Math 115|Math 220/1|Math 231|Math 241 on up	11	25	55	17	10	0	6	31	23	14	0	5	63	45	39

	Urban	*Micro*	*Suburb*	*Rural*	*Urban*	*Micro*	*Suburb*	*Rural*	*Urban*	*Micro*	*Suburb*	*Rural*
High School Type: Urban|Microurban|Suburban|Rural	13	14	65	12	6	5	56	4	12	6	110	9

Note: Not all variable fields were available for all students. Chi-square tests and Fisher's exact tests were not performed because students could be represented in more than one category (i.e., the category samples are not mutually exclusive).

APPENDIX E: RESULTS FOR PRINCIPAL COMPONENT ANALYSIS (PCA) ON POTENTIAL PREDICTOR VARIABLES

Variable	Component	Action
Chemistry Degree	6	Retain
First GPA	1	Retain
Second GPA	1	Retain
Third GPA	1	Retain
Fourth GPA	1	Retain
Final GPA	1	Retain
Research	11 (negative value)	Retain
Merit	5 (negative value)	Retain
First Generation	11	Retain
James	1	Retain
CPS	4	Retain
Urban	4	Retain
Micro	10	Retain
Suburb	4,9,10 (negative values)	Delete
Rural	9	Retain
AP Chem	2,3	Delete
AP Math	2	Retain
AP Other	2	Retain
Number AP Courses	2	Retain
ACT Comp	2	Retain
ACT Math	2	Retain
ACT SR	2,8	Delete
Chem Placement	3	Retain
Math ALEKS	3	Retain
Chem Course	3	Retain
Chem Combination	3	Retain
Math Course	2	Retain
Termination of math course enrollment	6	Retain
Termination of chemistry course enrollment	6	Retain
Asian	7	Retain
Black	4, [3,5 – negative value]	Delete
Hispanic	5 (negative value)	Retain
White	7 (negative value)	Retain
Not URM	5	Retain
Gender	8	Retain

Note: Only Component/Factor Loadings were included whose absolute value exceeded .40 (considered “large”).

Principal Component "Constructs" (Interpreted Component/Factor Patterns)

Component	Construct
***Component 1**: 1st GPA, 2nd GPA, 3rd GPA, 4th GPA, Final GPA, James	GPA
***Component 2**: AP Math, AP Other, Number AP, ACT Comp, ACT Math, Math Course	High School Preparation
***Component 3**: ALEKS, Chem Course, Chem Combination, Chem Placement	Chemistry Class
Component 4: CPS, Urban	Urban Students
Component 5: Not URM	Not URM Students
***Component 6**: Termination of Math Course Enrollment, Termination of Chemistry Course Enrollment, Chemistry Degree	Stopping Courses and Chemistry Degree Attainment
Component 7: Asian	Asian Students
Component 8: Gender	Male/Female Students
Component 9: Rural	Rural Students
Component 10: Micro	Microurban Students
Component 11: First Generation (Research)	First Generation Students

*At least 3 variables with significant loadings on the retained component/factor.

Principal Component Analysis SAS Output

The SAS System

The FACTOR Procedure

Input Data Type	Raw Data
Number of Records Read	394
Number of Records Used	266
N for Significance Tests	266

Means and Standard Deviations from 266 Observations		
Variable	Mean	Std Dev
CHEMDEG	0.657895	0.475309
FIRSTGPA	3.214549	0.513470
SECGPA	3.140977	0.600728
THIRDGPA	3.034098	0.710773
FOURGPA	3.161992	0.698061
FINALGPA	3.211974	0.474701
RESEARCH	0.218045	0.413697
MERIT	0.248120	0.432736
FIRSTGEN	0.233083	0.423591
JAMES	0.285714	0.452606
CPS	0.063910	0.245053
URBAN	0.105263	0.307471
MICRO	0.082707	0.275958
SUBURB	0.729323	0.445147
RURAL	0.082707	0.275958
APCHEM	0.500000	0.500943
APMATH	0.616541	0.487145
APOTHER	0.744361	0.437042
NUMBERAP	3.526316	2.652386
ACTCOMP	28.774436	3.282007
ACTMATH	30.390977	3.746363
ACTSR	28.251880	3.884232
PLCMT	20.360902	7.190495
ALEKS	82.165414	13.182997
CHEMCRSE	3.071429	1.045463
CHEMCOMB	1.838346	0.388752
MATHCRSE	3.101504	1.398462
ONEMATH	0.849624	0.358113
ONECHEM	0.954887	0.207943
ASIAN	0.266917	0.443183
BLACK	0.067669	0.251651
HISPANIC	0.060150	0.238213
WHITE	0.586466	0.493395
URM	0.872180	0.334518
GENDER	0.563910	0.496833

Principal Component Analysis SAS Output (cont.)

The SAS System

The FACTOR Procedure
Initial Factor Method: Principal Components

Prior Communality Estimates: ONE

Eigenvalues of the Correlation Matrix: Total = 35 Average = 1

	Eigenvalue	Difference	Proportion	Cumulative
1	8.29506175	5.01934933	0.2370	0.2370
2	3.27571242	0.63346475	0.0936	0.3306
3	2.64224767	0.42208463	0.0755	0.4061
4	2.22016303	0.38311531	0.0634	0.4695
5	1.83704773	0.17133844	0.0525	0.5220
6	1.66570928	0.21454335	0.0476	0.5696
7	1.45116593	0.12011531	0.0415	0.6111
8	1.33105063	0.17685805	0.0380	0.6491
9	1.15419258	0.07884411	0.0330	0.6821
10	1.07534847	0.05491036	0.0307	0.7128
11	1.02043811	0.11918037	0.0292	0.7419
12	0.90125775	0.08329017	0.0258	0.7677
13	0.81796758	0.00783164	0.0234	0.7911
14	0.81013594	0.08042276	0.0231	0.8142
15	0.72971318	0.04386272	0.0208	0.8351
16	0.68585047	0.04531311	0.0196	0.8547
17	0.64053736	0.08424853	0.0183	0.8730
18	0.55628883	0.02830659	0.0159	0.8889
19	0.52798224	0.08988374	0.0151	0.9039
20	0.43809850	0.01063821	0.0125	0.9165
21	0.42746029	0.07461210	0.0122	0.9287
22	0.35284819	0.01819274	0.0101	0.9388
23	0.33465545	0.02928743	0.0096	0.9483
24	0.30536802	0.03518444	0.0087	0.9570
25	0.27018358	0.01966168	0.0077	0.9648
26	0.25052190	0.02040395	0.0072	0.9719
27	0.23011796	0.02060818	0.0066	0.9785
28	0.20950977	0.03299660	0.0060	0.9845
29	0.17651317	0.04616145	0.0050	0.9895
30	0.13035172	0.02196796	0.0037	0.9932
31	0.10838376	0.01330289	0.0031	0.9963
32	0.09508087	0.06204501	0.0027	0.9991
33	0.03303586	0.03303586	0.0009	1.0000
34	0.00000000	0.00000000	0.0000	1.0000
35	0.00000000		0.0000	1.0000

11 factors will be retained by the MINEIGEN criterion.

```
Scree Plot of Eigenvalues
     ,
     ,
     ,
     ,
     ,
  10 ˆ
     ,
     ,
     ,
     ,
     ,
     ,          1
   8 ˆ
     ,
     ,
     ,
     ,
E    ,
i    ,
g  6 ˆ
e    ,
n    ,
v    ,
a    ,
l    ,
u    ,
e  4 ˆ
s    ,
     ,
     ,           2
     ,
     ,            3
```

```
  2 ^              4
    ,
    ,                5 6
    ,                    7 8
    ,                        9 0 1
    ,                              2 3 4 5
    ,                                      6 7 8 9 0
    ,                                                1 2 3 4 5 6 7 8 9
  0 ^                                                                  0 1 2 3 4 5
    ,
    ,
    ,
    ,
    Šƒƒƒƒƒƒƒƒƒ^ƒƒƒƒƒƒƒƒƒ^ƒƒƒƒƒƒƒƒƒ^ƒƒƒƒƒƒƒƒƒ^ƒƒƒƒƒƒƒƒƒ^ƒƒƒƒƒƒƒƒƒ^ƒƒƒƒƒƒƒƒƒ^ƒƒƒƒƒƒƒƒƒ^ƒƒƒƒƒƒƒƒƒ
              0         5        10        15        20        25        30        35

                                           Number
```

Factor Pattern

		Factor1		Factor2		Factor3		Factor4		Factor5		Factor6		Factor7		Factor8		Factor9		Factor10		Factor11	
CHEMDEG	CHEMDEG	47	*	12		15		31		6		-37	*	33		15		13		4		17	
FIRSTGPA	FIRSTGPA	49	*	53	*	-23		15		11		-1		9		7		-11		10		13	
SECGPA	SECGPA	46	*	54	*	-35	*	-1		-7		12		-6		6		0		6		5	
THIRDGPA	THIRDGPA	41	*	63	*	-27		-8		-11		-5		-19		10		15		-5		12	
FOURGPA	FOURGPA	51	*	41	*	-38	*	18		-3		1		-26		-7		3		1		7	
FINALGPA	FINALGPA	57	*	60	*	-41	*	9		-4		3		-17		3		-3		-2		7	
RESEARCH	RESEARCH	33		23		9		24		-14		-17		19		-15		-6		-48	*	-9	
MERIT	MERIT	-28		10		3		46	*	-42	*	-6		16		7		-6		-8		-21	
FIRSTGEN	FIRSTGEN	-28		-1		10		5		9		16		-10		31		46	*	48	*	-15	
JAMES	JAMES	46	*	23		-19		21		-6		24		14		-26		1		11		-26	
CPS	CPS	-26		45	*	39	*	19		43	*	30		2		20		4		-11		8	
URBAN	URBAN	-36	*	45	*	29		26		40	*	34		1		23		-7		-5		7	
MICRO	MICRO	-20		-10		-9		16		16		-1		-13		-73	*	-12		37	*	17	
SUBURB	SUBURB	50	*	-9		5		-57	*	-41	*	-29		3		22		-5		-8		10	
RURAL	RURAL	-19		-26		-32		47	*	6		10		6		13		28		-19		-42	*
APCHEM	APCHEM	49	*	5		39	*	-14		-2		32		-1		4		-21		-11		9	
APMATH	APMATH	62	*	11		24		-20		12		3		11		8		-4		23		-20	
APOTHER	APOTHER	47	*	17		38	*	-37	*	-15		10		27		3		0		9		-17	
NUMBERAP	NUMBERAP	67	*	21		35		-28		-5		13		12		2		-3		4		-22	
ACTCOMP	ACTCOMP	76	*	-16		-6		6		-8		22		14		-23		22		-8		-11	
ACTMATH	ACTMATH	79	*	-18		14		4		6		5		9		-14		19		9		2	
ACTSR	ACTSR	68	*	-13		-3		16		-12		14		10		-19		31		-10		-6	
PLCMT	PLCMT	67	*	-25		21		15		-2		29		-15		-12		-9		-18		21	
ALEKS	ALEKS	66	*	-25		-3		7		3		-6		-8		18		-1		25		7	
CHEMCRSE	CHEMCRSE	54	*	-45	*	20		29		-2		22		-33		12		-23		-5		-6	
CHEMCOMB	CHEMCOMB	55	*	-38	*	15		27		2		16		-35	*	18		-29		1		-6	
MATHCRSE	MATHCRSE	79	*	-9		15		4		1		-4		-1		-4		9		18		1	
ONEMATH	ONEMATH	36	*	-7		26		51	*	8		-41	*	26		8		-5		4		16	
ONECHEM	ONECHEM	26		-5		3		39	*	8		-41	*	18		12		-27		25		-3	
ASIAN	ASIAN	22		23		41	*	-11		38	*	-47	*	-41	*	-16		16		-16		-24	
BLACK	BLACK	-45	*	29		39	*	5		-13		22		35	*	-24		-2		6		12	
HISPANIC	HISPANIC	-22		7		18		28		-68	*	-1		-38	*	15		8		13		4	
WHITE	WHITE	12		-39	*	-65	*	-8		4		31		39	*	24		-16		3		12	
URM	URM	50	*	-26		-42	*	-23		58	*	-16		0		7		-4		-13		-12	
GENDER	GENDER	19		-37	*	12		4		6		5		1		6		50	*	-17		50	*

Printed values are multiplied by 100 and rounded to the nearest integer. Values greater than 0.35 are flagged by an '*'.

Variance Explained by Each Factor

Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Factor7	Factor8	Factor9	Factor10	Factor11
8.2950617	3.2757124	2.6422477	2.2201630	1.8370477	1.6657093	1.4511659	1.3310506	1.1541926	1.0753485	1.0204381

Final Communality Estima

CHEMDEG	FIRSTGPA	SECGPA	THIRDGPA	FOURGPA	FINALGPA	RESEARCH	MERIT	FIRSTGEN	JAMES	CPS	URBAN	MICRO	SUBURB	RURAL	APCHEM	APMATH	APOTHE
0.68114614	0.65762037	0.66351431	0.74992424	0.68951207	0.90230847	0.57621800	0.56732528	0.69708492	0.56673225	0.79510144	0.83346979	0.84701203	0.90606987	0.74992268	0.57889820	0.62773732	0.6687889

Principal Component Analysis SAS Output (cont.)

The SAS System

The FACTOR Procedure
Rotation Method: Varimax

Orthogonal Transformation Matrix

	1	2	3	4	5	6	7	8	9	10	11
1	0.46030	0.56163	0.46028	-0.26236	0.23550	0.26869	0.03781	0.20099	-0.00232	-0.05632	-0.13911
2	0.67284	0.12434	-0.42559	0.42800	-0.19258	-0.01462	0.22927	-0.22668	-0.12979	-0.04402	-0.08652
3	-0.48970	0.43933	0.15037	0.38076	-0.32510	0.15455	0.43467	0.10052	-0.26081	-0.04218	-0.03430
4	0.11567	-0.32363	0.30385	0.28963	-0.35014	0.52069	-0.04753	0.05913	0.49793	0.22778	-0.07985
5	-0.06369	-0.10796	0.03561	0.48779	0.79999	0.12089	0.20438	0.01225	0.04535	0.15681	0.14804
6	0.05852	0.26854	0.28991	0.45369	-0.09160	-0.57697	-0.48079	0.11404	0.15374	0.13188	0.09007
7	-0.22376	0.37292	-0.51619	0.09633	0.11573	0.39544	-0.53429	0.04208	0.14428	-0.03722	-0.23647
8	0.03526	-0.11019	0.16171	0.18318	-0.00943	0.19109	-0.20902	-0.07873	-0.06060	-0.83136	0.38156
9	0.06313	0.08753	-0.33570	-0.07254	-0.06009	-0.10148	0.25639	0.68738	0.40115	-0.09488	0.38514
10	0.04931	0.18958	-0.03825	-0.11408	-0.10805	0.24584	-0.15013	-0.23342	-0.19070	0.42557	0.76193
11	0.13047	-0.30460	0.00121	0.11932	-0.04499	0.14648	-0.25387	0.58865	-0.64786	0.12881	-0.07215

Rotated Factor Pattern

		Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Factor7	Factor8	Factor9	Factor10	Factor11
CHEMDEG	CHEMDEG	20	21	-2	1	3	72 *	6	24	1	-12	-8
FIRSTGPA	FIRSTGPA	70 *	17	1	14	12	29	-8	-6	-7	2	-7
SECGPA	SECGPA	78 *	18	0	-1	4	-1	-9	-4	-3	-4	-2
THIRDGPA	THIRDGPA	81 *	10	-10	-3	-3	-3	15	7	-11	-18	-2
FOURGPA	FOURGPA	79 *	1	17	-10	4	5	7	4	7	8	-6
FINALGPA	FINALGPA	93 *	11	9	-2	6	5	1	-4	0	-4	-11
RESEARCH	RESEARCH	20	16	0	1	-9	23	16	5	20	-12	-61 *
MERIT	MERIT	-7	-16	-11	4	-55 *	18	-11	-20	33	-7	-15
FIRSTGEN	FIRSTGEN	-10	0	-12	18	-15	-4	4	7	19	-6	76 *
JAMES	JAMES	43 *	38 *	10	-3	0	5	-12	-8	35	26	-11
CPS	CPS	1	0	-8	87 *	-2	-1	15	2	-3	-8	6
URBAN	URBAN	3	-11	-7	89 *	-6	-2	4	-10	-1	-4	8
MICRO	MICRO	-8	-20	-4	-6	2	-2	5	-3	-8	89 *	2
SUBURB	SUBURB	10	38 *	4	-58 *	2	2	1	8	-43 *	-46 *	-11
RURAL	RURAL	-11	-29	5	1	2	1	-12	1	79 *	-10	7
APCHEM	APCHEM	7	51 *	40 *	18	0	-6	-1	9	-25	-8	-20
APMATH	APMATH	17	66 *	19	-3	21	19	11	-8	-9	-6	11
APOTHER	APOTHER	4	78 *	-3	-4	-2	2	3	-3	-17	-16	-4
NUMBERAP	NUMBERAP	20	80 *	17	-1	7	4	14	-4	-11	-14	-8
ACTCOMP	ACTCOMP	25	54 *	30	-27	14	4	-9	34	30	11	-17
ACTMATH	ACTMATH	17	56 *	35 *	-20	19	25	5	36 *	9	12	-2
ACTSR	ACTSR	25	44 *	27	-24	4	11	-2	41 *	33	8	-15
PLCMT	PLCMT	12	32	67 *	-2	5	4	-3	37 *	-6	9	-26
ALEKS	ALEKS	20	26	48 *	-28	18	33	-7	14	-5	-4	19
CHEMCRSE	CHEMCRSE	-5	15	89 *	-7	0	10	-1	7	8	-2	-5
CHEMCOMB	CHEMCOMB	3	13	87 *	-8	4	14	0	-2	3	-4	0
MATHCRSE	MATHCRSE	25	51 *	39 *	-23	13	30	10	22	-2	6	4
ONEMATH	ONEMATH	-1	7	17	4	-4	81 *	8	15	3	1	-15
ONECHEM	ONECHEM	5	0	16	-8	4	70 *	-1	-22	1	6	0
ASIAN	ASIAN	5	12	4	4	23	9	93 *	-2	-5	-3	-5
BLACK	BLACK	-25	14	-41 *	44 *	-40 *	-6	-10	-2	-12	24	-13
HISPANIC	HISPANIC	4	-19	14	-12	-82 *	-6	10	-1	-3	-10	17
WHITE	WHITE	4	-9	8	-20	39 *	-3	-84 *	3	12	-10	3
URM	URM	16	3	21	-24	89 *	8	1	2	11	-11	-2
GENDER	GENDER	-12	-4	14	-5	8	7	-3	82 *	-5	-8	6

Printed values are multiplied by 100 and rounded to the nearest integer. Values greater than 0.35 are flagged by an '*'.

Variance Explained by Each Factor

Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Factor7	Factor8	Factor9	Factor10	Factor11
4.0158352	3.9113307	3.3108731	2.6130318	2.3609689	2.2202335	1.7883462	1.5281657	1.5168037	1.3707447	1.3318042

Final Community Estima

CHEMDEG	FIRSTGPA	SECGPA	THIRDGPA	FOURGPA	FINALGPA	RESEARCH	MERIT	FIRSTGEN	JAMES	CPS	URBAN	MICRO	SUBURB	RURAL	APCHEM	APMATH	APOTHE
0.68114614	0.65762037	0.66351431	0.74992424	0.68951207	0.90230847	0.57621800	0.56732528	0.69708492	0.56673225	0.79510144	0.83346979	0.84701203	0.90606987	0.74992268	0.57889820	0.62773732	0.6687889

APPENDIX F: FALL 2008 AND FALL 2009 COMBINED REGRESSION ANALYSIS (SAS OUTPUT)

Fall 2008 and Fall 2009 Combined Regression Analysis

The REG Procedure
Model: MODEL1
Dependent Variable: CHEMDEG CHEMDEG

Number of Observations Read	394
Number of Observations Used	298
Number of Observations with Missing Values	96

Maximum R-Square Improvement: Step 1

Variable ONEMATH Entered: R-Square = 0.3560 and C(p) = 39.8356

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	23.77242	23.77242	163.66	<.0001
Error	296	42.99603	0.14526		
Corrected Total	297	66.76846			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	-3.3307E-16	0.05619	5.10294E-30	0.00	1.0000
ONEMATH	0.78175	0.06111	23.77242	163.66	<.0001

Bounds on condition number: 1, 1

The above model is the best 1-variable model found.

Maximum R-Square Improvement: Step 2

Variable MATHCRSE Entered: R-Square = 0.3955 and C(p) = 21.3569

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F

SAS Output (cont.)

Model	2	26.40995	13.20498	96.52	<.0001
Error	295	40.35850	0.13681		
Corrected Total	297	66.76846			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	-0.13457	0.06256	0.63307	4.63	0.0323
MATHCRSE	0.07198	0.01639	2.63753	19.28	<.0001
ONEMATH	0.67467	0.06412	15.14531	110.70	<.0001

Bounds on condition number: 1.1691, 4.6764

The above model is the best 2-variable model found.

Maximum R-Square Improvement: Step 3

Variable RESEARCH Entered: R-Square = 0.4252 and C(p) = 7.9704

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	28.39164	9.46388	72.50	<.0001
Error	294	38.37681	0.13053		
Corrected Total	297	66.76846			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	-0.11896	0.06124	0.49260	3.77	0.0530
MATHCRSE	0.06363	0.01616	2.02483	15.51	0.0001
RESEARCH	0.20450	0.05249	1.98169	15.18	0.0001
ONEMATH	0.63434	0.06348	13.03298	99.84	<.0001

Bounds on condition number: 1.201, 10.391

The above model is the best 3-variable model found.

SAS Output (cont.)

Maximum R-Square Improvement: Step 4

Variable FIRSTGPA Entered: R-Square = 0.4328 and C(p) = 6.0279

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	28.89941	7.22485	55.90	<.0001
Error	293	37.86904	0.12925		
Corrected Total	297	66.76846			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	-0.34221	0.12806	0.92295	7.14	0.0080
FIRSTGPA	0.08038	0.04055	0.50777	3.93	0.0484
MATHCRSE	0.05940	0.01622	1.73415	13.42	0.0003
RESEARCH	0.19262	0.05257	1.73532	13.43	0.0003
ONEMATH	0.61499	0.06392	11.96384	92.57	<.0001

Bounds on condition number: 1.2297, 18.504

The above model is the best 4-variable model found.

Maximum R-Square Improvement: Step 5

Variable SUBURB Entered: R-Square = 0.4364 and C(p) = 6.1893

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	29.13622	5.82724	45.22	<.0001
Error	292	37.63223	0.12888		
Corrected Total	297	66.76846			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	-0.37378	0.12998	1.06578	8.27	0.0043
FIRSTGPA	0.08124	0.04050	0.51856	4.02	0.0458

MATHCRSE	0.05112	0.01731	1.12413	8.72	0.0034
RESEARCH	0.19107	0.05251	1.70671	13.24	0.0003
SUBURB	0.06838	0.05044	0.23681	1.84	0.1763
ONEMATH	0.62099	0.06398	12.14000	94.20	<.0001

Bounds on condition number: 1.3834, 29.802

The above model is the best 5-variable model found.

Maximum R-Square Improvement: Step 6

Variable CHEMCOMB Entered: R-Square = 0.4388 and C(p) = 6.9199

Analysis of Variance					
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	6	29.29970	4.88328	37.93	<.0001
Error	291	37.46875	0.12876		
Corrected Total	297	66.76846			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	-0.28131	0.15367	0.43150	3.35	0.0682
FIRSTGPA	0.07961	0.04051	0.49734	3.86	0.0503
MATHCRSE	0.05907	0.01868	1.28694	9.99	0.0017
RESEARCH	0.19035	0.05249	1.69362	13.15	0.0003
SUBURB	0.06725	0.05043	0.22896	1.78	0.1834
ONEMATH	0.63059	0.06452	12.29993	95.53	<.0001
CHEMCOMB	-0.06511	0.05778	0.16348	1.27	0.2608

Bounds on condition number: 1.6135, 45.006

The above model is the best 6-variable model found.

Maximum R-Square Improvement: Step 7

SAS Output (cont.)

Variable GENDER Entered: R-Square = 0.4409 and C(p) = 7.8433

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	29.43836	4.20548	32.67	<.0001
Error	290	37.33009	0.12872		
Corrected Total	297	66.76846			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	-0.29993	0.15469	0.48392	3.76	0.0535
FIRSTGPA	0.08397	0.04072	0.54749	4.25	0.0401
MATHCRSE	0.05691	0.01880	1.17995	9.17	0.0027
RESEARCH	0.18969	0.05248	1.68155	13.06	0.0004
GENDER	0.04474	0.04311	0.13866	1.08	0.3002
SUBURB	0.06832	0.05043	0.23622	1.84	0.1766
ONEMATH	0.62770	0.06457	12.16447	94.50	<.0001
CHEMCOMB	-0.07154	0.05811	0.19510	1.52	0.2193

Bounds on condition number: 1.6335, 60.274

The above model is the best 7-variable model found.

Maximum R-Square Improvement: Step 8

Variable NUMBERAP Entered: R-Square = 0.4427 and C(p) = 8.9318

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	8	29.55576	3.69447	28.69	<.0001
Error	289	37.21269	0.12876		
Corrected Total	297	66.76846			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F

SAS Output (cont.)

Intercept	-0.27522	0.15686	0.39638	3.08	0.0804
FIRSTGPA	0.07613	0.04154	0.43240	3.36	0.0679
MATHCRSE	0.05105	0.01978	0.85800	6.66	0.0103
RESEARCH	0.18110	0.05326	1.48893	11.56	0.0008
GENDER	0.04688	0.04318	0.15182	1.18	0.2785
NUMBERAP	0.00942	0.00987	0.11740	0.91	0.3405
SUBURB	0.05503	0.05232	0.14244	1.11	0.2938
ONEMATH	0.63422	0.06494	12.28118	95.38	<.0001
CHEMCOMB	-0.07681	0.05838	0.22290	1.73	0.1893

Bounds on condition number: 1.8076, 84.095

Maximum R-Square Improvement: Step 9

Variable SUBURB Removed: R-Square = 0.4427 and C(p) = 8.9110
Variable URM Entered

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	8	29.55844	3.69480	28.70	<.0001
Error	289	37.21002	0.12875		
Corrected Total	297	66.76846			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	-0.26564	0.15527	0.37685	2.93	0.0882
FIRSTGPA	0.06739	0.04179	0.33491	2.60	0.1079
MATHCRSE	0.05137	0.01970	0.87529	6.80	0.0096
RESEARCH	0.18154	0.05327	1.49566	11.62	0.0007
URM	0.06977	0.06572	0.14512	1.13	0.2893
GENDER	0.04415	0.04324	0.13428	1.04	0.3080
NUMBERAP	0.01208	0.00952	0.20742	1.61	0.2054
ONEMATH	0.63855	0.06520	12.34833	95.91	<.0001
CHEMCOMB	-0.08485	0.05855	0.27039	2.10	0.1484

Bounds on condition number: 1.7941, 82.546

The above model is the best 8-variable model found.

Maximum R-Square Improvement: Step 10

Variable SUBURB Entered: R-Square = 0.4445 and C(p) = 10.0000

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	9	29.67577	3.29731	25.60	<.0001
Error	288	37.09268	0.12879		
Corrected Total	297	66.76846			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	-0.29359	0.15803	0.44452	3.45	0.0642
FIRSTGPA	0.07067	0.04193	0.36581	2.84	0.0930
MATHCRSE	0.04749	0.02012	0.71782	5.57	0.0189
RESEARCH	0.18263	0.05329	1.51285	11.75	0.0007
URM	0.06374	0.06603	0.12001	0.93	0.3352
GENDER	0.04461	0.04325	0.13706	1.06	0.3031
NUMBERAP	0.00957	0.00987	0.12100	0.94	0.3332
SUBURB	0.05018	0.05257	0.11734	0.91	0.3406
ONEMATH	0.64011	0.06523	12.40090	96.28	<.0001
CHEMCOMB	-0.08203	0.05863	0.25205	1.96	0.1629

Bounds on condition number: 1.8702, 106.04

The above model is the best 9-variable model found.

No further improvement in R-Square is possible.

APPENDIX G: FALL 2008 AND FALL 2009 COMBINED REGRESSION ANALYSIS – FEMALES (SAS OUTPUT)

Fall 2008 and Fall 2009 Combined Regression Analysis - FEMALES

The REG Procedure
Model: MODEL1
Dependent Variable: CHEMDEG CHEMDEG

Number of Observations Read	175
Number of Observations Used	131
Number of Observations with Missing Values	44

Maximum R-Square Improvement: Step 1

Variable ONEMATH Entered: R-Square = 0.3644 and C(p) = 23.6025

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	11.50011	11.50011	73.96	<.0001
Error	129	20.05714	0.15548		
Corrected Total	130	31.55725			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	-2.2204E-16	0.07733	1.2819E-30	0.00	1.0000
ONEMATH	0.74286	0.08638	11.50011	73.96	<.0001

Bounds on condition number: 1, 1

The above model is the best 1-variable model found.

Maximum R-Square Improvement: Step 2

Variable MATHCRSE Entered: R-Square = 0.4421 and C(p) = 7.2042

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F

Model	2	13.95038	6.97519	50.71	<.0001
Error	128	17.60687	0.13755		
Corrected Total	130	31.55725			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	-0.14858	0.08081	0.46503	3.38	0.0683
MATHCRSE	0.09658	0.02288	2.45027	17.81	<.0001
ONEMATH	0.58607	0.08933	5.92026	43.04	<.0001

Bounds on condition number: 1.2091, 4.8363

The above model is the best 2-variable model found.

Maximum R-Square Improvement: Step 3

Variable RESEARCH Entered: R-Square = 0.4724 and C(p) = 2.0219

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	14.90692	4.96897	37.90	<.0001
Error	127	16.65033	0.13110		
Corrected Total	130	31.55725			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	-0.14366	0.07891	0.43454	3.31	0.0710
MATHCRSE	0.09338	0.02237	2.28443	17.42	<.0001
RESEARCH	0.22144	0.08198	0.95653	7.30	0.0079
ONEMATH	0.53643	0.08913	4.74884	36.22	<.0001

Bounds on condition number: 1.2628, 10.631

The above model is the best 3-variable model found.

SAS Output (cont.)

Maximum R-Square Improvement: Step 4

Variable CHEMCOMB Entered: R-Square = 0.4801 and C(p) = 2.1961

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	15.15008	3.78752	29.09	<.0001
Error	126	16.40717	0.13022		
Corrected Total	130	31.55725			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	-0.01927	0.12030	0.00334	0.03	0.8730
MATHCRSE	0.10577	0.02407	2.51492	19.31	<.0001
RESEARCH	0.22015	0.08171	0.94529	7.26	0.0080
ONEMATH	0.56362	0.09103	4.99198	38.34	<.0001
CHEMCOMB	-0.10361	0.07582	0.24316	1.87	0.1742

Bounds on condition number: 1.413, 20.649

The above model is the best 4-variable model found.

Maximum R-Square Improvement: Step 5

Variable NUMBERAP Entered: R-Square = 0.4832 and C(p) = 3.4689

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	15.24692	3.04938	23.37	<.0001
Error	125	16.31033	0.13048		
Corrected Total	130	31.55725			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	-0.02444	0.12057	0.00536	0.04	0.8397
MATHCRSE	0.09808	0.02569	1.90166	14.57	0.0002

RESEARCH	0.20675	0.08326	0.80461	6.17	0.0143
NUMBERAP	0.01154	0.01339	0.09684	0.74	0.3906
ONEMATH	0.57075	0.09150	5.07725	38.91	<.0001
CHEMCOMB	-0.11248	0.07659	0.28143	2.16	0.1445

Bounds on condition number: 1.6068, 33.681

The above model is the best 5-variable model found.

Maximum R-Square Improvement: Step 6

Variable URM Entered: R-Square = 0.4850 and C(p) = 5.0310

Analysis of Variance					
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	6	15.30524	2.55087	19.46	<.0001
Error	124	16.25202	0.13106		
Corrected Total	130	31.55725			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	-0.05276	0.12808	0.02224	0.17	0.6811
MATHCRSE	0.09356	0.02663	1.61791	12.34	0.0006
RESEARCH	0.21001	0.08359	0.82738	6.31	0.0133
URM	0.06218	0.09321	0.05831	0.44	0.5060
NUMBERAP	0.01044	0.01352	0.07814	0.60	0.4415
ONEMATH	0.57305	0.09177	5.11103	39.00	<.0001
CHEMCOMB	-0.11781	0.07718	0.30540	2.33	0.1294

Bounds on condition number: 1.7184, 48.608

The above model is the best 6-variable model found.

Maximum R-Square Improvement: Step 7

Variable SUBURB Entered: R-Square = 0.4851 and C(p) = 7.0051

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	15.30869	2.18696	16.56	<.0001
Error	123	16.24856	0.13210		
Corrected Total	130	31.55725			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	-0.04891	0.13076	0.01849	0.14	0.7090
MATHCRSE	0.09429	0.02711	1.59773	12.09	0.0007
RESEARCH	0.21079	0.08405	0.83079	6.29	0.0135
URM	0.06672	0.09770	0.06160	0.47	0.4960
NUMBERAP	0.01095	0.01394	0.08156	0.62	0.4335
SUBURB	-0.01335	0.08249	0.00346	0.03	0.8717
ONEMATH	0.57499	0.09290	5.06042	38.31	<.0001
CHEMCOMB	-0.11991	0.07856	0.30774	2.33	0.1295

Bounds on condition number: 1.7674, 68.508

The above model is the best 7-variable model found.

Maximum R-Square Improvement: Step 8

Variable FIRSTGPA Entered: R-Square = 0.4851 and C(p) = 9.0000

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	8	15.30937	1.91367	14.37	<.0001
Error	122	16.24788	0.13318		
Corrected Total	130	31.55725			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F

Intercept	-0.03543	0.23075	0.00314	0.02	0.8782
FIRSTGPA	-0.00494	0.06956	0.00067276	0.01	0.9435
MATHCRSE	0.09442	0.02728	1.59492	11.98	0.0007
RESEARCH	0.21125	0.08465	0.82952	6.23	0.0139
URM	0.06788	0.09946	0.06204	0.47	0.4962
NUMBERAP	0.01113	0.01422	0.08160	0.61	0.4353
SUBURB	-0.01370	0.08297	0.00363	0.03	0.8691
ONEMATH	0.57660	0.09600	4.80453	36.08	<.0001
CHEMCOMB	-0.12031	0.07909	0.30821	2.31	0.1308

Bounds on condition number: 1.7754, 89.712

The above model is the best 8-variable model found.

No further improvement in R-Square is possible.

APPENDIX H: FALL 2008 AND FALL 2009 COMBINED REGRESSION ANALYSIS – MALES (SAS OUTPUT)

Fall 2008 and Fall 2009 Combined Regression Analysis - MALES

The REG Procedure
Model: MODEL1
Dependent Variable: CHEMDEG CHEMDEG

Number of Observations Read	225
Number of Observations Used	167
Number of Observations with Missing Values	58

Maximum R-Square Improvement: Step 1

Variable ONEMATH Entered: R-Square = 0.3373 and C(p) = 20.0940

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	11.53693	11.53693	83.98	<.0001
Error	165	22.66667	0.13737		
Corrected Total	166	34.20359			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	4.44089E-16	0.08288	3.9443E-30	0.00	1.0000
ONEMATH	0.80952	0.08834	11.53693	83.98	<.0001

Bounds on condition number: 1, 1

The above model is the best 1-variable model found.

Maximum R-Square Improvement: Step 2

Variable RESEARCH Entered: R-Square = 0.3795 and C(p) = 10.4435

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F

SAS Output (cont.)

Model	2	12.97923	6.48962	50.15	<.0001
Error	164	21.22436	0.12942		
Corrected Total	166	34.20359			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	4.62771E-16	0.08044	4.28314E-30	0.00	1.0000
RESEARCH	0.22436	0.06721	1.44231	11.14	0.0010
ONEMATH	0.75000	0.08757	9.49219	73.35	<.0001

Bounds on condition number: 1.0432, 4.173

The above model is the best 2-variable model found.

Maximum R-Square Improvement: Step 3

Variable FIRSTGPA Entered: R-Square = 0.4045 and C(p) = 5.5344

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	13.83457	4.61152	36.90	<.0001
Error	163	20.36902	0.12496		
Corrected Total	166	34.20359			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	-0.37839	0.16482	0.65862	5.27	0.0230
FIRSTGPA	0.13207	0.05048	0.85534	6.84	0.0097
RESEARCH	0.19800	0.06680	1.09781	8.79	0.0035
ONEMATH	0.71379	0.08716	8.38094	67.07	<.0001

Bounds on condition number: 1.0702, 9.5983

The above model is the best 3-variable model found.

Maximum R-Square Improvement: Step 4

Variable SUBURB Entered: R-Square = 0.4220 and C(p) = 2.6967

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	14.43347	3.60837	29.57	<.0001
Error	162	19.77012	0.12204		
Corrected Total	166	34.20359			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	-0.49929	0.17178	1.03096	8.45	0.0042
FIRSTGPA	0.13312	0.04989	0.86893	7.12	0.0084
RESEARCH	0.19127	0.06609	1.02229	8.38	0.0043
SUBURB	0.13869	0.06261	0.59889	4.91	0.0281
ONEMATH	0.73122	0.08649	8.72251	71.47	<.0001

Bounds on condition number: 1.0792, 16.881

The above model is the best 4-variable model found.

Maximum R-Square Improvement: Step 5

Variable URM Entered: R-Square = 0.4253 and C(p) = 3.7743

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	14.54765	2.90953	23.83	<.0001
Error	161	19.65594	0.12209		
Corrected Total	166	34.20359			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	-0.56690	0.18549	1.14029	9.34	0.0026
FIRSTGPA	0.12737	0.05025	0.78433	6.42	0.0122

RESEARCH	0.18857	0.06616	0.99177	8.12	0.0049
URM	0.08744	0.09041	0.11419	0.94	0.3349
SUBURB	0.13989	0.06263	0.60910	4.99	0.0269
ONEMATH	0.73911	0.08689	8.83317	72.35	<.0001

Bounds on condition number: 1.0887, 26.348

The above model is the best 5-variable model found.

Maximum R-Square Improvement: Step 6

Variable NUMBERAP Entered: R-Square = 0.4268 and C(p) = 5.3640

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	14.59845	2.43308	19.86	<.0001
Error	160	19.60514	0.12253		
Corrected Total	166	34.20359			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	-0.54609	0.18862	1.02708	8.38	0.0043
FIRSTGPA	0.11923	0.05191	0.64649	5.28	0.0229
RESEARCH	0.17876	0.06801	0.84656	6.91	0.0094
URM	0.08378	0.09075	0.10443	0.85	0.3573
NUMBERAP	0.00815	0.01266	0.05080	0.41	0.5206
SUBURB	0.12057	0.06955	0.36820	3.00	0.0849
ONEMATH	0.73423	0.08738	8.65174	70.61	<.0001

Bounds on condition number: 1.4058, 42.26

The above model is the best 6-variable model found.

Maximum R-Square Improvement: Step 7

SAS Output (cont.)

Variable MATHCRSE Entered: R-Square = 0.4277 and C(p) = 7.1074

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	14.63022	2.09003	16.98	<.0001
Error	159	19.57337	0.12310		
Corrected Total	166	34.20359			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	-0.53774	0.18977	0.98842	8.03	0.0052
FIRSTGPA	0.11954	0.05203	0.64975	5.28	0.0229
MATHCRSE	-0.01459	0.02873	0.03177	0.26	0.6121
RESEARCH	0.18202	0.06847	0.87000	7.07	0.0087
URM	0.09341	0.09292	0.12442	1.01	0.3163
NUMBERAP	0.01097	0.01385	0.07724	0.63	0.4295
SUBURB	0.12931	0.07181	0.39920	3.24	0.0736
ONEMATH	0.74965	0.09269	8.05265	65.41	<.0001

Bounds on condition number: 1.7307, 65.133

The above model is the best 7-variable model found.

Maximum R-Square Improvement: Step 8

Variable CHEMCOMB Entered: R-Square = 0.4281 and C(p) = 9.0000

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	8	14.64351	1.83044	14.79	<.0001
Error	158	19.56008	0.12380		
Corrected Total	166	34.20359			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F

SAS Output (cont.)

Intercept	-0.48931	0.24096	0.51048	4.12	0.0440
FIRSTGPA	0.11885	0.05222	0.64118	5.18	0.0242
MATHCRSE	-0.01171	0.03012	0.01872	0.15	0.6979
RESEARCH	0.18175	0.06867	0.86734	7.01	0.0089
URM	0.09393	0.09319	0.12577	1.02	0.3150
NUMBERAP	0.01111	0.01390	0.07915	0.64	0.4251
SUBURB	0.12973	0.07202	0.40171	3.24	0.0736
ONEMATH	0.74981	0.09295	8.05594	65.07	<.0001
CHEMCOMB	-0.03017	0.09208	0.01329	0.11	0.7436

Bounds on condition number: 1.8918, 85.225

The above model is the best 8-variable model found.

No further improvement in R-Square is possible.

APPENDIX I: IRB APPROVAL

UNIVERSITY OF ILLINOIS
AT URBANA-CHAMPAIGN

Office of the Vice Chancellor for Research

Office for the Protection of Research Subjects
528 East Green Street
Suite 203
Champaign, IL 61820

May 14, 2015

Gretchen Adams
Chemistry
3671 Noyes Lab, Box A-2
501 S. Mathews
Urbana, IL 61801
M/C: 712

RE: *Factors that Lead to Retention and Recruitment of Chemistry Majors at the University of Illinois at Urbana-Champaign*
IRB Protocol Number: 15829

EXPIRATION DATE: 05/13/2018

Dear Dr. Adams:

Thank you for submitting the completed IRB application form for your project entitled *Factors that Lead to Retention and Recruitment of Chemistry Majors at the University of Illinois at Urbana-Champaign*. Your project was assigned Institutional Review Board (IRB) Protocol Number 15829 and reviewed. It has been determined that the research activities described in this application meet the criteria for exemption at 45CFR46.101(b)(1, 2, & 4).

This determination of exemption only applies to the research study as submitted. Please note that additional modifications to your project need to be submitted to the IRB for review and exemption determination or approval before the modifications are initiated.

We appreciate your conscientious adherence to the requirements of human subjects research. If you have any questions about the IRB process, or if you need assistance at any time, please feel free to contact me at the OPRS office, or visit our website at http://www.irb.illinois.edu.

Sincerely,

Rebecca Van Tine

Rebecca Van Tine, MS
Human Subjects Research Specialist, Office for the Protection of Research Subjects

c: Lizanne DeStefano

U of Illinois at Urbana-Champaign • IORG0000014 • FWA #00008584
telephone (217) 333-2670 • *fax* (217) 333-0405 • *email* IRB@illinois.edu

APPENDIX J: SURVEY PROTOCOL

UIUC Retention and Recruitment of Chemistry Majors Student Survey
Online Electronic Consent Form

We would like to invite you to participate in an evaluation study that is being conducted by Gretchen Adams**,** Director of Undergraduate Studies in the Chemistry Department from the University of Illinois at Urbana-Champaign. The main purpose of the study is to determine what factors affect the retention and recruitment of chemistry majors in the Department of Chemistry as a means of making improvements for the future. The study will involve secondary analysis of data, a survey, and interviews. We are asking you to complete this web-based survey. You will be asked questions related to all aspects of your experience with the Department of Chemistry and supporting coursework. This includes your level of satisfaction, academic preparation, and your general concerns. The online survey will take 20 minutes to complete.

There are no known risks in this study beyond those of ordinary life. The potential benefit of this study is to make improvements in the Chemistry Department that benefit chemistry majors.

While your participation is very important to us, it is completely voluntary. Please only participate if you are age 18 or older. You may choose not to answer any question or to stop the survey at any time. Any presentation or publication of data will not identify you as a participant in any way.

Your decision whether or not to participate will not affect your future relations with the University of Illinois at Urbana-Champaign. You are under no obligation to participate in the study. You are free to discontinue participation in the study at any time. Please contact Gretchen Adams at gadams4@illinois.edu or Lizanne DeStefano at destefan@illinois.edu with any questions or concerns about this research. If you have any questions about your rights as a participant in this study, please contact the University of Illinois Institutional Review Board at 217-333-2670 or via e-mail at irb@illinois.edu.

Please print a copy of this consent form for your records, if you so desire. Make your YES/NO choices to the statements below and click "submit".

I certify that I am 18 years old or older and have read and understand the above consent form.	☐ YES	☐ NO
I have read and understand the above consent form and voluntarily agree to participate in this study.	☐ YES	☐ NO

If you have read the consent information above and agree to participate in this study, please click on the 'next' button below to proceed.

NEXT (SUBMIT)

<u>**UIUC Retention and Recruitment of Chemistry Majors Student Survey**</u>

1. Gender
   - ☐ Male
   - ☐ Female
   - ☐ Other

2. Racial/Ethnic Identification: (Check all that apply.)
   - ☐ African/African American
   - ☐ Asian/Asian American
   - ☐ White/Caucasian
   - ☐ Latina/o/Hispanic American
   - ☐ Native American/Native Alaskan/Pacific Islander
   - ☐ Other (Please specify.)

3. What is your U.S. citizenship status? (Indicate one.)
   - ☐ I am a U.S. citizen.
   - ☐ I am a permanent resident (green card).
   - ☐ I am a foreign national.
   - ☐ Other (Please specify.)

4. How would you best describe your high school education location? (Indicate one.)
   - ☐ Urban (major metropolitan area like Chicago, Peoria, etc.)
   - ☐ Microurban (smaller metropolitan area like Champaign, Decatur, etc.)
   - ☐ Suburban (surrounding a major metropolitan area)
   - ☐ Rural (not surrounding a major metropolitan area; population below 5,000)
   - ☐ Other (Please specify.)

5. Which of the following best describes your University of Illinois standing? (Please define your standing by years in school and not by credit hours accrued.)
   - ☐ Undergraduate student (freshman)
   - ☐ Undergraduate student (sophomore)
   - ☐ Undergraduate student (junior)
   - ☐ Undergraduate student (senior)
   - ☐ Undergraduate student (fifth year and beyond)

6. What is the first chemistry class you enrolled in at this university? (Indicate one.)
   - ☐ Chemistry 101 (Introductory Chemistry)
   - ☐ Chemistry 102 (General Chemistry I)
   - ☐ Chemistry 202 (Accelerated Chemistry I)
   - ☐ Chemistry 222 (Quantitative Analysis)
   - ☐ Other (Please specify.)

7. What is the first math class you enrolled in at this university? (Indicate one.)
   - ☐ Math 112 (College Algebra)
   - ☐ Math 115 (Preparation for Calculus)
   - ☐ Math 220/221 (Calculus I)
   - ☐ Math 231 (Calculus II)
   - ☐ Math 241 (Calculus III)
   - ☐ Math 285 (Differential Equations)
   - ☐ Other (Please specify.)

8. When you started at this university, what was your major?

9. Please describe your reasoning for your initial major (i.e., why did you choose this initial major?)

10. What is your current (or intended) major?

11. If you changed majors or intend to change majors, please describe all the reasons why you are deciding or have decided to switch.

12. What are your career goals?

	Not at all confident	A little confident	Neutral	Somewhat confident	Very confident
13. How confident are you that you will succeed in your intended major?					

14. Did you or are you currently participating in undergraduate research in chemistry?
- ☐ Yes
- ☐ No

Reflect back on your high school experiences. How do you feel your high school has prepared you for:

	Not at all	Very little	Neutral	Somewhat	A great deal
15. The chemistry courses at this university.					
16. The chemistry labs at this university.					
17. The mathematics courses at this university.					
18. Other general courses at this university.					
19. Study skills needed to be a successful college student.					
20. Time management needed to be a successful college student.					
21. Confidence to succeed as a college student.					

22. Please share any other comments or concerns regarding your high school experiences.

To what extent has the following played a role in your decision to remain in your initial major or change majors here at the university?

	Not at all	Very little	Neutral	Somewhat	A great deal
23. Quality of instruction in the chemistry lecture(s)					
24. Quality of instruction in the chemistry lab(s)					
25. Quality of instruction in the chemistry discussion(s) with the teaching assistants (TAs)					
26. Chemistry topics taught					
27. Level of competition in the chemistry courses					
28. Chemistry class I started in (i.e., my first chemistry class)					
29. My ability to learn chemistry concepts quickly					
30. My grade performance in chemistry					
31. My sense of whether I can succeed in chemistry					
32. My sense of belonging in chemistry					
33. My interest in chemistry					
34. Alignment with career goals					
35. Support from the chemistry department					

36. Support from my chemistry instructors					
37. Support from my peers					
38. Support from my family					
39. Involvement with extracurricular activities					
40. Participating in a study group					
41. Participating in undergraduate research					
42. Having a mentor					
43. Quality of instruction in the mathematics courses					
44. Level of competition in the mathematics courses					
45. My ability to learn math concepts quickly					
46. My grade performance in mathematics					

47. Please share any other comments or concerns regarding what played a role in your decision to remain in your initial major or change majors.

48. The following is a list of extracurricular and professional development activities. Check all of the activities that you have participated in at least once during the past year:
    - ☐ A chemistry organization or group (e.g., American Chemical Society)
    - ☐ Merit Program (e.g., Chemistry Merit Program, Math Merit Program, MCB Merit Program, IB Merit Program)
    - ☐ Community activities (e.g., ballroom dancing, yoga classes, church)
    - ☐ Activities sponsored by your current major department (e.g., social activities, seminars, job fairs)
    - ☐ A campus intramural or community sports team (e.g., basketball, volleyball)
    - ☐ Fraternity of sorority
    - ☐ Campus activities (e.g., campus blurbs, student organizations)
    - ☐ Other (Please specify.)

49. What have been the most positive aspects of interacting with the Department of Chemistry?

50. Please write any suggestions you have for improving the undergraduate student experience in the Department of Chemistry.

51. Please write any additional comments you have about your experience in the Department of Chemistry or about this survey.

Thank you for taking the time to complete this survey.

NOTE: You must click the “SUBMIT” button below to record your answers.

The information you have provided will be used to help make improvements for our undergraduate majors in the Department of Chemistry.

If you have any questions, please feel free to contact:
Gretchen Adams
gadams4@illinois.edu
217-244-8279

APPENDIX K: INDIVIDUAL INTERVIEW PROTOCOL

Student Interview Protocol

Prior to Interview

1. Evaluator (e.g. Director of Undergraduate Studies) will recruit the students via email. The email will state the purpose of the interview and the consent form will be attached for student review prior to agreeing to participate.

Interview Introduction

1. State purpose of interview
   a. Intention of this interview is to understand your experiences with the chemistry major so far.
   b. We want to better understand why students choose the chemistry major or decide to switch out of the major to pursue a different direction.
   c. Our main purpose is to see if there are ways that the department and campus can create better experiences for students.
   d. I will take notes, audiotape, and compile an overall summary report of all of the interviews performed. The report will not contain information that identifies your experiences directly back to you. Your responses will remain anonymous and after the tapes are transcribed, they will be deleted.
   e. Confirm IRB protocol and get informed consent, including permission to audiotape the interview.
   f. Do you have any questions before we begin?

Primary Interview Questions

1. Icebreaker To start, could you please tell me a little bit about yourself?

Possible Probes

**Tell me about your major. What year in school are you?*
**What are some of your career goals?*
**Tell me about your some of your interests. What do you like to do for fun? What are some clubs you are involved in on campus?*

Thank you! Now I'd like to hear about your high school experiences in relation to academic preparation here at the university.

2. What type of courses did you take in high school to help you prepare for college?
3. In what ways has your high school done a good job in preparing you for college?
4. What are some areas in which your high school didn't prepare you so that we as a university can help with the transition?

Next, I'd like to hear about your experiences with the coursework here at the university.

5. If a student outside of this university came to you and asked what chemistry classes are like, how would you describe them?
6. What aspects of your classroom instruction in chemistry have been the most positive? In what ways have they helped you?
7. What aspects of your classroom instruction in chemistry have been the most challenging? How have they affected you?
8. How did/do you go about studying for a chemistry class?

Possible Probes
*Do you mostly study on your own? How do you study on your own?
*Do you have a study group? What are they like? How do you study as a group?
*What resources do you use?

9. What aspects of your classroom instruction in mathematics have been the most positive? In what ways have they helped you?
10. What aspects of your classroom instruction in mathematics have been the most challenging? How have they affected you?
11. How did/do you go about studying for a math class?
    Possible Probes
    *Do you mostly study on your own? How do you study on your own?
    *Do you have a study group? What are they like? How do you study as a group?
    *What resources do you use?
12. What courses (any courses) have been beneficial to your learning? In what ways?
13. What courses (any courses) have been difficult for you? In what ways?

Next I'd like to hear more about your major.

14. Can you please share the reasons you decided to choose your current major?
    Possible Probes
    *What was it about your major that attracted you to it?
    *Do you see yourself in this major long term? Are you thinking of switching majors? Why or why not?
    *If you started as a chemistry major but switched, why did you decide to switch?
15. What have been the most positive aspects of your current major?
    Possible Probes
    *How has the department supported you in your major? How have instructors? How have your peers? Family? Special programs?
    *What kind of learning opportunities have you found so far in your major?
    *What kind of professional opportunities have you found so far in your major?
    *What kind of social opportunities have you found so far in your major?
16. What have been the most challenging aspects of your current major?
    Possible Probes
    *Where have you experienced the most frustration? How have those frustrations affected you?
17. What has significantly contributed to you remaining in your major or switching majors?
    Possible Probes
    *Have there been any academic contributions?
    *Have there been any financial contributions?
    *Have there been any social contributions?
    *Have there been any personal contributions?

Now we are nearing the end of the interview. I have just a few more questions.

18. What has the Chemistry Department done well to contribute to a positive learning experience for students?
19. What can the Chemistry Department do to improve the learning experience for students?
20. What can the Chemistry Department do to retain majors and recruit more majors?
21. Is there anything else you would like to share?

Member check. Ask clarification questions if needed.

Thank you!!!!

Post Interview

1. Record details about the setting and observations about the interview.
    a. Where and when did the interview occur?
    b. Under what conditions?
    c. How did the interviewee react to questions?
    d. How well do I think I did asking questions?
    e. How was the rapport?
2. Send a follow-up thank you note to interviewee.
3. Transcribe audio recording.

APPENDIX L: FOCUS GROUP INTERVIEW PROTOCOL

Student Focus Group Interview Protocol

Prior to Interview

1. Evaluator (e.g. Director of Undergraduate Studies) will recruit the students via email. The email will state the purpose of the interview and the consent form will be attached for student review prior to agreeing to participate.

Interview Introduction

1. State purpose of interview
    a. Intention of this interview is to understand your experiences with the chemistry major so far.
    b. We want to better understand why students choose the chemistry major or decide to switch out of the major to pursue a different direction.
    c. Our main purpose is to see if there are ways that the department and campus can create better experiences for students.
    d. I will take notes, audiotape, and compile an overall summary report of all of the interviews performed. The report will not contain information that identifies your experiences directly back to you. Your responses will remain anonymous and after the tapes are transcribed, they will be deleted.
    e. Confirm IRB protocol and get informed consent, including permission to audiotape the interview.
    f. Do you have any questions before we begin?

Primary Interview Questions

1. <u>Icebreaker</u> To start, could each of you please tell me a little bit about yourself?

Possible Probes
**Tell me about your major. What year in school are you?*
**What are some of your career goals?*
**Tell me about your some of your interests. What do you like to do for fun? What are some clubs you are involved in on campus?*

Thank you! Now I'd like to hear about your high school experiences in relation to academic preparation here at the university.

2. What type of courses did you take in high school to help you prepare for college?
3. In what ways has your high school done a good job in preparing you for college?
4. What are some areas in which your high school didn't prepare you so that we as a university can help with the transition?

Next, I'd like to hear about your experiences with the coursework here at the university.

5. If a student outside of this university came to you and asked what chemistry classes are like, how would you describe them?
6. What aspects of your classroom instruction in chemistry have been the most positive? In what ways have they helped you?
7. What aspects of your classroom instruction in chemistry have been the most challenging? How have they affected you?
8. How did/do you go about studying for a chemistry class?

Possible Probes
*Do you mostly study on your own? How do you study on your own?
*Do you have a study group? What are they like? How do you study as a group?
*What resources do you use?

9. What aspects of your classroom instruction in mathematics have been the most positive? In what ways have they helped you?
10. What aspects of your classroom instruction in mathematics have been the most challenging? How have they affected you?
11. How did/do you go about studying for a math class?
    Possible Probes
    *Do you mostly study on your own? How do you study on your own?
    *Do you have a study group? What are they like? How do you study as a group?
    *What resources do you use?
12. What courses (any courses) have been beneficial to your learning? In what ways?
13. What courses (any courses) have been difficult for you? In what ways?

Next I'd like to hear more about your major.

14. Can you please share the reasons you decided to choose your current major?
    Possible Probes
    *What was it about your major that attracted you to it?
    *Do you see yourself in this major long term? Are you thinking of switching majors? Why or why not?
    *If you started as a chemistry major but switched, why did you decide to switch?
15. What have been the most positive aspects of your current major?
    Possible Probes
    *How has the department supported you in your major? How have instructors? How have your peers? Family? Special programs?
    *What kind of learning opportunities have you found so far in your major?
    *What kind of professional opportunities have you found so far in your major?
    *What kind of social opportunities have you found so far in your major?
16. What have been the most challenging aspects of your current major?
    Possible Probes
    *Where have you experienced the most frustration? How have those frustrations affected you?
17. What has significantly contributed to you remaining in your major or switching majors?
    Possible Probes
    *Have there been any academic contributions?
    *Have there been any financial contributions?
    *Have there been any social contributions?
    *Have there been any personal contributions?

Now we are nearing the end of the interview. I have just a few more questions.

18. What has the Chemistry Department done well to contribute to a positive learning experience for students?
19. What can the Chemistry Department do to improve the learning experience for students?
20. What can the Chemistry Department do to retain majors and recruit more majors?
21. Is there anything else you would like to share?

Member check. Ask clarification questions if needed.

Thank you!!!!

Post Interview

4. Record details about the setting and observations about the interview.
    a. Where and when did the interview occur?
    b. Under what conditions?
    c. How did the interviewees react to questions?
    d. How well do I think I did asking questions?
    e. How was the rapport?
5. Send a follow-up thank you note to interviewees.
6. Transcribe audio recording.

APPENDIX M: COMPARISON OF PREDICTOR VARIABLES FOR INCOMING FRESHMAN CLASSES FALL 2008-09 (EARNED DEGREES) AND CURRENT INCOMING FRESHMAN CLASSES INITIALLY DECLARED CHEMISTRY

	Mean Values (SD)					ANOVA Results		
Predictor Variable Measures	**FA2008-09 Students**	**4^{th} Yr Students**	**3^{rd} Yr Students**	**2^{nd} Yr Students**	**1^{st} Yr Students**	***F*-Test Values**	***p*-values**	**Effect Size (η_p^2)**
First-Semester GPA out of 4.0; N = 344, 184, 180, and 156	3.18 (0.57)	3.19 (0.62)	3.16 (0.60)	3.10 (0.75)	N/A	F(3,860) = 0.78	$p = .5068$	$\eta_p^2 = 0.0027$
Second-Semester GPA out of 4.0; N = 342, 181, 178, and 155	3.12 (0.64)	3.13 (0.74)	3.06 (0.70)	3.15 (0.70)	N/A	F(3,852) = 0.56	$p = .6433$	$\eta_p^2 = 0.0020$
Third-Semester GPA out of 4.0; N = 337, 175, and 171	3.05 (0.71)	3.15 (0.71)	2.98 (0.74)	N/A	N/A	F(2,680) = 2.32	$p = .0990$	$\eta_p^2 = 0.0068$
Fourth-Semester GPA out of 4.0; N = 336, 174, and 165	3.14 (0.72)	3.10 (0.69)	3.04 (0.77)	N/A	N/A	F(2,672) = 0.98	$p = .3777$	$\eta_p^2 = 0.0029$
Total Number of Reported AP Courses; N = 330, 183, 180, 153, and 151	3.43 (2.64)	3.41 (2.87)	3.29 (2.89)	3.97 (3.22)	3.72 (3.08)	F(4,992) = 1.52	$p = .1929$	$\eta_p^2 = 0.0061$
ACT Composite Score out of 36; N = 340, 183, 179, 152, and 151	28.87 (3.18)	28.91 (3.08)	28.46 (4.58)	29.67 (2.84)	29.13 (3.16)	F(4,1000) = 2.79	$p = .0254$	$\eta_p^2 = 0.0110$
ACT Math Score out of 36; N = 340, 183, 179, 152, and 151	30.89 (3.72)	30.37 (3.74)	30.30 (5.25)	31.05 (3.62)	30.31 (4.10)	F(4,1000) = 1.48	$p = .2069$	$\eta_p^2 = 0.0059$
ACT Science Reasoning Score out of 36; N = 308, 157, 135, 111, and 122	28.26 (3.90)	28.11 (3.70)	27.27 (4.82)	28.97 (4.02)	28.38 (4.07)	F(4,828) = 2.84	$p = .0236$	$\eta_p^2 = 0.0135$
Chemistry Placement Exam Score out of 30; N = 322, 174, 164, 147, and 148	20.74 (7.08)	21.87 (6.43)	21.72 (6.28)	23.57 (6.94)	21.97 (6.78)	F(4,950) = 4.52	$p = .0013$	$\eta_p^2 = 0.0187$
Math ALEKS® Placement Test Score out of 100; N = 332, 181, 175, 149, and 150	82.96 (12.87)	83.69 (10.38)	82.67 (12.51)	85.81 (10.10)	85.05 (11.64)	F(4,982) = 2.32	$p = .0556$	$\eta_p^2 = 0.0093$

Note: Not all variable fields were available for all students. 5^{th} year students were not included in the analysis because a portion of these students have graduated and are no longer attending the university (thus some students are still in progress and some have completed their degrees).

APPENDIX N: TRENDING COMPARISONS OF RETENTION OF STUDENTS IN THE CHEMISTRY MAJOR

Incoming Freshman Classes Fall 2008-2009 (EARNED Degrees) Compared to Current Incoming Freshman Classes Initially Declared Chemistry

	FA2008-09 Students			4th Yr Students			3rd Yr Students			2nd Yr Students		
	Initial	**Earned Chem Degree**	**Rate**	**Initial**	**Declared Chem Major**	**Rate**	**Initial**	**Declared Chem Major**	**Rate**	**Initial**	**Declared Chem Major**	**Rate**
Overall	192	74	38.5%	109	42	38.5%	115	57	48.7%	140	102	72.9%
Asian	43	25	58.1%	45	23	51.1%	52	24	46.2%	58	43	74.1%
African American	15	3	20.0%	7	2	28.6%	10	2	20.0%	4	3	75.0%
Hispanic	11	3	27.3%	9	2	22.2%	8	5	62.5%	15	11	73.3%
White	101	36	35.6%	54	18	33.3%	51	31	60.8%	71	51	71.8%
International	18	4	22.2%	18	7	38.9%	31	13	41.9%	24	18	75.0%
Male	101	42	41.6%	66	24	36.4%	67	32	47.8%	84	67	80.0%
Female	91	32	35.2%	43	18	41.9%	48	25	52.1%	56	35	62.5%
Suburban Student	121	56	46.3%	57	22	38.6%	45	28	62.2%	57	40	70.2%
Urban Student	19	6	31.6%	12	6	50.0%	14	6	42.9%	17	11	64.7%
Microurban Student	19	5	26.3%	8	4	50.0%	10	5	50.0%	13	10	76.9%
Rural Student	16	4	25.0%	8	2	25.0%	4	1	25.0%	6	5	83.3%
First Generation Student	41	14	34.1%	26	9	34.6%	17	8	47.1%	31	21	67.7%
James Scholar Student	46	26	56.5%	12	6	50.0%	21	13	61.9%	24	18	75.0%
Started in Chem 101	24	4	16.7%	4	1	25.0%	6	1	16.7%	8	5	62.5%
Started in Chem 102	67	25	37.3%	55	20	36.4%	57	33	57.9%	52	38	73.1%
Started in Chem 202	91	44	48.4%	38	17	44.7%	44	21	47.7%	65	52	80.0%
Started in Chem 103/105 (labs only)	4	1	25.0%	--	--	--	2	0	0%	2	1	50.0%
Started in Chem 222	1	0	0.0%	6	4	66.7%	2	2	100%	5	3	60.0%
No Chem	5	0	0.0%	6	0	0%	4	0	0%	8	3	37.5%
Started in Math 115	31	6	19.4%	9	1	11.1%	8	4	50.0%	8	6	75.0%
Started in Math 220/221	86	31	36.0%	48	22	45.8%	41	21	51.2%	59	47	80.0%
Started in Math 231	40	23	57.5%	29	11	37.9%	36	23	63.9%	36	27	75.0%
Started in Math 241	22	12	54.5%	14	8	57.1%	16	7	43.8%	21	16	76.2%
Started in Math 225 or 285	2	2	100.0%	--	--	--	1	0	0%	4	3	75.0%
No Math	11	0	0.0%	9	0	0%	12	0	0%	12	3	25.0%

Note: Not all variable fields were available for all students.

APPENDIX O: TRENDING COMPARISONS OF DECLARED CHEMISTRY MAJORS

Incoming Freshman Classes Fall 2008-2009 (EARNED Degrees) Compared to Current Students (Incoming Freshman Classes Fall 2012-2015) (Persisters and Switchers)

	FA2008-09 Students		4th Yr Students		3rd Yr Students		2nd Yr Students		1st Yr Students	
	Total No. Degrees Awarded	% of Total	Current Chem Majors	% of Total	Current Chem Majors	% of Total	Current Chem Majors	% of Total	Current Chem Majors	% of Total
Overall	226	100%	117	100%	123	100%	118	100%	151	100%
African American and American Indian/Alaska Native	8	3.5%	4	3.1%	3	2.3%	3	2.4%	13	8.1%
Asian	72	31.9%	56	43.8%	46	35.4%	52	41.3%	62	38.8%
Hispanic	12	5.3%	9	7.0%	13	10.0%	13	10.3%	15	9.4%
White	115	50.9%	59	46.1%	68	52.3%	58	46.0%	70	43.8%
International	16	7.1%	12	10.3%	25	20.3%	24	20.3%	24	15.9%
Male	136	60.2%	71	60.7%	73	59.3%	74	62.7%	81	53.6%
Female	90	39.8%	46	39.3%	50	40.7%	44	37.3%	70	46.4%
Suburban Student	166	73.5%	63	53.8%	64	52.0%	47	39.8%	69	45.7%
Urban Student	18	8.0%	18	15.4%	13	10.6%	12	10.2%	20	13.2%
Microurban Student	11	4.9%	10	8.5%	13	10.6%	11	9.3%	5	3.3%
Rural Student	13	5.8%	7	6.0%	4	3.3%	5	4.2%	13	8.6%
"Other" (not able to be identified)	18	8.0%	19	16.2%	29	23.6%	43	36.4%	44	29.1%
First Generation Student	48	21.2%	33	28.2%	21	17.1%	22	18.6%	32	21.2%
James Scholar Student	71	31.4%	20	17.1%	28	22.8%	23	19.5%	20	13.2%
Started in Chem 101	23	10.2%	9	7.7%	4	3.3%	5	4.3%	8	5.3%
Started in Chem 102	87	38.5%	65	55.6%	74	60.2%	46	40.0%	49	32.5%
Started in Chem 202	99	43.8%	34	29.1%	37	30.1%	56	48.7%	73	48.3%
Started in Chem 103/105, 223 or Chem 236	17	7.5%	9	7.7%	8	6.5%	8	7.0%	4	2.6%
No Chem	--	--	--	--	--	--	--	--	17	11.3%
Started in Math 115	11	4.9%	5	4.3%	8	6.7%	6	5.3%	24	15.9%
Started in Math 220/221	94	41.6%	58	49.6%	51	42.9%	55	48.7%	66	43.7%
Started in Math 231	68	30.1%	33	28.2%	40	33.6%	28	24.8%	28	18.5%
Started in Math 241	48	21.2%	20	17.1%	18	15.1%	18	15.9%	18	11.9%
Started in Math 225 or 285	5	2.2%	1	0.9%	2	1.7%	6	5.3%	1	0.7%
No Math	--	--	--	--	--	--	--	--	14	9.3%

Note: Not all variable fields were available for all students. Also, students could self-select more than one race/ethnicity category except for the FA08-09 student sample (only selected one). Thus, to calculate the % of Total for this area, the total majors used were the sum of the race/ethnicity categories instead of the actual number of current majors.

APPENDIX P: ANOVA SURVEY RESULTS FOR LEAVERS, PERSISTERS, AND SWITCHERS

	Mean Values (SD)					
Variable Measures (1-5 scale)	**Leavers**[*]	**Persisters**[+]	**Switchers**[#]	***F*-Test Values**	***p*-values**	**Effect Size (η_p^2)**
Confidence to succeed in current major; N = 73, 121, and 55	4.18 (0.96)	4.01 (0.98)	4.25 (1.04)	F(2,246) = 1.40	p = .2479	η_p^2 = 0.0113
How do you feel your high school has prepared you for:						
Chem classes at UIUC; N = 72, 120, and 56	3.53 (1.23)	4.13 (1.07)	3.86 (1.23)	F(2,245) = 6.03	p = .0028	η_p^2 = 0.0469
Chem labs at UIUC; N = 73, 120, and 56	3.18 (1.28)	3.37 (1.33)	3.23 (1.33)	F(2,246) = 0.52	p = .5979	η_p^2 = 0.0042
Math classes at UIUC; N = 73, 120, and 56	3.66 (1.33)	3.86 (1.19)	3.82 (1.15)	F(2,246) = 0.64	p = .5307	η_p^2 = 0.0051
Other general classes at UIUC; N = 73, 120, and 56	3.78 (1.13)	3.92 (1.03)	3.91 (1.07)	F(2,246) = 0.41	p = .6661	η_p^2 = 0.0033
Study skills needed; N = 73, 120, and 56	3.40 (1.26)	3.55 (1.26)	3.48 (1.35)	F(2,246) = 0.32	p = .7233	η_p^2 = 0.0026
Time management needed; N = 73, 120, and 56	3.14 (1.27)	3.57 (1.21)	3.57 (1.28)	F(2,246) = 3.11	p = .0465	η_p^2 = 0.0246
Confidence needed to succeed in college; N = 73, 119, and 56	3.67 (1.09)	3.76 (1.18)	3.70 (1.19)	F(2,245) = 0.13	p = .8741	η_p^2 = 0.0011
To what extent has the following played a role in your decision to remain in your initial major or change majors here at the university?						
Quality of instruction in chem lecture(s); N = 73, 116, and 56	3.21 (1.47)	3.70 (1.18)	3.86 (1.18)	F(2,242) = 4.97	p = .0077	η_p^2 = 0.0394
Quality of instruction in chem lab(s); N = 73, 115, and 56	3.12 (1.44)	3.27 (1.23)	3.21 (1.07)	F(2,241) = 0.30	p = .7423	η_p^2 = 0.0025
Quality of instruction in chem discussion(s); N = 73, 116, and 56	3.11 (1.44)	3.23 (1.25)	3.41 (1.19)	F(2,242) = 0.86	p = .4250	η_p^2 = 0.0070
Chem topics taught; N = 73, 116, and 56	3.18 (1.38)	3.75 (1.14)	4.11 (0.97)	F(2,242) = 10.42	p < .0001	η_p^2 = 0.0793
Level of competition in chem courses; N = 73, 114, and 56	3.04 (1.34)	3.23 (1.27)	3.38 (1.00)	F(2,240) = 1.19	p = .3050	η_p^2 = 0.0098
First chem class; N = 72, 116, and 56	3.04 (1.46)	3.28 (1.38)	3.63 (1.37)	F(2,241) = 2.74	p = .0665	η_p^2 = 0.0222
Ability to learn chem concepts quickly; N = 73, 116, and 56	3.23 (1.38)	3.77 (1.20)	3.91 (1.10)	F(2,242) = 5.94	p = .0030	η_p^2 = 0.0468
Grade performance in chem; N = 73, 116, and 56	3.19 (1.54)	3.55 (1.26)	3.70 (0.97)	F(2,242) = 2.77	p = .0648	η_p^2 = 0.0224
My sense of whether I can succeed in chem; N = 73, 114, and 56	3.59 (1.46)	3.86 (1.20)	3.96 (1.11)	F(2,240) = 1.62	p = .2007	η_p^2 = 0.0133
My sense of belonging in chem; N = 73, 115, and 56	3.64 (1.39)	3.93 (1.20)	4.00 (1.10)	F(2,241) = 1.65	p = .1936	η_p^2 = 0.0135
My interest in chem; N = 73, 115, and 56	3.55 (1.36)	4.31 (1.06)	4.38 (1.04)	F(2,241) = 11.87	p < .0001	η_p^2 = 0.0896
Alignment with career goals; N = 72, 115, and 56	3.83 (1.26)	4.24 (0.92)	4.14 (0.86)	F(2,240) = 3.64	p = .0276	η_p^2 = 0.0295
Support from Chem Dept; N = 73, 115, and 56	2.93 (1.35)	3.23 (1.27)	3.20 (1.23)	F(2,241) = 1.27	p = .2832	η_p^2 = 0.0104
Support from chem instructors; N = 73, 115, and 55	2.95 (1.30)	3.37 (1.29)	3.36 (1.14)	F(2,240) = 2.83	p = .0610	η_p^2 = 0.0230
Support from peers; N = 73, 115, and 56	2.77 (1.26)	3.20 (1.19)	3.27 (1.20)	F(2,241) = 3.64	p = .0277	η_p^2 = 0.0293
Support from family; N = 73, 114, and 56	2.89 (1.28)	3.95 (0.99)	3.71 (1.07)	F(2,240) = 20.99	p < .0001	η_p^2 = 0.1488

(cont.)

Involvement with extracurricular activities; N = 73, 115, and 56	2.48 (1.14)	2.88 (1.26)	2.86 (1.17)	$F(2,241) = 2.72$	$p = .0682$	$\eta_p^2 = 0.0220$
Participating in a study group; N = 73, 115, and 55	2.29 (1.09)	2.54 (1.22)	2.44 (1.27)	$F(2,240) = 0.99$	$p = .3738$	$\eta_p^2 = 0.0082$
Participating in undergrad research; N = 72, 114, and 56	2.26 (1.17)	2.80 (1.51)	2.79 (1.44)	$F(2,239) = 3.62$	$p = .0283$	$\eta_p^2 = 0.0294$
Having a mentor; N = 72, 115, and 56	2.18 (1.18)	2.61 (1.43)	2.41 (1.25)	$F(2,240) = 2.35$	$p = .0980$	$\eta_p^2 = 0.0192$
Quality of instruction in math courses; N = 72, 115, and 55	2.69 (1.38)	2.80 (1.31)	2.38 (1.08)	$F(2,239) = 1.99$	$p = .1384$	$\eta_p^2 = 0.0164$
Level of competition in math courses; N = 72, 115, and 55	2.71 (1.41)	2.64 (1.24)	2.16 (1.00)	$F(2,239) = 3.55$	$p = .0302$	$\eta_p^2 = 0.0289$
Ability to learn math concepts quickly; N = 72, 115, and 56	2.99 (1.43)	3.03 (1.32)	2.95 (1.21)	$F(2,240) = 0.07$	$p = .9322$	$\eta_p^2 = 0.0006$
Grade performance in math; N = 72, 115, and 56	2.93 (1.48)	3.14 (1.30)	2.91 (1.21)	$F(2,240) = 0.80$	$p = .4491$	$\eta_p^2 = 0.0066$

[*]Leavers: Students that were chemistry majors but switched out of chemistry (or indicated that they are switching out).
[+]Persisters: Students that were admitted as chemistry majors and are remaining in chemistry.
[#]Switchers: Students that were not admitted as chemistry majors but switched into chemistry.
Note: Not all variable fields were available for all students.

APPENDIX Q: OPEN-ENDED SURVEY RESULTS – ALL STUDENTS

Survey Q9. Please describe your reasoning for your initial major (i.e., why did you choose this initial major?)

[Students who were admitted as chemistry majors – Leavers and Persisters]

Emerged Categories	# Times Cited by Respondents: Leavers	# Times Cited by Respondents: Persisters	# Times Cited by Respondents: TOTAL
High School Chemistry Experience	**21**	**47**	**68 (29.7%)**
Chemistry "Connection"	**17**	**47**	**64 (27.9%)**
Career Options & Prospects	15	17	32 (14.0%)
Chemistry Major NOT First Choice	15	3	18 (7.9%)
Health Career Goals	9	27	36 (15.7%)
Research & Lab Experiences	4	5	9 (3.9%)
Social Pressures	2	0	2 (0.9%)

Category Descriptions:

High School Chemistry Experience – attributed to high school chemistry class(es), high school chemistry teacher, was good at chemistry in high school

Chemistry "Connection" – attributed to interest in chemistry, like chemistry, passion for chemistry, fascinated by chemistry, good at chemistry, chemistry is application-based, a problem-solving science (not memorization), more interested in chemistry than other science fields, like the challenge

Health Career Goals – attributed to alignment with career goals as pre-medicine, pre-pharmacy, or pre-dentistry

Career Options & Prospects – attributed to aligning with career goals (non-health related, e.g. HS chemistry teacher, attending grad school, pharmaceuticals), good career options in the future, flexibility to pursue multiple STEM majors/fields

Research & Lab Experiences – attributed to liking lab work, love doing experiments, interested in research

Chemistry Major NOT First Choice – attributed to being redirected by chemical engineering or computer science, admission more likely under this major

Social Pressures – attributed to pressures from other people or family, other family members in the field

Quotes:

"My whole family is about chemistry studying, so I thought I may continue to develop in chemistry."

"Chemistry is the central science that can bridge physics and biology. Chemistry can be use in a myriad of different ways to solve problems in biology or biomedical science."

"It was really interesting and it is application to the real world fascinated me."

"I have always loved chemistry since high school and my greatest fascination with it is how it correlates to every single small thing in our everyday life."

"For me Chemistry is like a huge puzzle and puzzles intrigue me immensely. I have always found enjoyment in figuring puzzles out. Therefore, besides the fact that chemistry all around interests me, I find that it correlates to another enjoyment of mine."

"Chemistry was interesting in that it incorporated many scientific principles that other science majors don't reach."

"I'm fit best in desciplines that both involve theoretical learning and hand-on experience. I found my particular prowness and sincere interest in chemistry since 9th grade and has been doing well on this subject throughout my highschool. Also I'm looking forward to do some research that will enable me to apply my knowledge and examine some of my chemical insights and ideas generated both from classroom learning and extended reading."

"I chose this major for the love of what chemistry studies and involves. In my opinion it's the best science as it applies mathematical skills and not simply remote memorization like biology. It also involves many conceptual problems that need to be understood before solving a problem (similar to physics also but not as abstract thankfully) and is heavily involved in experiments and laboratory work. I also feel comfortable with my major since I was privileged enough to take 2 years of chemistry in high school. Honors Chem my junior year and AP Chem my senior to finish off strong. A strong science and math background will serve me well and will develop and refine my abilities to perform research and experiments that help promote change and facilitate progress."

"I am pre-med, and I thought that chemistry would provide me with a good background for medical school. I also knew that U of I has one of the best chemistry programs in the country."

"Throughout high school, chemistry was my favorite subject. I've always had a passion for almost every subject of science, but what tipped the scale to chemistry was the teacher I had in my high school career. She was so passionate about the subject and that ultimately influenced me on choosing chemistry."

[Students who were NOT admitted as chemistry majors but switched to this major – Switchers]

Emerged Categories	**# Times Cited by Respondents: Switchers**
Undecided	**15**
Interest	**11**
Career Options & Prospects	8
Health Career Goals	8
Admitted as Undeclared Major	7
High School Experience	4
Social Pressures	3

<u>*Category Descriptions:*</u>
High School Experience – attributed to high school class and/or teacher
Health Career Goals – attributed to alignment with career goals as pre-medicine
Career Options & Prospects – attributed to aligning with career goals, had an internship in field
Social Pressures – attributed to pressures from other people or family, other family members in the field
Undecided – attributed to varied interests, no idea what to major in, interested in math and science but not sure which major
Admitted as Undeclared Major – attributed to admission more likely under this major, redirected from engineering
Interest – interested in biology, engineering, chemistry

Quotes:

"I chose the initial major because I am from a rural town of 900 people and my father is a veterinarian. So, I knew a lot about animals and thought the major would be appropriate given my background."

"People said I should be an engineer."

"I wasn't sure about what to major in and DGS was relatively cheaper tuition so less financial burden on my family."

Survey Q11. If you changed majors or intend to change majors, please describe all the reasons why you are deciding or have decided to switch.

[Students who were NOT admitted as chemistry majors but switched to this major – Switchers]

Emerged Categories	**# Times Cited by Respondents: Switchers**
Chemistry "Connection"	**30 (49.2%)**
Career Options & Prospects	11 (18.0%)
Professors/Teachers	7 (11.5%)
Health Career Goals	4 (6.6%)
Research & Lab Experiences	3 (4.9%)
Could Not Succeed in Other Major	3 (4.9%)
"In Transition"	3 (4.9%)

<u>*Category Descriptions:*</u>
Chemistry "Connection" – attributed to interest in chemistry, enjoy chemistry, love material, like chemistry better than other majors
Health Career Goals – attributed to alignment with career goals as pre-medicine
Career Options & Prospects – attributed to aligning with career goals (non-health related, e.g. HS chemistry teacher, attending grad school, pharmaceuticals), had an internship in this field
Research & Lab Experiences – attributed to interest in research
Professors/Teachers – attributed to professors going out of their way to assist students, professors show that chemistry is interesting and exciting, teachers left good impression
Could Not Succeed in Other Major – attributed to not being able to succeed in other majors such as biochemistry and chemical engineering
"In Transition" – attributed to needing to switch into chemistry for awhile until s/he can switch to chemical engineering, mechanical engineering, etc.

Quotes:

"I found once i started organic chemistry that I really liked it. It fascinated me that chemistry is involved with everything in our day to day lives and could be applied anywhere. This versatility made me choose chemistry because no matter what I decided to do career-wise, I would be knowledgeable about a very important topic."

"I am fascinated by science and how things work and feel chemistry is the basic building blocks of everything. I also really enjoy learning about space and I feel that this has also encouraged me to pick chemistry because chemistry plays a big role in space exploration and I like to be able to understand information I read about it. I also feel, that even though chemistry is one of the first sciences studied, I believe there is still much to be learned and explored in the field. I would like to take part in being one of the first people to discover or work on something. I feel like chemistry can offer me that."

"I added the Chemistry double major after taking organic chemistry. I really liked how applicable it was and how challenging and fulfilling the problems were in the class. 236 is a really well taught class and I like how research professors teach it and bring in their own examples from their work."

"Biochemistry was not quantitative enough (math required only through Calc III) and the major itself was very inflexible (only one study abroad option and virtually no choice of technical electives). Biochemistry also required all of the work but offered none of the benefits of being a chemistry major (such as the SCS career center). Also, I did not enroll as a chemistry major initially because I did not have a great chemistry program at my high school and I was unsure I wanted to major in it. However, [Professor X] showed that chemistry, although at times challenging, can be very interesting and exciting."

"I will transfer into chemical engineering. I won't staying in chemistry major, it's just that I can't transfer into chemical engineering yet so my adviser suggested me to be a chemistry major first (so that I can take the chemistry courses that only chem students can take)"

"I took [Professor Y's] organic chemistry class. The first day of class I learned a great deal about him. He came off as a type of celebrity. I was really inspired to follow the same career path. I think that the first class teaching me about a person in the chemistry field had a lot to do with my decision for chemistry."

[Students who were admitted as chemistry majors – Leavers]
(*Recall:* Please describe all the reasons why you are deciding or have decided to switch out of chemistry.)

Emerged Categories	# Times Cited by Respondents
Engagement/Interest in Other Major	**21 (18.8%)**
Usefulness of BS Chemistry Degree	**21 (18.8%)**
Other Major More Relevant to Future Career Goals	12 (10.7%)
Redirect	9 (8.0%)
Issues with Supporting Coursework	9 (8.0%)
First Semester Experience	8 (7.1%)
Not Connecting with Chemistry	8 (7.1%)
Chemistry Grade Performance	7 (6.3%)
Overwhelmed with Course Load	6 (5.4%)
Social Isolation	6 (5.4%)
Chemistry Advising	5 (4.5%)

Category Descriptions:
Chemistry Grade Performance – attributed to not performing well in chemistry class(es)
Not Connecting with Chemistry – attributed to not enjoying chemistry, hating chemistry class, not as happy in chemistry, poor experience with chemistry professors
Engagement/Interest in Other Major – attributed to the other major as more interesting, other major more engaging, passionate about other major, wanting the challenge of the other major
Overwhelmed with Course Load – attributed to feeling overwhelmed with course load, felt unprepared for pace and level of courses, couldn't handle the labs, felt discouraged
Social Isolation – attributed to feeling isolated in chemistry classes, having a peer group in another major, other major is more inclusive to its students, not enough support
Other Major More Relevant to Future Career Goals – attributed to other major more relevant to what they wanted to do, MCB would prepare them better for medical school
Issues with Supporting Coursework – attributed to not performing well in math and/or physics class(es), didn't want to take future calculus and/or physics class(es), not sure if could handle calculus class(es)
Usefulness of BS Chemistry Degree – attributed to other major degree more useful career wise, not as many job prospects/options in chemistry major, don't want to go to graduate school so the other major is better for getting a job with a BS degree, chemistry majors are only pre-med majors
Chemistry Advising – attributed to not receiving good course advising by advisors, felt unwelcomed and rushed by advisors, other major advisors more supportive and helpful
First Semester Experience – attributed to poor experience in first chemistry class, poor experience with advisors first semester, poor experience with chemistry professor first semester
Redirect – attributed to never intending to be a chemistry major, redirected from some other major

Quotes:
"Chemistry at UIUC was considered a weed out course for me. The structure was difficult and I wasn't engaged. The professor was also not very helpful. No matter how hard I tried, I always seemed to fail and it took a toll on me. Why would I continually hurt myself like this with something I'm not even passionate about?"

"I think that there are several factors that impaired my ability to succeed in the chemistry major. First of all, the large group setting for instruction was new and inconsistent to how I had always learned in the past. The fear of not knowing who to ask for help was also very strong my freshman year. Finally, the grades I received in math and science courses at the U of I were so much different from my grades in high school that I felt very discouraged."

"I hated my chemistry class and I wanted to not be miserable for four years. My classes were isolating."

"I switched to geology and I am still doing the secondary education minor. I decided to switch because the initial course load (my freshman year) was overwhelming and I was not prepared for the level and pace at which the classes were moving at."

"[Professor X] made me really uncomfortable. He was unapproachable, and when I actually tried to approach him to introduce myself he was standoffish and really impolite. It made me feel like he didn't actually care about his students and just wanted to get on with his life after class was over. I realized Chemistry is still a male dominated STEM field and I didn't want to continue feeling inferior."

"I knew after the first week at the University of Illinois that I wanted to change my major. In the first week of chem102, I felt very overwhelmed and realized that college chemistry was going to be very different from what I had experienced in high school. I had a gut feeling it just was not for me and knew I would spend too much time struggling. I debated switching to biology, but after taking a kinesiology course, I knew I had found the right fit. Not only did I have no desire to continue on as a chemistry major, I also no longer wanted to be a teacher. Prior to deciding on chemistry education, I had considered athletic training and later learned about physical therapy. I felt kinesiology would allow me to develop skills specifically for this field."

"I took a class with a professor who didn't teach us general chemistry and taught quantum mechanics which was things that our graduate student TAs had not learned yet. I didn't enjoy it and the labs were a lot more than I could handle. I loved to cook and so food science was a perfect fit."

"I decided to switch to be honest because I felt terribly unwelcomed in any chemistry advising office every time I tried to visit. I was quickly rushed out and didn't get thorough answers to any questions I had regarding the major. When I signed up for classes as an incoming freshman, my advisor forgot to put me into a lab which was Chem 103 at the time. Being a clueless freshman I went through alms it a month of classes before realizing I was supposed to be in a lab. When I went to the chemistry advisors for guidance they blamed it on me and told me I should have registered myself for it. Also I had a very careless Chem 102 TA. He did not explain things at all to us and left me really struggling in what was my first chemistry class at u of I."

"I still enjoy chemistry, but the major was very math and physics based. I felt that I was gaining general knowledge on several subjects and felt lost in what I wanted to do as a career. The food science major still includes chemical aspects and feels more specific and inclusive to its students. The food science advisers were much more supportive and helpful and I felt like I knew what kind of careers I could have while still enjoying chemistry."

"As previously stated, the advisers in the food science department made the school seem very small and inclusive. I was told about research opportunities and invited to info nights and clubs. After planning my courses with an adviser, I felt that I knew what to do and where to go toward getting a job and starting my career, where as in the chemistry department my education felt very general and I felt that I was not important enough to get accepted to research or internship positions."

"Human Nutrition is much more focused, and I realized it is a more useful degree to have."

"I think chemical Engineering is more practical. I figured out that graduating as a chemical Engineering will give me more opportunities than chemistry. I still like chemistry. In fact, I enjoy my chemistry classes more than my chemical engineering one's."

"I feel Chemical Engineering is a more marketable major, and the amount of work and dedication that is needed for it gives a more comprehensive feel of Chemistry for me, as well as carries a higher prestige."

"Calculus is ridiculous here. Professors are much more focussed on showing off their knowledge then actually teaching when it comes to Math."

"It was all just a one big combination of my personal interests in other subjects, lack of substantial/effective/passionate teaching, courses designed to basically try to accumulate as many points as possible rather than test adequate knowledge of the given subject, not being clearly aware of student interest/confusion/ability/etc, and/or having obscure grading policies that are subjected towards unfair bias or consequences (i.e- not curving an exam if the class average is around a 40% or having too much/too little weight to a given category (such as having a commutative final exam only account for 10% of the final grade or having 2 or 3 exams that are worth 50%-90% of one's overall total grade)), and just the sheer apathetic nature researcher-based lecturers have when teaching the class. The unenthusiastic, uninspired, and seemingly bored professors really do take a huge toll on student performance and how they go about adapting the course by other means (if that is such a case). These factors also played a major role for me as well. I guess this isn't so much a problem for the students who may plan on going into research themselves as it is for pre-health students respectively."

"Another thing that played a role in my switch was my advisor at the time. I do not think she was supportive and she did not provide me with essential information needed to make my decision."

Leavers - Current/Intended Major	Number of Students
Accountancy	1
Actuarial Science	1
Aerospace Engineering	1
Animal Sciences	1
Anthropology	1
Atmospheric Sciences	1
Chemical Engineering	21
Community Health	3
Computer Engineering	1
Computer Science	4
Crop Science	1
Earth, Society, & Environment	1
Economics	1
Electrical & Computer Engineering	1
Engineering Mechanics	1
English	1
Food Science	3
Geology	2
Graphic Design	1
Human Nutrition	1
Industrial Engineering	1
Integrative Biology	4
Kinesiology	2
Materials Science & Engineering	4
Mathematics	2
Molecular & Cellular Biology	7
Music Education	1
Nuclear, Plasma & Radiological Engineering	1
Psychology	2
Recreation, Sport & Tourism	1
Speech-Language Pathology	1
Undeclared	1

[Students who were admitted as chemistry majors – Persisters]

Considering Switching – made note in this field that that are considering another major but not sure (N = 7 respondents)

Survey Q12. What are your career goals?

Emerged Categories	# Times Cited by Respondents: Leavers	# Times Cited by Respondents: Switchers	# Times Cited by Respondents: Persisters	# Times Cited by Respondents: TOTAL
Academia	0	4	6	10
Art Conservation	0	0	1	1
Attorney	1	1	1	3
Business Field/ Health Administration	9	2	6	17
Computer Science/Data Analyst	2	1	1	4
Dentist	2	0	2	4
Engineer	9	1	1	11
Environmental Work	1	2	3	6
Entrepreneur	1	0	1	2
Forensics	0	0	4	4
Graduate School	**9**	**11**	**15**	**35**
Industry/Corporate	**17**	**12**	**18**	**47**
Liberal Arts	2	0	0	2
Medical Doctor	**7**	**12**	**22**	**41**
Military	2	0	1	3
Nonspecific	3	1	4	8
Pharmacist	3	3	6	12
Physical Therapist	1	0	0	1
Physician's Assistant	2	2	0	4
Researcher	**9**	**11**	**30**	**50**
Teacher	6	3	8	17
Unsure	3	6	6	15

Quotes: (Leavers)

"I'm not 100% sure but I think I may want to do R&D for a food processing company or do something where I can help make good, healthy, food available to everyone in the world."

"With graphic design, I want to head towards more of the advertising/marketing route. I want to be a part of the ad design process or even take up branding/logo design. As I work my way up, I want to head more towards Art Direction for digital media."

"I would like to work at a chemical plant working with a chemist to determine how to create a product and then determine what mechanical processes must the product go through to produce it at a grand scale. Also, the salary of a chemical engineer is far superior to that of a chemist."

Quotes: (Switchers)

"I planned to go the PA school to become a physician assistant, but decided that ultimately this may not be what I want to do. I still love chemistry and I am thinking about applying my chemistry knowledge into my career with a dual degree in chemistry and some sort of engineering. While I am not sure whether I will choose electrical, bioengineering, or some other engineering, chemistry was my first passion and I want to stick with it and learn more about it and be able to apply it elsewhere in my career."

"Mostly unsure, I've recently developed the philosophy that it is better to follow your curiosities than define your career goals. With that said, I have most of my professional experience in communication, technology, and entrepreneurship. I know for a fact that I will not be pursuing chemistry at the graduate level. I have very varied interest, however, so I am still uncertain if my career will be in communication."

"I want to be a polymer material scientist. I love working with chemicals, and getting paid to synthesize something and test its efficacy as a useful material would be a godsend."

"To be a software engineer in computational chemistry and continue to build on my technical abilities at a company that values individual growth."

"To make 6 figures one day, and to live in Colorado."

Quotes: (Persisters)

"My career goal is to become a proficient chemist that uses science and math as his tools to bring about a positive impact on society and change the way it sees and uses chemistry in everyday life. I am confident that I will find a effective way of changing society for the better whether that be researching, performing experiments, working with other renowned scientists to innovate and implement new ideas or products, or consulting doctors/lawyers/businessmen on the effects of a certain medicine or science product."

"Originally I wanted to be a doctor, more specifically a radiologist. I then decided I wanted to attend law school. I am again having second thoughts."

"Um. I have none, to be honest. I just want to learn."

Survey Q22. Please share any other comments or concerns regarding your high school experiences.

Emerged Categories	**# Times Cited by Respondents: Leavers**	**# Times Cited by Respondents: Switchers**	**# Times Cited by Respondents: Persisters**	**# Times Cited by Respondents: TOTAL**
HS did not prepare me well	12	8	12	32
HS prepared me fairly well	4	0	5	9
HS prepared me very well	6	7	11	24
Self ownership in being a college student	4	1	1	6
Poor career/major counseling in HS	1	0	2	3
Good student and HS experience	1	2	5	8

Quotes: (*HS did not prepare me well*)

"High school was a breeze for me so studying and time management and anything with self learning is out of the question. Plus I got praised for being smart but now I don't feel this way anymore which can cause alot of pressure and sadness."

"High school came very easy to me and I could receive A grades without having to study much. College is a very different experience in that aspect. I have to study harder than I ever did in high school to get average grades here, which was expected."

"They did not prepare for university level courses. My high school catered too much to the student so I, as a student, became spoiled and comfortable. I was able to get by with decent grades without studying and that does not prepare one for college."

"My high school was very lenient on the coursework covered, and as such we covered very little material over a very large amount of time, so it is a good change of pace to be able to feel a challenge, but also slightly terrifying that I have to learn so much more that most of my peers have already learned in high school."

"I just felt that I was not prepared well enough to come to this university and find myself really struggling to get by. I am not sure if it just the difficult major or if I am up to par to be attending the university."

"As is the story for most honors kids, school was easy. Never studied. Still don't know how to study"

"My high school is in a very poor rural area, so there are very few resources available at my high school given its limited budget. Also, many adults in my area are not college graduates, and only ever completed high school. So, while many of them do acknowledge the value of education, they do not realize just how low the educational standards are at the high school I attended."

"The education I received in high school was very lacking. The teachers ideas about what would prepare us for college were completely wrong. Also, at the time, my school only allowed students to take 1 AP course their Junior year but then we could take as many as we wanted our senior year (but they advised a limit of two). When entering the U of I, I was significantly behind other students who were coming into college with practically a sophomore standing due to all of the AP course credits and college credits they had already received in high school."

"My high school experience seemed to put me at a set back compared to those of my classmates. Or I just didn't get as much out of high school as I would have liked...I don't know which it is."

"Coming from a small school, it's a culture shock to be surrounded by so many people. It's kind of scary."

"I went to a high school where I did not have to work very hard to succeed. As a result I jumped into higher level classes, even though I was not prepared to do so. I still struggle with working hard to this day because I never learned how to when I was younger."

"I was cheated, my STEM courses in high school were no match to some "other" student's courses"

"High school made me very confident in my ability to succeed but college destroyed much of that confidence."

"My high school experience was somewhat hectic. The administration decided to end finals at the end of each semester my sophomore and stuck with it even to this day. They also took away any and all homework grades my senior year. They really supported a behavior of laziness."

Quotes: (*HS prepared me fairly well)*

"I come from an incredibly small high school that had very limited resources as far as preparation for nationally ranked universities go. But the top 15% of the class or so almost always end up adapting fairly well accordingly and go on to be very successful in life."

"My high school education is pretty much exam-oriented and gives little attention on cultivating students' scientific investigation and critical thinking ability. I was only taught textbook knowledge, problem solving skills and experiment practice that are related to CIE and AP exam syllabus. Though it has helped me building a substantial theoretical basis, in fact, I am very diffident with my practical technique and completely unfamiliar with the process of composing a good lab report as I never heard about or wrote any throughout my high school. For the lab, we merely need to record experimental data and answer simple calculation questions on worksheet. Also chemistry laboratories in my school were frequently pre-occupied and not very accessible(about 2-3 class per semester) for science students like me who wish to conduct individual research projects or simply refine experimental insights."

"High school experiences gives some help, but always needs more study in college."

Quotes: (*HS prepared me very well)*

"My high school made me be confident and find my own way to explore the world. To try, to fail and be confident."

"In high school I was challenged daily in my academics, cultural relations, family and friend dynamics, as well as personal perseverance. I also lived away from home during this education and it heavily prepared me for the responsibility of my own academics/time management."

Quotes: (*Self ownership in being a college student)*

"I went to a very good high school. However, I don't think any high school can prepare you for all the things that go on in college. Getting better with time management, difficult classes, etc come with time and effort. You learn from your mistakes and figure out what works best for you."

Survey Q47. Please share any other comments or concerns regarding what played a role in your decision to remain in your initial major or change majors.

[Students who were admitted as chemistry majors – Leavers]
[Students who were NOT admitted as chemistry majors but switched to this major – Switchers]
Combined with Q11.

[Students who were admitted as chemistry majors – Persisters]

Quotes:

"My first semester freshman year was not the best start to my collegiate career, however, the following semesters helped me to confirm my decision of choosing to remain in my initial choice, Chemistry. I had formed study groups, worked closely with my Professor and TAs to learn the material, and did not give up in the thick of the difficult material. My interest never waned, but how I approached the material changed everything and reaffirmed my desire to dedicate my studies to Chemistry."

"The main reason I have stayed in chemistry is because of my research interests in the field. I continue to enjoy research even though my grades tend to suffer as a result."

"I do feel that chemistry can be overwhelming at times, but I know that when I need help there will be many resources available."

"Basically, I mostly struggled in Physics and the highest levels of math needed to obtain a degree in engineering."

"I really struggled with whether to remain in chemistry or switch to something else or double major because I didn't think that an undergrad degree in chemistry would get me a decent job."

"I have always wanted to study Chemistry, to work in a lab and write lab reports, regardless of how tedious and time-consuming the process may be. My desire to improve and strengthen my Chemistry knowledge has only grown as I've taken more Chemistry courses at UIUC, especially when lab work was involved."

"well, although I can see that it is not easy to find a decent job with chemistry BS or MS or even Phd, this is the only thing I am really good at. So I guess I will keep going"

"Labs are poorly taught, some TA's haven't taken the course they are teaching. See chem 203, my ta's had taken the 100 level course and knew shit about the cobalt lab In 315, they didnt know how to run gel electrophoresis resulting in 4 wasted hours."

"UIUC is one of the best Chemistry graduate school and I could learn a lot from participating in a research lab."

"Even though Chemistry is probably going to slowly kill my GPA, I plan to stick with it because I genuinely enjoy learning about it. Lab sucks though. If I based my major solely off of the lab courses, I would have left by now. The labs themselves are really awesome but the structure of the class just isn't coherent."

"My major lets me study computer science classes that I really enjoy and take the premed classes."

"I came into college with the mindset that I would not change my major, but now that I am a couple months away from graduation and am looking for a job, I'm realizing chemistry does not correlated very much with my current career interests."

"The biggest thing was that I was able to do research and it really made me feel like this is what I wanted to do for a living."

[FEEDBACK FOR CHEMISTRY DEPARTMENT]

Survey Q49. What have been the most positive aspects of interacting with the Department of Chemistry?

Emerged Categories	# Times Cited by Respondents: Leavers	# Times Cited by Respondents: Switchers	# Times Cited by Respondents: Persisters	# Times Cited by Respondents: TOTAL
Chemistry Professor(s)/Classes	**17**	**20**	**28**	**65**
Chemistry Scholarships	0	0	4	4
Learned A Lot	**5**	**4**	**7**	**16**
Advisor(s)	**17**	**7**	**7**	**31**
Outside Help	0	1	3	4
SCS Career Services	2	2	4	8
Undergraduate Research	**2**	**3**	**10**	**15**
Mentoring	0	2	5	7
Overall Staff Experience	**7**	**7**	**15**	**29**
TAs	4	0	2	6
Chemistry Clubs	0	0	1	1
Being a TA	0	1	2	3
Merit Program	1	3	3	7
Support from/Community of Chemistry Peers	0	0	7	7
Overall Not a Positive Experience	5	1	0	6

Quotes:

"Because the chemistry program isn't the biggest on campus, I definitely a close, personal experience with my academic advisor in the School of Chemical Sciences. She helped me understand what needs to be done in the next four years as a chemistry major, and they are very knowledgeable."

"Being challenged a great deal my first year helped me to prepare for the following years."

"I have always had a great experience with the professors, especially at office hours. They have always been very good at explaining chemistry concepts and answering any questions I have related to the material taught in the course."

"The department of chemistry is focused and professional. The faculty cares about the students and wants students to reach their potential."

"Having a mentor has been the best, but the chemistry professors do a great job of teaching, being available, and answering questions."

"One of my professors helped and encouraged me while I was struggling through tough material, and that was enough to give me the determination to not give up in my second semester of Gen Chem. The flexibility when one of my ROTC courses interfered with Chem 332 and I was able to move into a full lecture with no problems."

"The teachers are nice and straight forward and seem actually interested and engaged in what they are teaching. They seem to love chemistry and their jobs."

"The professors have all conducted great lectures and classes. They all seem well prepared in their content and fair in what they expect from us. The advisers of the department hae also been extremely friendly and hepful in the past."

"All staff (counselors, professors, TAs) genuinely care about their students, are easy to approach, and are very knowledgeable in their respective areas."

"Any chemistry major is extremely supportive in helping you succeed in any way they can."

"I came from a very small high school, so the most positive aspect of interacting with the Department of Chemistry is being surrounded by people who love Chemistry as much as I do."

"I love the atmosphere that the department gives off, and the professors and laboratories at the University make it such a welcoming place, as if it is where I am meant to be."

"We're told what to expect right from the beginning. They don't ease you into the curriculum by providing ridiculously easy Gen Chem questions in CHEM 202. They show you the reality, and give you questions, projects, and challenges that constantly remind you that you are no longer a high school student, and that this is university-level chemistry. The demonstrations and explosions make class fun. There's a Career Services division just for the Department of Chemistry. You get a 1000 free prints as a Chemical Engineer. 4-hour labs really push you to assimilate ALL your talents to perform successfully - practical lab skills while performing experiments, analytical and academic skills while writing lab reports. They also help enhance your research skills."

"I was only in the major for one year, and had a very negative overall experience."

Survey Q50. Please write any suggestions you have for improving the undergraduate student experience in the Department of Chemistry.

Emerged Categories	**# Times Cited by Respondents: Leavers**	**# Times Cited by Respondents: Switchers**	**# Times Cited by Respondents: Persisters**	**# Times Cited by Respondents: TOTAL**
Smaller Class Sizes	2	1	1	4
First Year Chemistry Class Experience	**6**	**0**	**6**	**12**
Community Needed	**1**	**3**	**6**	**10**
Cost	1	1	3	5
Online Chem 232 Course	**1**	**5**	**3**	**9**
Undergraduate Research	**1**	**2**	**6**	**9**
More Variety within Major	3	1	3	7
Issues with Lab Experience	2	1	4	7
Issues with TA(s)	4	1	3	8
Issues with Professor(s)	1	1	3	5
Issues with Advisor(s)	**5**	**5**	**6**	**16**
Issues with Career Advising	1	2	4	7
Mentoring	2	0	4	6
Everything is Fine	4	1	2	7
Other (e.g. improve 100 Noyes Lab, not require calc 3)	2	3	4	9

Quotes:

"Build more of a community where students have the opportunity to interact with one another at social events. Perhaps even have t-shirts to bring everyone together."

"Reach out to students for personal or small group meeting with professors. Don't make group emails. Some will naturally be able to connect and network, but others struggle with trying to do that and need more help. Maybe in the students sophomore year, reach out to the ones that have not gotten to know more of the staff."

"I would have set groups of people who are willing to study together so no one is left behind."

"I wish the Chemistry department would take the time to focus on people who are just chemistry majors. There is so much emphasis on Chemical Engineering, that people who are just Chemistry majors feel brushed to the side."

"The first level of chemistry courses are extremely intense and intimidating. I bet the attrition rate is heavily influenced by this."

"Suggest that students who have not taken AP chemistry to begin in Chem 101. 102 was very difficult for an tiro level class. I should have tried harder my freshman year, but it was so difficult to where it was not enjoyable."

"be more personable and lower ur expectations. Not everyone does AP chem in high school."

"Well as a freshman coming into 202 it was a little overwhelming, especially when you're just learning the campus, so maybe ease a little more into so students who aren't as prepared don't feel like they are being forced out."

"From the point of view of an innocent little high school graduate, coming to CHEM 202 right after a long summer vacation can be a frightening experience. The difficulty level of the questions we get asked, the amount of questions we are asked to solve in an unfairly small amount of time, combined with a 4-hour lab in which we have to stand and work with hazardous chemicals like hydrofluoric acid (it dissolves bone...that's scary stuff for 18-year olds) - for a mere 2 credit hours, all gives a collective impression of Chemistry being a highly difficult field to pursue. While these things were exactly what attracted me to ChemE (I knew right from Day 1 what I was getting myself into), they are also the most commonly cited reasons given by dropouts. Such a competitive environment makes it difficult to get a good starting grade in Freshman Semester 1, which makes the students re-evaluate whether they have the aptitude to pursue the field. My suggestion would be to make the curriculum gradually increase in difficulty, so that you don't scare away students so quickly. It's like getting the frog in warm water, and gradually getting the water boiling."

"I think its important to look at the student individually. If one thinks a student is not prepared for a class, they probably are not. The adviser asked my if I wanted to take physics in the spring and I said yes but in reality she should have looked at my grades from the fall and should have offered an alternative path even if it took longer."

"I think that there should be more support and more useful advice from the advisors. More times than not I definitely felt like I could do everything on my own and was not advised well enough. Organic Chemistry 1 is a class that should not be taught online and is the main reason why I have lost interest in this major."

"I do not know if it's in anyone's power but I would say the main course that made me really think about whether or not I wanted to remain in chemistry was Orgo I, because that class is not something that should be taught online."

"I mean we all basically hate the lab courses. We never know what exactly is expected of us and that makes learning and satisfying requirements really hard."

"I've thought about this a lot and I coming up with suggestions is exceptionally hard. I think one way that I could have had a better experience is if I had built up the confidence to do chemical research in undergrad, or just confidence in my ability to do chemistry at a higher level, at all. My suggestion would then be to do more to introduce undergrads to research. The process is so student-initiated right now that anyone with self-efficacy issues is likely to never get involved. Perhaps there could be an independent study with the goal of having students define their interests in chemical research that simultaneously puts chemistry into real-world contexts and is an introduction to the world of academic chemical research."

"I would highly recommend you guys do a study on research credits. I can only have up to 3 credit hours, that is 12 h/week in lab. We have two meetings per week which generally will take up to 6 hours. I can barely do anything with the remained 6 h. I always work much longer than that. I will normally spend 20-24 h/ week in lab, and that means my time spend in lab is way more than 3 credit hours for a semester. Also, there is no criteria for grading. I spend tons of time in lab and sure, I learned tons as well, but I am still an undergraduate, and my performance may not be comparable to that of a graduate student. My research adviser has been giving me B grade for the past year for this reason, which negatively affects my GPA. If I use the time on any other courses, a straight A+ is guaranteed. so, please think about this!"

"I feel that the higher level courses vary too much when taught by different professors. In some cases the topics covered are completely different than another section, which makes me feel like I am either missing crucial information or learning things that are not important."

"I think that there is a very big disparity between the specialized chemistry curriculum and the normal chemistry curriculum. Sometimes this takes away from the legitimacy of the "normal" chemistry majors. Maybe it would be good to make one chemistry major but I also understand why the department has chosen to make two separate majors."

Survey Q51. Please write any additional comments you have about your experience in the Department of Chemistry or about this survey.

Quotes: (LEAVERS)

"Really was not thrilled. At least the advisors actually cared about my mental state and how much beating down I took from these classes to where I almost broke."

"Everyone was nice, but it wasn't for me."

"its necessary bc my experience sucked I quit my first week"

"I wish that this degree would have worked for me, but I am more interested in the environment and sustainability."

Quotes: (SWITCHERS)

"The Department of Chemistry has been wonderful throughout my experience here at Illinois. It's very supportive of my educational endeavors and the advisors are extremely understanding."

"The quality of the professors is great"

“I have had nothing but good experiences with the department of chemistry.”

“After transferring to the department of chemistry, my adviser was helpful in determining what classes I should take but failed to mention extra support or opportunities provided by the department of chemistry such as career services. After that adviser transferred to a different department I worked with another adviser who was exceptionally more helpful and responsive. Last semester, two new advisers were transferred into the department of chemistry. In order to make sure I was on track, I decided to seek advising. I first went to my new adviser (specified by my last name) and they helped me a little but then pointed out that I still had multiple more courses that I needed to take to finish my major than I had been previously advised. I waited a couple days to mull over my options, I looked into my major requirements and what they said wasn't adding up. I then decided to go to walk in hours and received advising from the second new adviser. They directed me in the exact opposite direction and couldn't answer all of my questions. I waited a little longer then decided to try and meet with the only adviser I had ever had luck with in the department of chemistry. He helped me significantly and corrected all of the wrong advising I had received and confirmed that I had already known what courses I had remaining before I even started the whole process. This was an awful experience for me. Due to bad advising (TWICE) in the same week, my stress levels increased severly as I started to think about my financial situation and the number of courses I had remaining along with the number of semesters I would need to finish it all and whether or not I should just transfer down to the regular chemistry major due to these reasons.”

“I love the major however, I do feel as though the Chem Labs are meant to be so challenging to the point that they are not engaging and the material is not sticking. I sometimes feel like a number in this major and not a student”

Quotes: (PERSISTERS)

“New advisors every year/semester make it hard to get to know one and have consistency.”

“I have had a great experience so far and I'm sure it will get better in the future.”

“I also wish the advisors knew how to properly advise students about which classes to take instead of just saying "Well, it's really up to you."”

“The advisors could be better.”

“The Department of Chemistry needs to seriously up its game. There is no middle ground between Spec Chem and Gen Chem. Being in Spec Chem is basically being a ChemE, where is being in Gen Chem is a joke, as there's barely any course requirements. In addition, very poor guidance and direction is given to Chem majors. LAS 101 should not be for Chem majors. They do not introduce you to what the department offers such as SCS Career Services and research opportunities. It took me a long time to learn what steps to take to be successful. The advisors are absolutely pathetic. They put me in Chem 232 as a freshman, with no understanding of how that could impact me, even if I was proficient. They do not have the knowledge to guide or mentor you and show absolutely no interest in your growth. Studying Chemistry at U of I is definitely my biggest regret in life so far.”

“I love chemistry”

“The most rewarding experience of being in the chemistry department has been the ability to do high quality research since I was a freshman. While it is an extremely large time commitment, nothing has been more fun to learn about and be apart of during the past three years.”

“Poor organization is everywhere. To much is placed on being a research university and less on teaching.”

“Offer more specified chemistry courses will be better.”

“I think the Department of Chemistry is doing a phenomenal job with assisting undergraduate students. I especially enjoy the focus on undergraduate research.”

“I do not know of any other chemistry organizations on campus besides the American Chemical Society, but even then, I am not entirely sure how to get involved with it.”

“I think that the advisors should make it more clear to the incoming students, what the difference between specialized chemistry and chemistry science and letters is. When I got here I had no idea what I was signed up for and I also didn't know what other options I have. I think every student should know their options when they come into school.”

“I enjoy visiting my advisor and Patricia Simpson”

“I love it! I am very happy with my choice in major and school.”

“If I was more open minded to changing my major freshman year, or if I entered undeclared, I would not still be in the chemistry major.”

APPENDIX R: OPEN-ENDED SURVEY RESULTS – DISAGGREGATED BY GENDER

Survey Q9. Please describe your reasoning for your initial major (i.e., why did you choose this initial major?)

[Students who were admitted as chemistry majors – Leavers and Persisters]

Emerged Categories	**# Times Cited by Respondents: Leavers**		**# Times Cited by Respondents: Persisters**		**# Times Cited by Respondents: TOTAL**	
	Female	Male	Female	Male	Female	Male
High School Chemistry Experience	**14**	5	**23**	**23**	**37**	**28**
Chemistry "Connection"	8	**8**	**23**	**24**	**31**	**32**
Career Options & Prospects	**12**	3	9	8	21	11
Chemistry Major NOT First Choice	5	**8**	1	1	6	9
Health Career Goals	6	3	16	11	22	14
Research & Lab Experiences	2	2	2	3	4	5
Social Pressures	1	1	0	0	1	1

[Students who were NOT admitted as chemistry majors but switched to this major – Switchers]

Emerged Categories	**# Times Cited by Respondents: Switchers**	
	Female	Male
Undecided	**10**	5
Interest	5	**6**
Career Options & Prospects	5	3
Health Career Goals	4	4
Admitted as Undeclared Major	4	3
High School Experience	3	1
Social Pressures	0	3

Survey Q11. If you changed majors or intend to change majors, please describe all the reasons why you are deciding or have decided to switch.

[Students who were NOT admitted as chemistry majors but switched to this major – Switchers]

Emerged Categories	**# Times Cited by Respondents: Switchers**	
	Female	Male
Chemistry "Connection"	**19 (47.5%)**	**11 (52.4%)**
Career Options & Prospects	8 (20.0%)	3 (14.3%)
Health Career Goals	2 (5.0%)	2 (9.5%)
Research & Lab Experiences	2 (5.0%)	1 (4.8%)
Could Not Succeed in Other Major	2 (5.0%)	1 (4.8%)
"In Transition"	2 (5.0%)	1 (4.8%)
Professors	5 (12.5%)	2 (9.5%)

[Students who were admitted as chemistry majors – Leavers]

Emerged Categories	**# Times Cited by Respondents**	
	Female	Male
Engagement/Interest in Other Major	**11 (15.7%)**	10 (25.6%)
Usefulness of BS Chemistry Degree	10 (14.3%)	**11 (28.2%)**
Other Major More Relevant to Future Career Goals	6 (8.6%)	5 (12.8%)
Redirect	2 (2.9%)	6 (15.4%)
First Semester Experience	8 (11.4%)	0
Issues with Supporting Coursework	6 (8.6%)	2 (5.1%)
Not Connecting with Chemistry	5 (7.1%)	3 (7.7%)
Overwhelmed with Course Load	5 (7.1%)	1 (2.6%)
Chemistry Grade Performance	6 (8.6%)	1 (2.6%)
Social Isolation	6 (8.6%)	0
Chemistry Advising	5 (7.1%)	0

(cont.)

Leavers - **Current/Intended Major**	**No. Females**	**No. Males**
Accountancy	0	1
Actuarial Science	1	0
Aerospace Engineering	1	0
Animal Sciences	1	0
Anthropology	1	0
Atmospheric Sciences	1	0
Chemical Engineering	8	13
Community Health	3	0
Computer Science	1	1
Crop Science	0	1
Earth, Society, & Environment	1	0
Economics	1	0
Electrical & Computer Engineering	0	1
Engineering Mechanics	0	1
English	1	0
Food Science	3	0
Geology	1	1
Graphic Design	1	0
Human Nutrition	1	0
Industrial Engineering	0	1
Integrative Biology	2	2
Kinesiology	1	1
Materials Science & Engineering	3	1
Mathematics	1	1
Molecular & Cellular Biology	3	3
Music Education	1	0
Nuclear, Plasma & Radiological Engineering	0	1
Psychology	1	1
Recreation, Sport & Tourism	1	0
Speech-Language Pathology	1	0
Undeclared	1	0

[Students who were admitted as chemistry majors – Persisters]

Considering Switching – made note in this field that that are considering another major (N = 7 respondents; Females = 3; Males = 4)

Survey Q12. What are your career goals?

Emerged Categories	# Times Cited by Respondents: Leavers		# Times Cited by Respondents: Switchers		# Times Cited by Respondents: Persisters		# Times Cited by Respondents: TOTAL	
	F	M	F	M	F	M	F	M
Academia	0	0	1	3	2	4	3	7
Art Conservation	0	0	0	0	1	0	1	0
Attorney	1	0	0	1	0	1	1	2
Business Field/ Health Administration	**8**	1	2	0	4	2	14	3
Computer Science/Data Analyst	0	2	1	0	0	1	1	3
Dentist	1	1	0	0	1	1	2	2
Engineer	4	4	1	0	1	0	6	4
Environmental Work	1	0	2	0	2	1	5	1
Entrepreneur	0	1	0	0	1	0	1	1
Forensics	0	0	0	0	3	1	3	1
Graduate School	5	3	5	**6**	3	**12**	13	**21**
Industry/Corporate	**10**	**6**	**10**	3	**11**	7	**31**	16
Liberal Arts	2	0	0	0	0	0	2	0
Medical Doctor	2	4	**9**	3	**10**	11	**21**	**18**
Military	1	1	0	0	0	1	1	2
Nonspecific	1	2	0	1	3	1	4	4
Pharmacist	2	1	1	1	5	0	8	2
Physical Therapist	1	0	0	0	0	0	1	0
Physician's Assistant	1	0	2	0	0	0	3	0
Researcher	3	**5**	6	**5**	9	**21**	**18**	**31**
Teacher	4	1	2	1	2	6	8	8
Unsure	2	1	3	3	3	3	8	7

Survey Q22. Please share any other comments or concerns regarding your high school experiences.

Emerged Categories	# Times Cited by Respondents: Leavers		# Times Cited by Respondents: Switchers		# Times Cited by Respondents: Persisters		# Times Cited by Respondents: TOTAL	
	F	M	F	M	F	M	F	M
HS did not prepare me well	6	6	4	4	7	5	17	15
HS prepared me fairly well	1	3	0	0	3	2	4	5
HS prepared me very well	3	3	3	4	4	7	10	14
Self ownership in being a college student	3	1	1	0	1	0	5	1
Poor career/major counseling in HS	0	1	0	0	2	0	2	1
Good student and HS experience	1	0	2	0	2	3	5	3

Survey Q47. Please share any other comments or concerns regarding what played a role in your decision to remain in your initial major or change majors.

[Students who were admitted as chemistry majors – Leavers]
[Students who were NOT admitted as chemistry majors but switched to this major – Switchers]
Combined with Q11.

[FEEDBACK FOR CHEMISTRY DEPARTMENT]

Survey Q49. What have been the most positive aspects of interacting with the Department of Chemistry?

Emerged Categories	# Times Cited by Respondents: Leavers		# Times Cited by Respondents: Switchers		# Times Cited by Respondents: Persisters		# Times Cited by Respondents: TOTAL	
	F	M	F	M	F	M	F	M
Chemistry Professor(s)/Classes	**9**	**8**	**10**	**10**	**9**	**19**	**28**	**37**
Chemistry Scholarships	0	0	0	0	2	2	2	2
Learned A Lot	4	1	1	3	3	4	8	8
Advisor(s)	**10**	**6**	**6**	1	5	5	**21**	**12**
Outside Help	0	0	1	0	2	1	3	1
SCS Career Services	1	1	1	1	4	0	6	2
Undergraduate Research	2	0	0	3	4	6	6	9
Mentoring	0	0	2	0	3	2	5	2
Overall Staff Experience	4	3	5	2	**8**	**7**	**17**	**12**
TAs	1	3	0	0	1	1	2	4
Chemistry Clubs	0	0	0	0	1	0	1	0
Being a TA	0	0	1	0	1	1	2	1
Merit Program	1	0	3	0	1	2	5	2
Support from/Community of Chemistry Peers	0	0	0	0	6	1	6	1
Overall Not a Positive Experience	2	3	0	1	0	0	2	4

Survey Q50. Please write any suggestions you have for improving the undergraduate student experience in the Department of Chemistry.

Emerged Categories	# Times Cited by Respondents: Leavers		# Times Cited by Respondents: Switchers		# Times Cited by Respondents: Persisters		# Times Cited by Respondents: TOTAL	
	F	M	F	M	F	M	F	M
Smaller Class Sizes	2	0	1	0	1	0	4	0
First Year Chemistry Class Experience	**4**	2	0	0	3	3	**7**	5
Community Needed	1	0	2	1	**4**	2	**7**	3
Cost	1	0	0	1	2	0	3	1
Online Chem 232 Course	1	0	**4**	1	0	3	5	4
Undergraduate Research	1	0	2	0	0	**6**	3	**6**
More Variety within Major	2	1	0	1	1	2	3	4
Issues with Lab Experience	2	0	1	0	1	3	4	3
Issues with TA(s)	0	**4**	1	0	2	1	3	5
Issues with Professor(s)	0	1	**4**	1	0	3	4	5
Issues with Advisor(s)	**4**	1	0	1	3	3	**7**	5
Issues with Career Advising	1	0	0	2	2	2	3	4
Mentoring	1	1	0	0	1	3	2	4
Everything is Fine	3	1	0	1	1	1	4	3
Other	0	2	1	2	2	2	3	6

APPENDIX S: OPEN-ENDED SURVEY RESULTS – DISAGGREGATED BY RACE/ETHNICITY

Note: Abbreviations are necessary to condense the table sizes. See below:
AA = African American students
As = Asian students
Wh = White students
Hi = Hispanic students
NA = Native American students
O = Other

Survey Q9. Please describe your reasoning for your initial major (i.e., why did you choose this initial major?)

[Students who were admitted as chemistry majors – Leavers and Persisters]

Emerged Categories	# Times Cited by Respondents: Leavers						# Times Cited by Respondents: Persisters						# Times Cited by Respondents: TOTAL					
	AA	As	Wh	Hi	NA	O	AA	As	Wh	Hi	NA	O	AA	As	Wh	Hi	NA	O
High School Chemistry Experience	1	4	12	1	0	1	2	11	26	7	0	0	3	15	38	8	0	1
Chemistry "Connection"	1	4	9	3	0	0	4	18	16	6	1	1	5	22	25	9	1	1
Career Options & Prospects	1	3	10	0	0	0	1	6	8	2	0	0	2	9	18	2	0	0
Chemistry Major NOT First Choice	2	6	4	2	0	0	0	0	2	0	0	0	2	6	6	2	0	0
Health Career Goals	2	2	5	0	0	0	4	7	11	3	1	0	6	9	16	3	1	0
Research & Lab Experiences	0	3	0	1	0	0	0	3	0	2	0	0	0	6	0	3	0	0
Social Pressures	0	2	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0

[Students who were NOT admitted as chemistry majors but switched to this major – Switchers]

Emerged Categories	# Times Cited by Respondents: Switchers					
	AA	As	Wh	Hi	NA	O
Undecided	0	5	8	2	0	0
Interest	0	4	7	0	0	0
Career Options & Prospects	0	1	6	1	0	0
Health Career Goals	0	4	4	0	0	0
Admitted as Undeclared Major	1	1	5	0	0	0
High School Experience	0	1	1	2	0	0
Social Pressures	0	0	2	0	0	0

Survey Q11. If you changed majors or intend to change majors, please describe all the reasons why you are deciding or have decided to switch.

[Students who were NOT admitted as chemistry majors but switched to this major – Switchers]

Emerged Categories	# Times Cited by Respondents: Switchers					
	AA	As	Wh	Hi	NA	O
Chemistry "Connection"	1	8	18	2	0	0
Career Options & Prospects	0	3	7	1	0	0
Health Career Goals	0	3	1	0	0	0
Research & Lab Experiences	0	2	1	0	0	0
Could Not Succeed in Other Major	0	0	1	2	0	0
"In Transition"	0	2	1	0	0	0
Professors	0	1	5	0	0	0

[Students who were admitted as chemistry majors – Leavers]

Emerged Categories	# Times Cited by Respondents					
	AA	As	Wh	Hi	NA	O
Engagement/Interest in Other Major	3	6	9	3	0	0
Usefulness of BS Chemistry Degree	4	7	8	2	0	0
Other Major More Relevant to Future Career Goals	0	3	7	1	0	0
Redirect	1	3	3	2	0	0
First Semester Experience	0	2	5	1	0	0
Issues with Supporting Coursework	0	2	6	0	0	0
Not Connecting with Chemistry	0	1	7	0	0	0
Overwhelmed with Course Load	0	0	5	1	0	0
Chemistry Grade Performance	1	3	2	1	0	0
Social Isolation	0	0	5	0	0	1
Chemistry Advising	1	0	3	1	0	0

[Students who were admitted as chemistry majors – Persisters]

Considering Switching – made note in this field that that are considering another major (N = 7 respondents; As = 4; Wh = 3;)

Survey Q12. What are your career goals?

Emerged Categories	# Times Cited by Respondents: Leavers						# Times Cited by Respondents: Switchers						# Times Cited by Respondents: Persisters						# Times Cited by Respondents: TOTAL					
	AA	As	W	H	N	O	AA	As	W	H	N	O	AA	As	W	H	N	O	AA	As	W	H	N	O
Academia								1	2	1				5		1				6	2	2		
Art Conservation														1						1				
Attorney		1							1						1					1	2			
Business Field/ Health Administration	2	3	4				1	1					2	3	1				5	7	1			
Computer Science/Data Analyst		1	1					1							1					2	2			
Dentist		1	1											1	1					2	2			
Engineer		5	1	1				1							1					6	2	1		
Environmental Work			1						1	1				1	1	1				1	3	2		
Entrepreneur			1											1						1	1			
Forensics															3	1					3	1		
Graduate School	1	1	5	1			1	2	8					9	4	2			2	10	17	3		
Industry/Corporate	3	5	7	2		1		4	5	3			1	3	10	4			4	12	22	9		1
Liberal Arts			2																		2			
Medical Doctor	1		4	1			1	5	5	1			2	4	11	2	1	1	4	9	20	4	1	1
Military				2											1						1	2		
Nonspecific		2	1						1					2	1	1				4	3	1		
Pharmacist			3					1	2				1	1	3				1	2	8			
Physical Therapist			1																		1			
Physician's Assistant		1	1						2											1	3			
Researcher	2	2	2	1		1		3	5	3				15	6	7			2	17	13	11		1
Teacher		1	4	1					2					3	6	1				4	12	2		
Unsure			2	1				1	5				1	2	2	1				3	9	2		

Survey Q22. Please share any other comments or concerns regarding your high school experiences.

Emerged Categories	# Times Cited by Respondents: Leavers						# Times Cited by Respondents: Switchers						# Times Cited by Respondents: Persisters						# Times Cited by Respondents: TOTAL					
	AA	As	W	H	N	O	AA	As	W	H	N	O	AA	As	W	H	N	O	AA	As	W	H	N	O
HS did not prepare me well	3	1	6	2					6	2				3	7	2			3	4	19	6		
HS prepared me fairly well		2	2											3	2					5	4			
HS prepared me very well		3	2	1			1	2	4				1	4	3	3			2	9	9	4		
Self ownership in being a college student	1		3						1						1				1		5			
Poor career/major counseling in HS		1												1		1				2		1		
Good student and HS experience		1						1	1					4	1					6	2			

Survey Q47. Please share any other comments or concerns regarding what played a role in your decision to remain in your initial major or change majors.

[Students who were admitted as chemistry majors – Leavers]
[Students who were NOT admitted as chemistry majors but switched to this major – Switchers]
Combined with Q11.

[FEEDBACK FOR CHEMISTRY DEPARTMENT]

Survey Q49. What have been the most positive aspects of interacting with the Department of Chemistry?

Emerged Categories	# Times Cited by Respondents: Leavers						# Times Cited by Respondents: Switchers						# Times Cited by Respondents: Persisters						# Times Cited by Respondents: TOTAL					
	AA	As	W	H	N	O	AA	As	W	H	N	O	AA	As	W	H	N	O	AA	As	W	H	N	O
Chemistry Professor(s)/Classes	1	4	11	1			1	5	14					7	18	3			2	16	25	4		
Chemistry Scholarships														3	1					3	1			
Learned A Lot		2	1	2				1	3					3	3	1				6	7	3		
Advisor(s)	2	8	5	2				4	3					6	4				2	18	12	2		
Outside Help								1					1	2					1	3				
SCS Career Services	1	1						1	1					3	1				1	5	2			
Undergraduate Research		2						1	2					6	3	1				9	5	1		
Mentoring								1		1			2		1	2			2	1	1	3		
Overall Staff Experience	2		4	1				1	5	1			2	2	7	4			4	3	16	6		
TAs		1	3											1	1					2	4			
Chemistry Clubs														1						1				
Being a TA								1						1	1					2	1			
Merit Program	1								3						1	2			1		4	2		
Support from/Community of Chemistry Peers														4	3					4	3			
Overall Not a Positive Experience		1	4							1										1	4	1		

Survey Q50. Please write any suggestions you have for improving the undergraduate student experience in the Department of Chemistry.

Emerged Categories	# Times Cited by Respondents: Leavers						# Times Cited by Respondents: Switchers						# Times Cited by Respondents: Persisters						# Times Cited by Respondents: TOTAL					
	AA	As	W	H	N	O	AA	As	W	H	N	O	AA	As	W	H	N	O	AA	As	W	H	N	O
Smaller Class Sizes			1	1				1						1						2	1	1		
First Year Chemistry Class Experience		1	4			1							1		3	2			1	1	7	2		1
Community Needed			1					2	1				1		3	2			1	2	5	2		
Cost		1							1					2	1					3	2			
Online Chem 232 Course		1					1	2	2						3				1	3	5			
Undergraduate Research		1							2					2	2	2				3	4	2		
More Variety within Major		2	1					1						1	2					4	3			
Issues with Lab Experience		1				1			1					3	1					4	2			1
Issues with TA(s)	1		2	1					1					2	1				1	2	4	1		
Issues with Professor(s)			1											2	1					2	2			
Issues with Advisor(s)	1	1	3				1	1	2	1				1	4	1			2	3	9	2		
Issues with Career Advising		1						2					1	1	2				1	4	2			
Mentoring			2											2	2					2	4			
Everything is Fine	1	1	1	1					1							2			1	1	2	3		
Other			2					1	2					2	1	1				3	5	1		

APPENDIX T: INTERVIEW RESULTS

Case-Level Display Meta-Matrix for Interviewed Students

	No. of Students
Total Students Interviewed	67
Females Interviewed	38
Males Interviewed	29
URMs Interviewed	21
International Students Interviewed	7

LEAVERS

Leavers: 14/23 (61%) of the students interviewed also completed the online survey.

	No. of Students
Total Students Interviewed	23
Females Interviewed	17
Males Interviewed	6
URMs Interviewed	7
International Students Interviewed	2

Emerged Categories (for switching out of the major)	# Times Cited by Respondents
Issues with Chemistry Coursework	19
Issues with Supporting Coursework	16
More Interested in Other Major	12
Peer Group in Other Major	10
Overwhelmed/Study Skills	10
Usefulness of the Chemistry Degree	7
Issue with Class Size	3

Interview Responses: LEAVERS

Student ID	***Why did you initially decide to choose a chemistry major?***	***Why did you switch out of the chemistry major and choose your current major?***	***Emerged Categories (for switching out of the major)***	***Current Major***
2 (female)	"I liked chemistry in high school. I applied to chemical engineering but got redirected to chemistry; I liked the job description of a chem engineer. I was interested in medicine and health in high school."	"Poor grade performance in calculus and physics 211; I have a lot of friends in MCB and MCB didn't require calculus and physics; In the beginning I struggled with managing time and studying."	Issues w/ Supporting Coursework, Peer Group in Other Major, Overwhelmed/Study Skills	Molecular & Cellular Biology
10 (female)	"I was close with my chemistry teacher in high school and I like science."	"[My chemistry major] was very difficult and got to the point where I wasn't excited about it (didn't want to do it for 3 more years); Math classes were not review for me and I felt unsure as to how to succeed; I had no advanced, AP, or honors courses available to take in high school; I did not have good experiences in Math 220 (lecture involved constant writing with a ton of information and no time to ask questions); It was math 220 that I realized chemistry was not going to be for me; GRADES were huge to my retention in chemistry; I also was not sure what I could do with my chemistry degree afterwards; It was hard for students to relate the labs to the material in the course…not sure why I was doing the lab; I had no idea how to manage time and study; I was very overwhelmed (took 18 hours both semesters freshman year); In my current major classes, the class sizes are small (versus a large lecture) so that everyone has to contribute and discuss and ask questions"	Issues with Supporting Coursework, Issues with Chemistry Coursework, Usefulness of the Chemistry Degree Overwhelmed/Study Skills, Class Size an Issue	Anthropology

Interview Responses: LEAVERS (cont.)

14 (female) (URM)	"I liked general chemistry at [my community college]."	"Easier to get the food science major with chemistry minor versus the other way around because food science closes off classes to their majors; Food science is better if I decide not to attend graduate school - with a food science major, I can work right in industry"	Usefulness of the Chemistry Degree	Food Science
15 (female) (URM)	"I loved chemistry in high school; I took AP chem and loved it."	"I switched to MCB because of the math requirement (don't have to go up through calc 3); Calc I went too fast and I couldn't keep up with the material by the end; I didn't take AP math and didn't have calculus before in high school; The grading of math exams were frustrating; The math requirement scared me the most and I would have stayed in chemistry otherwise but decided taking all that math was not worth my time; I found that the MCB requirements went more hand-in-hand with pre-med requirements and prep for MCAT"	Issues with Supporting Coursework, Usefulness of the Chemistry Degree	Molecular & Cellular Biology
18 (female) (URM)	"I wanted to do pre-pharmacy."	"I got C's in general chemistry classes; The beginning chemistry classes were already not making sense; I struggled in chem 104 where orgo did not make sense to me; Overall, calculus didn't "click" with my brain; It didn't make sense to me as a subject; I was always decently good at math until calculus - I didn't know what the teachers were saying; TA was frustrating because he got confused; I took a community health class at the same time which caught my interest; My cousin told me about this major so I researched it and decided I wanted to do that instead; Community health is a closer knit major than chemistry was; Community health classes are a little smaller and I see the same people"	Issues with Chemistry Coursework, Issues with Supporting Coursework, More Interested in Other Major, Peer Group in Other Major, Class Size an Issue	Community Health
20 (female) (URM)	"I was interested in pharmacy (worked at Target pharmacy); I was pressured by my family to go into science because it's a more respectable degree; I took gen chem at a community college and I enjoyed and loved chemistry."	"I switched out because I couldn't take it; I had a total course overload and I gave up and stopped trying; The advisors put me in online orgo [232], IB 150, and calc 3 - switched to calc 2 early in the semester because in calc 3, the prof said I should know this already; It was a hard transition because I did so well at my community college and worked 40 hours per week; Since I was a transfer student, I didn't have connections with others students; I couldn't keep up with the material and got really frustrated; I had trouble adapting to the environment and I just gave up and stopped studying orgo; I took calc 2 and decided I was done with chem as a major"	Overwhelmed/Study Skills, Issues with Chemistry Coursework, Issues with Supporting Coursework	Undeclared
24 (female)	"I really like chemistry and computer science; I took a community college chem course over the summer."	"I love chemistry, I'm just not that good at it; My dad told me I have to pick a balance of what I like versus what I'm good at; I was interested in pharmaceuticals but chemistry is a struggle for me; I have to reread it over and over and I'm still not getting it (don't like that feeling); The online quizzes don't really assess what I know (paper quizzes are a better gauge); I love computer science (logic and problem solving); I love math; I'm taking statistics 100 and I got a 100 on my last exam (I'm very excited); I'll take calc 3 next semester (got AP credit for calc 1 and 2); I participate in women & computer science (WCS) - makes it okay if you don't know what you want to do – they say to just join; I tried attending a chemical engineering club but I felt like it wasn't good if you don't know what you want to do…like I didn't fit in because I was unsure and didn't know what I wanted"	Issues with Chemistry Coursework, More Interested in Other Major, Peer Group in Other Major	Computer Science + Math

Interview Responses: LEAVERS (cont.)

26 (male) (interntl)	(did not answer this question)	"The chem 203 lab class really drained me and I thought I can't do this all of college; I thought it would be all of my college life at the time; I struggled in Chem 203 because I had no former lab experience; I struggled with the difficulty of lab and writing 20-30 page lab reports; They didn't explain how to use the equipment; I really struggled and it was draining; I didn't think I could do much with a chemistry degree at the time (just experiments and applications); I thought engineering was "fancy" so I chose that instead; I am interested in finance; I had an internship on investment banking (get to do analysis and research and meet clients); I use a similar methodology that's needed for chemistry"	Overwhelmed/Study Skills, Issues with Chemistry Coursework, Usefulness of the Chemistry Degree	Electrical Engineering
28 (male)	"I am pre-dentistry; Chemistry was easy for me."	"Calculus 3 scared me! I was worried I would have to take calc 2 again (placed out of calc 1 and 2 from AP credit) and was told that calc 2 was the hardest math class here; I switched to IB because no more math was required and it worked for my pre-dental requirements"	Issues with Supporting Coursework	Integrative Biology
29 (female)	"I really liked my high school chemistry teachers and AP chem."	"In chem 203, there was no help with lab report writing; TAs would not help even if I brought a rough draft in advance…said it wasn't fair…yet nothing was clarified ahead of when it was due; There was no structure from the TA so there was so much guessing and little instruction; I did NOT like the lab - Chem 203 took so much time so that I had no free time; I just wanted 1 hour in my day; It was too rigorous for what I wanted in college that I didn't even join clubs until sophomore year; Chem 202 was not gen chem to me…the professor did not teach general chemistry (topics were quantum mechanics and physics); I started in calc 3 but I did not like 3 dimensions and didn't understand it and the professor said if I don't get it, then I should just drop the class (plus I was rushing a sorority); I switched to calc 2 after 2 weeks and this was much better because I already knew a lot of it from AP; I never went on to calc 3 because I had decided to switch to a major that didn't require it; Physics 100 class was also difficult because it was hard to understand the professor and the TA got annoyed; I wasn't learning in lecture and the TA wasn't helpful; Time management was a transition and what to expect in college in terms of structure; Within one month, I was not getting enough sleep and couldn't finish assignments so that I understood them; I was fed up with it and didn't like the chem classes I was taking; Not knowing anything was a big shock and I had prep but it wasn't similar at all which threw me off; I was told that there were a lot of opportunities in food science and also had an internship; I liked the food science application and I got to talk to others in the company (liked the social aspect); I previously shadowed at Honeywell and decided I didn't like the oil industry...so I thought what else can I do with a chemistry degree?"	Issues with Chemistry Coursework, Issues with Supporting Coursework, Overwhelmed/Study Skills, Usefulness of the Chemistry Degree	Food Science

Interview Responses: LEAVERS (cont.)

30 (female)	"I enjoyed chemistry and wanted to learn about it."	"I had to switch out of chemistry because I was on probation; Calculus classes were awful; I took calc 2 twice and failed both times; I struggled so hard in math that I didn't have the time I wanted to give to chemistry classes; Groups in math classes were terrible…discussions were brutal - if I asked for help, the students ignored me or talked down to me; It was really difficult; A smart person didn't want to give me the time of day; I was in class with sexist engineers and quiet international students and then a group of "lost" people; It would be me with three other guys that discussed the problem without me and I was completely ignored; When they found out I was "just" a chemistry major, they put me down especially because I was also a woman; I went to tutoring to try and get help but I didn't click with the TAs because they expected me to get it right away; Professor's methods and TA's methods didn't match so it caused confusion for me; TAs were really bad; I was not able to balance chemistry and calculus at the same time; In high school I didn't have to do much outside of the classroom and then a brick wall hit me when I got here because I have to do so much self teaching and budget my time; I mostly studied on my own; I found it hard to mesh with people here because I'm from a small town; I need one-on-one time here so that I can talk it through with someone but people would look at me like I'm stupid, especially boys in the class; I felt like they looked down upon me because I was a woman in science; Even races were clicky with each other; Because English is a more female dominated major, it's easier to work in groups; however it was easier to click with people in chemistry too because there are more girls and a better mix - but I was outweighed in calc classes"	Issues with Chemistry Coursework, Issues with Supporting Coursework, Overwhelmed/Study Skills, Peer Group in Other Major	English
31 (male)	(did not answer this question)	"I always loved food and cooking; I found out about the food science major from a friend about a month into starting the chemistry program (didn't know this major existed); Food science major was a better fit for me; I didn't align with the other chem major's aspirations; I felt out of place; FSHN is together…professors are tight with each other and accessible; I was not loving chemistry and struggling; I dropped the Chem 223 lab because it was unorganized and the TAs did not know what they were doing; The professor just dropped in and out; I started in calc 2 but dropped it because I decided to change majors; It was hard to pay attention and get it because the professor seemed disinterested; The online HW didn't accept formatting of answers and the exams were not related to the material"	More Interested in Other Major, Peer Group in Other Major, Issues with Chemistry Coursework, Issues with Supporting Coursework	Food Science
32 (female)	"I wanted to be a science teacher and I didn't like biology in high school; I was good at chem in high school; My uncle was a high school chem teacher and I didn't take enough physics to know that field."	"The combination of classes that you take in a semester can set you up for failure; I thought I was good at chemistry but now, maybe not; I looked at the course sequence needed in chemistry vs. earth science and I was struggling in math and not as good at chemistry as I thought; Earth science didn't require calc 2; I dropped calc 2 because it was really hard and decided to switch majors that didn't require it; I was struggling in math; I was not ready for the course combination; I really liked the earth science teachers so I really liked the classes; The classes in this major seemed more manageable and I could still do other endorsements in chemistry and physics; I like the variety of science classes I get to take; I had a friend switch from elementary ed to the earth science ed major as well so this made me feel better; I would have stayed in chemistry if I did better grade wise; I would have still stayed in chemistry if I didn't take the combination of classes that I did"	Issues with Chemistry Coursework, Issues with Supporting Coursework, Overwhelmed/Study Skills, More Interested in Other Major, Peer Group in Other Major	Earth Science w/ Sec. Ed

Interview Responses: LEAVERS (cont.)

33 (female)	"I loved chem in high school; I took AP chem and loved it; The chemistry major is a very broad major and could transfer to other majors easily; I was not sure about nutrition at the time; I also toured the UIUC chem dept."	"Chemistry is a narrow path; I figure that if I don't get into medical school, then I have a backup and can have a career in nutrition, but what can I do with a chemistry degree? I have job security with this major; I really disliked my chem 102 teacher and I advise others to choose other professors instead; Chem 102 was my roughest chemistry class along with the combination of being a freshman and taking calculus at the same time - hadn't developed study adjustment yet; I was overwhelmed; I really hated calc 221; It was really difficult my freshman year…very fast paced and no time for reviewing; I had a cool TA though; I don't think I'm very good at calculus…although I got an A in high school; I'm not a numbers person; I really like the College of ACES; My advisor is great and lays out my plan for me; I really disliked my chemistry advisor…didn't give me a 4-year plan; The FSHN culture is great - smaller classes and professors know us"	Usefulness of the Chemistry Degree, Issues with Chemistry Coursework, Issues with Supporting Coursework, Overwhelmed/Study Skills, More Interested in Other Major	Food Science
34 (male)	"I had a great high school chemistry teacher; I did really well in high school and it was accelerated; I wanted to become a HS chemistry teacher."	"The main reason I switched was because of my grades in chemistry - I didn't find it interesting anymore but that was because of my grades; I started in chem 202 and then got out; I switched to chem 102 and still earned a D+ (retook it and got a B); I got to college and realized that chemistry was really hard and accelerated chemistry was a lot different than high school; I dropped math 241 because I couldn't keep up with the class; The professor was foreign and hard to understand - did problems on the board and the students just copied; I was not the best student my freshman year - should have studied more (it's on me); I struggled with big lectures - hard to pay attention and take notes; I really like the sciences and in biology, I can visualize it more; I like the different topics in biology; Chemistry is more abstract and you need a certain mind	Issues with Chemistry Coursework, Issues with Supporting Coursework, Overwhelmed/Study Skills, Class Size an Issue, More Interested in Other Major	Biology w/ Sec. Ed
35 (male) (interntl)	"My high school experience led me to chemistry; I felt confident and learned chemistry; I participated in olympic chemistry - already covered 102, 104, and 232; I picked the most familiar thing (chemistry) from high school."	"My grade performance kind of contributed to switching - the exam averages were so low; Chem 203 lab reports were frustrating - 20 hours of work per week; There were lots of calculations and formulas in both 202 and 203 and I hate lots of calculations; I also don't like physics; The calculations were too frustrating to me and I doubted myself to finish the degree; Computer science is the best for balance of what I could do and what I was interested in; I thought the same for chemistry but too many calculations"	Issues with Chemistry Coursework, More Interested in Other Major	Computer Science
36 (female)	"I really liked chemistry; Chemistry came easier for me; I was pre-pharmacy."	"I had a negative experience with chem 102 - new professor and didn't present material well; However I had a positive experience with chem 104 and after; I looked at the chemistry course sequence offerings and less chemistry classes interested me (outside of orgo); More MCB classes popped out as interesting to me; I ruled out pharmacy school and decided on grad school; Micro and immunology classes appeal to me more; I also had friends in MCB"	More Interested in Other Major, Issues with Chemistry Coursework, Peer Group in Other Major	Molecular & Cellular Biology
37 (female)	"I liked chemistry in high school; High school chem teachers were fun; I was good at chemistry."	"The main reason for leaving was because of the calculus required for the major; I knew going on would be super challenging for me; Math 115 was fine (repeat of high school) but math 220 was really difficult for me; It was different than in high school where the teacher made sense; My calc professor explained but I was so confused when I left; The discussions were not too helpful because the TA was quiet and didn't explain well; The students wanted to leave and not talk about the material; Chemistry classes were really hard and math 220 was really difficult for me; I was staying up all night trying to understand things; In IB 150 we worked in groups to help with understanding – the TA guided and was helpful; Everyone wanted to talk about the material; MCB and IB were easier for me and I enjoyed them more; IB classes seemed more interesting than the MCB classes"	Issues with Supporting Coursework, Issues with Chemistry Coursework, Peer Group in Other Major, More Interested in Other Major	Integrative Biology

Interview Responses: LEAVERS (cont.)

38 (female) (URM)	"I just picked it because it was an easy major to tell my parents until I figured out what I wanted to do; I felt pressured to major in something concrete because chemistry was well known and I could get a job."	"I knew I would change majors the summer before I started; I struggle a lot with chemistry classes; I'm getting through them; The classes are fine, they are just hard for me and I don't really like them; I don't enjoy chem even though I enjoy food science; I need it so that I can understand what's going on with food; It's very interesting to me how food is made"	More Interested in Other Major, Issues with Chemistry Coursework	Community Health (but wants to transfer to Food Science)
39 (female)	"I am pre-pharmacy; I really liked chemistry in high school; Chemistry was interesting and I was good at it."	"The main reason for switching was because of frustrations with chem 104; I started in chem 104; It was not a consistent experience from 104 professor to 104 professor; My professor went through the motions; [My professor] got off topic with examples; The clickers were weird; The exams were different than lecture and discussion worksheets; I was overwhelmed at first - UIUC is a major leaguer; I got a C on my first test; I studied a lot with other people - with my boyfriend and friends who were MCB majors; In my MCB 150 class, the professor made it interesting and made me want to learn more...big deal for my first semester; I looked at the advanced courses in MCB and chemistry and MCB looked more interesting"	Issues with Chemistry Coursework, More Interested in Other Major, Overwhelmed/Study Skills, Peer Group in Other Major	Molecular & Cellular Biology
40 (male) (URM)	"I'm a fan of science fiction; I'm gadget and gizmo oriented; I was good at chemistry in high school; I taught others in chemistry and physics in high school; I stood out in high school."	"The main reasons why I left are: not feeling like I could succeed - that it wasn't possible no matter what I did and that the major was also time consuming; After lots of effort, I didn't get the result I wanted so I felt like I couldn't do it; I started in chem 202/203 but moved to 104/105; Chem 203 was done sloppily; The lecture was not helpful; They didn't give us a way to know how to write the lab reports - what's the structure?; If you don't know, you're less fortunate; It took awhile for lab reports to get back to me so I would continue to make the same mistakes; In Chem 202, I couldn't make it to a lot of office hours because of my class schedule which was not fun; In Chem 202, you're in there by yourself; I was the only African American kid; I was uneasy; There was one other African American, but he quickly switched to Chem 102 (said 202 is not for me); Made me feel like it wasn't for me...not really my place; Math 220 taught why in this class; The professor was helpful even though it was hard; In Math 231 I did not have a helpful professor; The discussion was not very helpful - no explanation of why from the TA; Calc 2 was my most difficult class"	Issues with Chemistry Coursework, Issues with Supporting Coursework	Economics and Creative Writing
41 (female)	"I really liked chemistry in high school; It's fun to problem solve; I liked to learn about the world around me."	"The main reason why I switched is that I'm more interested in other things; The upper level MCB classes were targeted more to what I wanted to do (pre-med); They seemed more applicable to medicine - although now I know I can major in anything; I'm thinking of switching to psychology because it's more interesting - I don't care about memorizing steps; For chemistry, the Chem 104 and 105 TAs were condescending at times; I felt belittled by my TA so I got frustrated and wouldn't ask any more questions; I felt not smart and not capable; I was feeling sort of prepared for exams but not really - didn't know enough but I didn't know how to bridge that gap; I wanted to do office hours but when I'm lost it's hard to come with a lot of questions because the professors are intimidating; [Professor X] never forgets a face so if I ask a dumb question she'll remember; I AP'ed through calc 2 and didn't want to take calc 3; My best friend and other friends are MCB majors so I looked into MCB and it sounded cool"	More Interested in Other Major, Issues with Chemistry Coursework, Issues with Supporting Coursework, Peer Group in Other Major	Molecular & Cellular Biology (wants to transfer to Psychology)

Interview Responses: LEAVERS (cont.)

67 (female) (URM)	"I took AP chemistry in high school; I loved it and had a great time; My teacher was really encouraging and helped me; I liked her class; I was premed"	"One significant factor was that I was not doing as well as I wanted in the chemistry major; The classes were challenging and I studied weeks in advance but the exams still didn't go well; I still like helping others in chemistry; I like explaining; I loved chemistry in high school and I still enjoy the classes now; One reason why I left chemistry was that I was scared of taking physics and it's required for the major; I took it in high school and other students (not even from this college) scared me about taking it; I was interested in becoming a nursing major and an advisor in the College of Nursing encouraged me to switch to Community Health because they go more hand in hand for the requirements"	Issues with Chemistry Coursework, Issues with Supporting Coursework, Usefulness of the Chemistry Degree	Community Health

LEAVERS: Indicated That They Used Chemistry Study Groups/Had a Chemistry Peer Community in Their Classes

All Students		Female		Male		URM		Non-URM	
Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
7	16	4	13	3	3	1	6	6	10

[FEEDBACK FOR CHEMISTRY DEPARTMENT]

Student ID	**What has the Chemistry Department done well to contribute to a positive learning experience for students?**
2 (female)	"The AICHE group - their mentor program; The department is very welcoming and organized and helpful; The professors"
10 (female)	"The chemistry classes helped me prepare and understand college courses in general; The discussion sections - there are other people and asking questions; I need a conversation to learn it"
14 (female) (URM)	"Willingness to help - everyone including professors, TAs, and counselors which is good because I get intimidated"
15 (female) (URM)	"The Merit Program - all were positive; The TAs and talking to me; Professors are "iffy" because it depends on who you get"
18 (female) (URM)	"The teachers were friendly and helpful; The CLC was a God send - it was great; the tutor website"
20 (female) (URM)	"not really"
24 (female)	"TAs – there are so many of them and they have office hours; The professors answer questions in class; i-clickers – I learn from them and can see other people are confused too"
26 (male) (interntl)	"The greatest legacy of chemistry for me was chem 202 – the way of thinking and how to approach the material; It taught me to divide the problem, analyze it, and then recombine it; I will keep applying this to my life and use this for investment banking and research in economics"
28 (male)	"People are available for help and lots of resources; TAs and office hours"
29 (female)	"I got to know people in my chemistry classes and build a little community - Chem 332 fostered that"
30 (female)	
31 (male)	"not really; I only took two classes in chemistry; There were resources like SI leaders so you can learn"
32 (female)	"They do as much as any other subject"
33 (female)	"Orgo lab chem 233 exposed me to the environment with TAs - the TAs were really good"
34 (male)	"nothing (but that's on me)"
35 (male) (interntl)	"Studying in the Chemistry Library; Professors and advisors; Everyone is easy to talk to and happy to help"
36 (female)	"The advisors are easy to talk to and were supportive of my switch; I still enjoy taking chemistry classes; The professors know what they are talking about; Professors can teach and interest students"
37 (female)	"CLC was very helpful - can go whenever and sometimes they are there to help you"
38 (female) (URM)	"We are nice"

FEEDBACK FOR CHEMISTRY DEPARTMENT (cont.)

39 (female)	"I liked the emails from the advisors; I had a good experience with advisors – the class layout was nice"
40 (male) (URM)	"I learned a lot about chemistry and have a deeper appreciation; I have good relationships with friends"
41 (female)	"Nothing that jumps out"
67 (female) (URM)	"I don't have many things; The CLC helps a lot; I liked Chem 101 and 104/105"

Student ID	***What can the Chemistry Department do to improve the learning experience for students?***
2 (female)	"Have a program where new students can talk to older students in the major and ask questions - like a mentoring program; The discussion sections were not helpful - TAs were not good; Better advising from the advisors - make the advising more individualized especially because I was doing poorly"
10 (female)	"I was given everything I needed from the department; A student has to learn how to be a student for themselves"
14 (female) (URM)	"Transfer students should take a proficiency class to help guide placement; I started in Chem 236 and was lost; I switched to Chem 232 and 233 which I loved"
15 (female) (URM)	"Make online chem 232 more personal; I feel totally by myself – but it's good I have to take responsibility though"
18 (female) (URM)	"Advising – I didn't know I declined my AP credit by taking Chem 102"
20 (female) (URM)	"Any science class should be in class (in person), not online like Chem 232; My friend at UIC took the same class and it moved at the same pace, however my friend understood it and I didn't; If you see students struggle, help them and go up to them (TAs or even professors); I would like more time with professors and maybe practice packets"
24 (female)	"More lecture or discussion time would be helpful; Have a chemistry major night in the first few weeks or social and learning opportunities in the major - other departments do this already"
26 (male)	"More information on the differences between specialized chem, chem engineering, and sciences & letters; If I knew about Chem 102/103, I may not have switched majors; It's hard to drop down from Chem 202/203 to 102/103 once you start"
28 (male)	"The format of Chem 232; There are online lectures from someone that is NOT your professor; There is no continuity and this is much harder on people"
29 (female)	"More structure for lab and tell students what to expect on the first day - not knowing anything was a big shock; Online Chem 232 scares people from taking Chem 332 where the teacher is in person; The video lectures didn't correspond to what we're learning so it's hard to know what is important and it's confusing; This makes it hard to connect with the organic professor in office hours"
30 (female)	"More resources for math help; It's hard for women in science to find others like them; Address the scariness of the difficulty of the major - taking calc and chem together; TAs should be hand picked better"
31 (male)	"Improve relationships between teachers and students and students to students"
32 (female)	"Advising could have helped me better; I would have liked a mentor (junior to be paired with) - paired with someone doing the same thing to share advice about classes and go about the major, help prepare for the future, and someone to study with; Smaller classes because the larger environment makes it hard to ask questions because people judge you and want to get out of class and it's hard to get to know professors because they're intimidating; Students need to be aware of the different paths you can take in the major - I thought there was just one path; LAS 101 had a lot of potential but I didn't learn much because there were so many different majors"
33 (female)	"The teachers - very difficult teaching styles from one course to the next and the way the course is run impacts my grade; Unfortunately I got stuck with two of the not great teachers"
34 (male)	"Have a live lecture for Chem 232; Have smaller lectures - I've done better in smaller classes; I suggest Chem 101 because so many students struggle in Chem 102"
35 (male)	"Make a new building - the labs need to be new"
36 (female)	"More courses related to organic chemistry or more hybrid courses with MCB; Online 232 is difficult and hard to interact"
37 (female)	"Change the requirements for chemistry majors; Change the math classes for chemistry majors like they have math for biology majors"
38 (female) (URM)	
39 (female)	"Standardize Chem 104 across courses; Chem 232 needs a lecture - I only see the orgo professor at tests and the videos are not him so I'm uncomfortable going to his office hours"
40 (male) (URM)	"Maybe an open mentorship would be beneficial - all students can voluntarily choose a mentor"
41 (female)	"Chem 232 is TERRIBLE – I'm watching you tube videos of someone I don't know; The professor is at discussions but doesn't teach them, the TAs do; It feels like UIUC randomly found these you tube videos; I pay a lot of money so 232 should be put in a classroom; I want a live teacher; Most people in the class are confused; Also tell profs not to scare us, it's just intimidating!"
67 (female) (URM)	"Online orgo has to go; The videos are confusing because the professor doesn't go in depth or else the video would get too long; My discussion TA didn't project and was shy so it was hard to understand; The professor should teach in person; Also, maybe try to have smaller classes but that's hard with so many students"

SWITCHERS

Switchers: 12/16 (75%) of the students interviewed also completed the online survey.

	No. of Students
Total Students Interviewed	16
Females Interviewed	8
Males Interviewed	8
URMs Interviewed	4
International Students Interviewed	1

Emerged Categories (for switching into the major)	# Times Cited by Respondents
Engagement with chemistry major	12
Flexibility of the Major	5
Aligns with Career Goals	4
Disinterest in other major	4

Interview Responses: SWITCHERS

Student ID	*Can you please share the reasons you decided to choose chemistry as a major?*	*Emerged Categories*	*First Major*	*Current Major*
3 (male) (URM)	"I was in FSHN but it's very focused. I wanted flexibility so I'm majoring in chem and minoring in FSHN; I'm interested in food science and food chemistry. I want to go to graduate school and do research"	Flexibility of the Major, Aligns with Career Goals	Psychology, then FSHN	Chemistry (S&L)
13 (female)	"I was MCB for 1 year but it's not my thing – I first wanted to be a pediatrician; I didn't like bio; I felt like MCB 150 and IB 150 were weed out classes; I realized that chemistry labs are hands on and liked them; A lot of my coursework already transferred to the chemistry major and I felt pressure to finish in 4 years; I want to go into the pharmaceutical industry – I had an internship over the summer"	Disinterest in other major, Engagement with Chemistry Major, Flexibility of the Major, Aligns with Career Goals	MCB	Chemistry (S&L)
17 (male)	"I liked the ease of being able to do the chemistry major because it overlaps with my MCB requirements; I enjoy chemistry; I could have done another science with MCB but I enjoy chem"	Flexibility of the Major, Engagement with Chemistry Major	MCB	Double Major: MCB Honors/ Chemistry (S&L)
21 (male)	"I started as an animal science major because my dad is a vet but I found that I like the cellular level more and biology is chemistry; A friend told me to double major because it's doable with Sciences & Letters; My high school chemistry teacher was good and the 100-level chemistry lectures here were really good so they reinforced my enjoyment of chemistry and I like it"	Disinterest in other major, Flexibility of the Major, Engagement with Chemistry Major	Animal Sciences	Double Major: MCB/ Chemistry (S&L)
23 (male)	"Originally I wanted to do chemical engineering but I couldn't handle the courses; I really liked chemistry so I didn't want to leave chemistry; I couldn't work in a lab because I wouldn't be happy (did for one summer and I didn't really like it); I decided on PA school or pharmacy (and ultimately PA school); My aunt is a chemical engineer and I thought what she did was cool; I like how chemistry applies to everything"	Engagement with Chemistry Major	Undeclared	Chemistry (S&L)
25 (male) (URM)	"I took IB 150 and MCB 150 and hated them!; I really liked AP chem in high school; I saw that the requirements weren't too hard and I liked the material; Liking the material is the main reason I'm a chemistry major"	Engagement with Chemistry Major, Disinterest in Other Major	Biology	Chemistry (S&L)
44 (female) (URM)	"I was undeclared and on an engineering track and then I found out engineering was a lot of desk job type of work - a lot of computer modeling and integration; I was like oh my god no I can't do this so then I switched into geology and that was fun for awhile but I realized that I kept adding chemistry classes; At some point I had a geology department meeting and I wanted to incorporate all of these chemistry classes for my technical electives for my geology degree and they told me that maybe I should switch majors because if I want to switch every geology class to something chemistry related then maybe chemistry is a better fit for me; What has significantly kept me in chemistry - professors, teachers, the department, [my mentor] - it makes a huge impact because I've jumped from department to department and I've mingled with a lot of people and their ability to reason with you and talk with you is very different; The chemistry department is just very open, warm, and friendly; You have to reach out to the chemistry department but you have to reach out to any department"	Engagement with Chemistry Major, Disinterest in Other Major	Undeclared	Chemistry (S&L)

Interview Responses: SWITCHERS (cont.)

47 (female) (URM)	"I was undeclared and at the time I was going to major in biology but I had to take chemistry courses and I didn't remember anything from high school so I took chem 101; I really liked the professors; They did cool demos and my TA was super knowledgeable and very enthusiastic; I thought it was fun and I'm not super bad at it so I might want to do this in the future; The most significant contribution to staying in chemistry is definitely the professors - every course I've taken, the professor is always enthusiastic and makes the material fun and makes me want to learn and apply it to the future"	Engagement with Chemistry Major	Undeclared	Chemistry (S&L)
52 (male)	"A good friend and former boss from back home is a chemistry grad student in Arizona right now; I knew I wanted to do something in STEM, science related; The appeal of chemistry is that it just makes sense; It makes perfect sense and they can explain it - unlike physics where they just talk about perfect worlds; You see things happen in real life and you can explain exactly what's going on"	Engagement with Chemistry Major	MCB	Chemistry (S&L)
56 (male)	"I liked chemistry and it was around organic chemistry that I realized I wanted to continue chemistry because that's when it basically ends for MCB majors; I realized it was only adding on a couple of calculus classes and p-chem so it wasn't too bad; The material itself is very interesting and the logic used to solve chemistry problems is a lot how I think; It's very diagnostic…it's very logical; Being a chemistry major opens up a lot of doors for academia, government, research, industry; There are all sorts of opportunities for chemistry"	Engagement with Chemistry Major, Aligns with Career Goals	MCB	Double Major: MCB/ Chemistry (S&L)
57 (male)	"When I was trying to become an engineer, I enjoyed my science classes a lot better than my engineering courses; I leaned towards chemistry because I enjoyed my chemistry classes the most of the classes I took; Chemistry is the most applicable to going into a big range of industries like going into materials science or food science or actual chemistry; There's a lot more you can do with chemistry versus some of the other sciences; I like knowing how things work and most people don't know"	Engagement with Chemistry Major	Undeclared	Chemistry (S&L)
58 (female)	"The whole application process of chemistry and not just memorizing information definitely geared me towards chemistry; I loved orgo I and working through it and not just memorizing facts"	Engagement with Chemistry Major	Undeclared	Double Major: MCB/ Chemistry (S&L)
59 (female)	"I took orgo 236 because it was in the IB Honors curriculum and 236 is what made me want to do chemistry; I got in an orgo research lab and now I want to go to grad school; I like the research environment here - esp. since U of I is so highly ranked; It's ridiculous that we can be in these labs doing a senior thesis with a project in these labs that are so high level"	Engagement with Chemistry Major	IB	Double Major: IB Honors/ Chemistry (S & L)
61 (female) (interntl)	"I started as engineering undeclared and at the end of my freshman year I decided I wanted to transfer into chemical engineering but to do that I need some other coursework first; So the spec chemistry major is just an interim major for me right now; Chemistry is great but chemical engineering applies math with it in the application"	Aligns with Career Goals	Engineering Undeclared	Chemistry (Specialized)
64 (female)	"The versatility of what you can do with your future; It's what you make of it when you're here"	Flexibility of the Major	Undeclared	Chemistry (S&L)

SWITCHERS: Indicated That They Used Chemistry Study Groups/Had a Chemistry Peer Community in Their Classes

All Students		Female		Male		URM		Non-URM	
Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
11	4	8	0	3	4	2	2	9	2

SWITCHER RESPONSES: POSITIVE ASPECTS

Student ID	***Classroom Instruction in Chemistry***	***Classroom Instruction in Math***	***Of Your Chemistry Major***	***Chemistry Department***
3 (male) (URM)	"I love the organization of the introductory chemistry classes; The higher level orgo classes are taught by professors that are famous in the field"	"Calc 2 and calc 3 were organized; The professors were invested in the class, cared about students, and the TAs were good at explaining; Discussion sections were good; Overall a good experience"	"The amount of stuff that you learn; Outside of the chemistry department - those chemistry classes are watered down; The chemistry major is prestigious; Sciences & letters major is open and a lot of other schools don't have this; There are a lot of options to do research – I do research in a FSHN lab	"Good advisors; The professors bring on their own critiques of each other in a good way; The department sticks together - professors help throughout so that you can get good answers
13 (female)	"Smaller class sizes in the upper level classes - more 1-on-1 instruction; Even in a class size of 100 you can ask questions; Professors enjoy teaching; I like the labs more – I see how the material relates"	"In calc 3 I struggled quite a bit but discussion was helpful - took calc 1 and 2 elsewhere"	"Getting to know people in my courses; I made friends and study partners; I connected with teachers"	"Talking to advisors have helped- they recommend certain classes to take"
17 (male)	"I can see how chemical concepts apply to real life - the relevance"	"Calc 3 but that wasn't hard for me because the teacher did a good job at IMSA; It was a different style but it's good to have it twice"	"Lots of collaboration between peers that help each other; It's more laid back and not as much stress - more distrust between students in MCB"	"CLC - best resources and available to everyone; It's not limited by TA's office hours; orgo 2 (chem 332) - pushed the facebook group which promoted a sense of collaboration (TAs, students, and professor were all involved)"
21 (male)	"I really liked the chem 101 labs; I liked the orgo 1 video lectures and went to the professor's office hours; I liked the video lectures with live lecture for chem 104; I can ask questions after class; The professors explain well"	"The professors are key for all of them and go to a lot of office hours (pre-calc through calc 3); In office hours, usually other kids would ask questions and the answer tells me I wasn't aware of what I didn't know (learn new things)"	"I like the material a lot, especially mechanisms"	"I like lecture setups - especially the combination of videos and live lecture"
23 (male)	"Merit classes were very helpful – the Merit TAs were helpful; Professors have no tricks - you have to know how to apply the material"	"I took calc I, II, and III (re-taking calc III); They taught good problem solving (not just formulas; You have to apply theories; I see problems from the bigger picture with multiple theorems"	"My biology courses are now a lot easier because my problem solving is better; I see medicine in everyday life and see things more clearly"	"The advisors; Chemistry Library; TAs have all been good; Professors (meeting with them is comfortable and I can relax)"
25 (male) (URM)	"The discussion sections are good especially for chem 232; The demonstrations in lecture"	"I started in calc 2 but knew I didn't have everything from calc 1 because I couldn't remember so I went back and took calc 1; I finished through calc 3; I really liked all of my professors - they were engaged"	[My advisor]; The requirements are straight forward and not too hard; The major is very flexible, especially with moving physics from 211 to 102; I like the material"	"[Advisor] in advising and the extra walk-in hours; The office hours and availability for help"

SWITCHER RESPONSES: POSITIVE ASPECTS (cont.)

44 (female) (URM)	"I've jumped a couple of majors and one thing that I can say is that the professors in this department here are absolutely phenomenal; For example, in engineering when you're trying for engineering, a lot of professors look at you as someone who's competing to get into their program so they have a very stand off-ish attitude and they're like okay, prove it to me, what do you got, what are you telling me and everything is like an interview or an interrogation; Whereas with the chemistry department teachers…it was a genuine effort; I have these questions, can we talk about this? Professors would work out problems on the board and would show you the way or what you're missing so that you understand those gaps in your knowledge; A lot of other departments don't do that and I've switched majors three times"		"The enthusiastic students - some of the majors I've been in the students are depressed and taking anti-anxiety medication and need more love and attention"	
47 (female) (URM)		"I like the Merit discussion for calc 1; We did worksheets and if we finished early he would make up problems for us to solve and I thought that was good practice; My TA was really good"	"I definitely like the labs the most; I haven't done undergrad research but from Chem 233, I really enjoyed it; I really want to do more like that in the future"	
52 (male)	"The instructors are the strong part of the courses because they all know what they're talking about to the point where you ask questions, they can answer questions clearly and honestly; There is a lot of information in lecture but if you pay attention and take notes, you should be fine"	"Calc 2 was my favorite as well; Calc 1 the professor was good even though I liked calc 2 more; The calc 1 professor was really good at making sure we knew the information"	"The instructors - phenomenal and informed and knowledgeable; Easy to listen to in lecture the entire time"	"Good job stating pre-reqs for courses so that you have the base knowledge that you need"
57 (male)	"I thought the labs were good even though they're really annoying especially with the prelabs ; You learn a lot of lab techniques and processes which are important if you ever do research or go into a lab for industry; What I mean by annoying is that for orgo lab for example, you have the entire procedure given to you but they make you re-write the entire procedure again which I thought was pointless because it's right there; Lon capa was annoying for 103 and 105 because if you were off by a decimal or didn't type it in right, it wouldn't give you the points"			"Had good advisors in chemistry; The amount of courses too are good"
58 (female)	"I did the Merit Program and I found it very helpful; It prepared me especially for my first semester of chemistry; It allowed me to collaborate with people and get ideas"		"It's cool to have a different understanding of things; I want to be a PA; It's cool to understand the biology and understand the reactions behind it and how things work"	

SWITCHER RESPONSES: POSITIVE ASPECTS (cont.)

59 (female)	"Chem 236 and 436 levels are taught by research professors and people in these classes are supposed to be up to the challenge of taking these upper level classes; The research professors are good at teaching students that are driven and incorporating upper level thoughts and current research which is what got me into chemistry and made me like organic chemistry which is why I'm going to graduate school for it"			
61 (female) (interntl)	"I found similar enthusiasm from the professor in chem 202 and he was amazing; He did experiments and explosions in class and that really kept your attention; and I was coming in from engineering undeclared and his class made me switch to chemical engineering; My professor was intelligent and good at teaching and identifying what we were having a problem with"	"My calc 2 professor - that was the best class in the universe; He would go through a set of questions in lecture and we'd go to discussion and get the same questions but I felt it was the best way for me to learn; I would see it done and then I'd do the problem myself with a few others in discussion with minor changes; I did really well in that course; The teaching method of the professor really makes a difference"		
63 (female)	"One thing I like - how much these classes facilitate forming study groups; So you can study independently but some of my best experiences were in a group setting and learning from and discussing a mock exam together"	"I really like the math textbook for both calculus and differential equations; There are lots of variation for Math Merit - some classes I had a great experience and some not as good - some TAs are better at facilitating than others; Sometimes you leave not knowing whether you're right and even though they don't give us the answers there are other times that we know we're right before we leave"		
64 (female)	"The enthusiasm - my professor made it fun and loved it and I had him for both 102 and 104; The way he liked to keep everyone happy about it especially at the beginning level because that can determine whether you're going to keep going or not"		"It's nice that we have such amazing professors here; We forget and then you overhear their conversation at a coffee shop and they are talking about all of this high level stuff and we have so many resources here"	

SWITCHER RESPONSES: CHALLENGING, NEGATIVE, AND/OR FRUSTRATING ASPECTS // IMPROVING EXPERIENCE

Student ID	*Classroom Instruction in Chemistry*	*Classroom Instruction in Math*	*Of Your Chemistry Major*	*What Chemistry Dept Can Do To Improve Experience*
3 (male) (URM)	"One orgo lab class in particular was not organized, too high paced, and the professor was not there for the students; The TAs can be positive or negative (depends)"		"Having the right prerequisites for classes (e.g. 102/104 to 236/436); There isn't a diversity of classes to take for chemistry majors - typically hard core; I want more applied classes…even Dr. Mitchell's class they have over in vet med already"	"Tutoring for more classes in the CLC for higher level classes"
13 (female)	"Bigger courses are distracting; People are not as focused on the subject"	"The teacher wrote on the board and it wasn't clean so the writing was illegible and hard to understand; I did a lot of self teaching through the book"	"In lower level gen chem - harder to ask for help and we're young; Not being able to get the prerequisites transferred and it scared me"	"More advertising of career services; I hear more from the College of LAS than the Chemistry Department; If there are get togethers, then I'm not hearing about them; I would like more events to get to know peers more"
17 (male)	"Online chem 232 - hated the online format (the learning is our's but the professor was disengaged and I needed someone to introduce the material); In gen chem, the exams are multiple choice so I'm not being asked to produce knowledge; However orgo 2 was a different beast - I had to change the way I studied because exams were free response; I have to know what I'm doing in the entire process."	"Stats 212 (easy and trivial)"	"Not a lot of variety of chemistry classes - the different options and fields"	"Promote why chemistry is relevant and what you can do with a chemistry degree; This is the main reason why I didn't come in as a chemistry major; Promote the high rank of the department more"
21 (male)	"Chem 103 and 105 labs - the video lectures didn't explain well (had to Google and You Tube to find better videos); I didn't learn much conceptually in orgo 2 - lots of memorizing and reactions without the mechanisms"	"Four professors are teaching calc 3; I found one of them that teaches better; The professor's ability to teach"	"The labs are often led by TAs (so it depends)"	"For orgo I (232) – the professor should do the video discussions because that's available to all students; The TAs are just not as good as the professor"
23 (male)	"Chemistry with other classes are stacked and it all gets stressful - balancing all of the work"	"Calc III - hard to see in 3D; Balancing the workload"	"Chem 233 lab kind of (but not really)"	"Nothing"
25 (male) (URM)	"Chem 232 online is really difficult; It's better if we went to class; It's hard with the videos online"	"Web Assign was finicky"	"Chemistry research – I don't know much about it (whereas MCB has a lot and I found it on their web page)"	"Make research more available"

SWITCHER RESPONSES: CHALLENGING, NEGATIVE, AND/OR FRUSTRATING ASPECTS // IMPROVING EXPERIENCE (cont.)

44 (female) (URM)	"TAs are hit or miss per class; It's a really big one"	"Very few, very few, very few; I actually had one of my professors tell me that math in some ways is almost like a skill and he told me that if you don't have the skill or you're not ready, this class is impossible and there's nothing about this that makes sense; You have to have the skill and then the homework is just practice; and he looked at me and said if you don't have the skill then you need to practice this 10 times as much as everybody else and you just have to keep going with it; so I asked him where's the limit? when do I gain the skill? and he said I don't know; it could be 100 times or I could be doing problems until I die and I may never pick this up; so I was like I don't know how I feel about math anymore but I'm definitely not coming to office hours; Made me realize that some of what they teach you here is that you need fundamental knowledge from high school and if you missed that, that's gone; If you didn't read the book to gain the knowledge then you are double screwed and then by the time you get to calc 3, we're doing 3 dimensions; I would say it's a matter of catching up really fast whereas if you take 100-level chemistry classes there's more emphasis on the fundamentals and they're repeated consistently whereas in calc 1, calc 2, and calc 3, there's different fundamentals emphasized in each one so you don't get the same message repeated over and over and doesn't stick as well unless you've had that background"		
52 (male)	"In orgo 1, you have to attend office hours and it's not really emphasized; I enjoyed it because of the office hours but if you have to go to office hours to understand, why not just make a live lecture then"		"Obviously it's rigorous; You have to study and commit to doing the work; You can't do it the night before"	"Get rid of the advanced LAS hours requirement because I'm taking filler courses that are taking up my time when I could be focusing on more important courses"

SWITCHER RESPONSES: CHALLENGING, NEGATIVE, AND/OR FRUSTRATING ASPECTS // IMPROVING EXPERIENCE (cont.)

56 (male)	"There are issues with orgo 1 - namely the videos used for the lecture component; When they were first made they were paired well with the homework component but since then it's been like 7 or so years and homework has diverged a lot so you're learning something not in the homework; Students feel like they're learning random things; Whereas in orgo 2 the professor makes it very clear; Orgo 1 is just a mixed bag"			
57 (male)			"Applying for jobs - a lot of times the chemical engineers overpower us when applying; and a lot of times people just don't understand the importance of being a chemist - there are so many things you can do being a chemist (sometimes companies or other students don't really understand the importance)"	
58 (female)		"Having grades more spread across; You could have anxiety during your exams and be so stressed and it doesn't necessarily test your knowledge and the stress of being an exam and being worth so many points"		
59 (female)		"I came in with calc BC credit and I came in with a really solid foundation; My advisor my freshman year told me not to take calc 3 and there was no way I would be able to do well because I wasn't adjusted to college classes because I was taking MCB 150 and chemistry labs; So I ended up not taking calc 3 until my junior year and I did terribly; So I think advisors should stress a continuous calculus education"		"Advising is hard especially when you have students that are ahead, which is why you have students overloaded or not in enough classes at a time when students are trying to get ahead; A third level orgo class for undergrads because if I want to take one, it has to be 500-level and we're not ready for that; It would be good preparation for undergrads wanting to go to grad school for orgo as well"
61 (female) (interntl)		"For me calc 221 - maybe it was a fact that my teacher wasn't good or maybe it was me that I didn't understand it that well; But calc 2 and 3 were fine; For calc 3 the professors have extremely different techniques for teaching calc 3 - some professors use techniques from both calc 1 and heavily calc 2; others only use calc 1 and that's easier; Some students have harder experiences than others; So an A versus a B for different professors don't mean the same comparison; Professors should use the same techniques for students"		

SWITCHER RESPONSES: CHALLENGING, NEGATIVE, AND/OR FRUSTRATING ASPECTS // IMPROVING EXPERIENCE (cont.)

64 (female)	"Orgo online almost made me want to switch out of my chemistry major because it's so isolated"	"They put so much of your actual grades on the grades you get on exams; and quizzes and homework only add up to like 3% of your grade; So if you're not good at taking tests or have an off day it will throw you"		"If LAS 101 was changed to group by science majors you could even find potential study partners that way"

PERSISTERS

Persisters: 21/28 (75%) of the students interviewed also completed the online survey.

	No. of Students
Total Students Interviewed	28
Females Interviewed	13
Males Interviewed	15
URMs Interviewed	10
International Students Interviewed	4

Emerged Categories (for remaining in the major)	# Times Cited by Respondents
Aligns with Career Goals	17
Engagement with Chemistry Major	14
Sense of Belonging/Mentorship/Community	9
Flexibility of the Major	2

Interview Responses: PERSISTERS

Student ID	***Why did you initially decide to choose a chemistry major?***	***What has significantly contributed to you remaining in the chemistry major?***	***Emerged Categories (for remaining in the major)***	***Current Major***
1 (male)	"I was always interested in science - both of my parents are scientists"	"Chemistry is the most interesting - it's the central science; I love lab!; I want to do basic research - expand the knowledge of the human race"	Engagement with Chemistry Major, Aligns with Career Goals	Chemistry (Specialized)
4 (female) (interntl)	"In South Korean schools, you have to choose early - I chose the science/math track"	"I was more confident that I belonged in chemistry; I feel I belong here; All of my experiences have been good - with people, research, and especially classes; I want a research career; Organic chemistry is very interesting and has its own unique language"	Sense of Belonging/Mentorship/ Community, Aligns with Career Goals, Engagement with Chemistry Major	Chemistry (Specialized)
5 (female) (URM)	"I like how my high school teacher taught chemistry and I took organic chemistry in high school"	"I like this major because I can be free; There is a lot of wiggle room in the major and most schools don't have that; I was going to be biochemistry but the 30 hours of chemistry won me over because I could put in other classes that I like; Chemistry is a promising degree; I love chemistry! I'm good at it and I get it; Chemistry challenges me"	Flexibility of the Major, Aligns with Career Goals, Engagement with Chemistry Major	Chemistry (S&L)
6 (male)	"My dad was a chemistry major but now he's a physician; My grandfather was a physicist; They encouraged me to take a chemistry class because they're generally good; I'm from a family of chemistry majors"	"I see many chemistry majors go to grad school or get an MDPhD; I see a grad student and I think, I can do this."	Aligns with Career Goals, Sense of Belonging/Mentorship/ Community	Chemistry (Specialized)
7 (female)	"I always liked chemistry; It was my favorite in high school"	"This [major] is helpful to be an oncologist in my career; The problems are challenging but I understand them at the same time"	Aligns with Career Goals, Engagement with Chemistry Major	Chemistry (S&L)
8 (male) (interntl)	"In high school I got the most points in chemistry; My parents are in medicine"	"Switching to LAS chem [from Specialized] will allow me to graduate in 2 years; I'm not a lab person; I'm more talkative; I plan to get an MS in chemical engineering but then get an MBA"	Flexibility of the Major, Aligns with Career Goals	Chemistry (S&L)

Interview Responses: PERSISTERS (cont.)

9 (male)	"I always liked neuro-chemistry (cognitive drugs) and body chemistry; My parents stressed STEM for jobs and pay"	(did not answer this question)		Chemistry (S&L)
11 (female) (interntl)	"I took chemistry my freshman year of high school; My sophomore year I was in a high school competition; Chemistry is more interesting and fun"	"I want to do doctoral studies and research at a university"	Aligns with Career Goals	Chemistry (Specialized)
12 (female)	"I had a really good AP chemistry teacher in high school; I enjoyed the experiments in my high school class; I really liked the subject"	"I like chemistry and feel like the department is there to back me up; I'm premed"	Engagement with Chemistry Major, Sense of Belonging/Mentorship/ Community, Aligns with Career Goals	Chemistry (S&L)
16 (male)	"I got interested in honors chemistry in high school – it was the right medium between application and theory and how nature works; I knew I could find a job in the field"	"It's the drive for discovery; I want to invent and create something - research is a way to do that"	Engagement with Chemistry Major	Chemistry (Specialized)
19 (male)	"Chemistry was harder for me in high school - the greatest challenge to me; A lot comes easy to me; I chose this because I understood it the least; It's also practical if I don't go to medical school because then I can go to grad school"	"I like how well chemistry now explains everything; It's practical if I don't go to medical school because then I can go to grad school"	Engagement with Chemistry Major, Aligns with Career Goals	Chemistry (Specialized)
22 (male)	"I took chemistry at Adams State in Colorado - decided on chem; It interested me in chemistry - got me into the subject; I liked the covered material"	"I like the experiments - performing, analyzing data, and seeing the application; It can describe the physical so well; Chemistry holds other sciences within it and it explains a lot; I can create and discover and analyze; It's a culminating subject"	Engagement with Chemistry Major	Chemistry (Specialized)
27 (female)	"Chemistry was the one thing in high school that clicked; I wanted to be in that class all day; I like knowing why something works and the why behind everyday things"	"I like learning the reasons why; The main reason why I've stayed is because of my peer mentor, faculty mentor, and the Merit TAs; I hear that it's okay to fail - we think a C is the end of the world; they teach me how to look at things differently; My Merit TA reminds me that failing isn't the end of everything; The upperclassmen majors help to get me excited especially the way they talk about the major - they're excited; I work in the demo room with other chemistry majors"	Engagement with Chemistry Major, Sense of Belonging/Mentorship/ Community	Chemistry (Specialized)
42 (female) (URM)	"My middle school science teacher actually taught chemistry and I loved that class; I liked chemistry whether it was good (middle school) or bad (high school not as great)"	"Chemistry labs are positive for me"	Engagement with Chemistry Major	Chemistry (Specialized)
43 (female) (URM)	"I wanted to do science or math; No good reason for chemistry but a few friends chose chemistry so I chose it too, but it's not really a passion"	"I know I'll have a bright future with a chemistry background"	Aligns with Career Goals	Chemistry (S&L)
45 (male) (URM)	"Taking AP chemistry in high school made me want to be a chemistry major; My chemistry teachers in high school were so awesome and I just succeeded so well at it so why not pick a science I was very good at and take that premed major to go along with it"	"[My mentor] most significantly contributed - I remember when I was struggling in my classes my sophomore year I came to my mentor and she put her arm around me and told me to put in more effort and go to office hours and I'll get the grade in the class that I want and that helped a lot for me; A lot of students in classes as a whole want to help each other and they make a lot of Facebook groups so they create an atmosphere in general that makes it easy to make friends and study groups"	Sense of Belonging/Mentorship/ Community	Chemistry (S&L)

Interview Responses: PERSISTERS (cont.)

46 (male) (URM)	"Since high school I was always wanting to be a doctor so I did everything that I could in high school to take the right classes; At first I was going to pick a biology major but then I thought what if I have some type of epiphany in college and I don't want to do premed so what can I do as a bio major that's not premed and it's more limited than if I were to do chemistry because a chemistry major has a lot more options besides medical school; Plus I wasn't too bad at chemistry"	"What most significantly contributed was Merit - extra exposure where you have to work with people; Some of the people I met in Merit are my best friends to this day so it was just really comfortable plus we take pretty much the same classes so I get the same study group"	Sense of Belonging/Mentorship/ Community	Chemistry (S&L)
48 (male) (URM)	"I started liking chemistry in high school; I took a chemistry class at my community college and I liked it so I decided to transfer over and become a chemistry major"	"I really enjoy lab and that's a plus for me and I joined a research group which is the main reason I'm still a chemistry major; I have a lot of fun; The research - I can really see myself doing this after; I like the support from everyone chemistry related"	Engagement with Chemistry Major, Aligns with Career Goals, Sense of Belonging/Mentorship/ Community	Chemistry (Specialized)
49 (female) (URM)	"My honors chemistry class in high school was so easy, so when I started at my college I was competing against a lot of students that had AP chemistry in high school; I did so bad on my first test, but my chemistry professor from my [former] college is the main reason I chose chemistry because I had that one on one experience with him and he was able to show me the applications with chemistry and that continued through orgo, and not just the hard core science but that it applied to real life; I learned that if I put in some more effort than the other students than I could do it too; and I think that's what really drove me and that first chem course was so rough but yeah"	"The professors - I've been in office hours so many times and if wasn't for that I wouldn't have done so well on the exams; I would also say that I have a pretty good study group also - a group of friends that I can study with and are reliable and can help you on your homework and study for exams"	Sense of Belonging/Mentorship/ Community	Chemistry (S&L)
50 (male) (URM)	"Senior year I took AP chem and that's when I really started focusing on it; I really liked it with the teacher; It's nice that I'm good at it and it helped that I had a very enthusiastic teacher that taught me to enjoy that subject; I enjoyed seeing how he went about it and into that he was in problem solving; That's what I like about chemistry is that you try to problem solve and try to understand and get it as opposed to other subjects"	"[My mentor], professors and the combination of Merit; Everyone wants to do something and all the students in the department are ambitious"	Sense of Belonging/Mentorship/ Community	Chemistry (S&L)
51 (male) (URM)	"I had a good experience with chemistry in the past before college; It was the one subject that always worked out"	"It's the the science that's most applicable to life and most useful in research; There is top of the line research and it's most applicable - a very useful science"	Engagement with Chemistry Major	Chemistry (Specialized)

Interview Responses: PERSISTERS (cont.)

53 (male)	"My high school chemistry teacher was my honors chem teacher and AP chem teacher; That's what inspired me to go into chemistry because she was so passionate about what she did; Compared to the other AP teachers we had, she was so experienced and overqualified because she knew so many things"	"My high school chemistry teacher set me up with a tour of Argonne; There are many opportunities in the long run to do research especially with astrochemistry"	Aligns with Career Goals	Chemistry (S&L)
54 (male)	"My dad's a chemist so it kind of made sense that I go into that and the fact that I can finish in 4 years and make $50,000 for a job entry level as a backup"	"I want to do premed so having a chemistry major would make me stick out just a little bit and it's a good fall back in case I want to go to grad school or something"	Aligns with Career Goals	Chemistry (S&L)
55 (male)	(did not answer this question)	"In biology you're just memorizing and regurgitating material; In chemistry you learn something and apply it; Overall the material I learned in chemistry leaked into my biology courses where I can understand why things work and the study habits and other habits I've made studying for chemistry have been very beneficial for all of my other courses; I study more efficiently now; I took an internship this past summer and every single person I met emphasized taking as many chemistry courses as you can if you want to go to grad school, med school, whatever it is"	Engagement with Chemistry Major, Aligns with Career Goals	Chemistry (S&L)
60 (female) (URM)	(did not answer this question)	"I want to get a PhD and go into international pharmaceuticals"	Aligns with Career Goals	Chemistry (Specialized)
62 (female)	"I took a gamble when I chose chemistry for my college application; I was trying to figure out if I should click bio or chemistry and I literally just clicked chemistry"	"I really enjoy chemistry so far because it has a wide variety of applications in many sciences and because you can take chemistry from pharmaceuticals to materials to organic to inorganic; I think that's why I really appreciate chemistry; Biology is too centralized...it's just biology; I've definitely developed stronger critical thinking skills because of chemistry"	Engagement with Chemistry Major	Chemistry (S&L)
65 (female) (interntl)	"I started in a science and math oriented high school in 9th grade"	"I wanted to go into industry after I graduate but the advisors should have told me to go into chemical engineering because I literally cannot compete with the engineers to get a job; They have the upper hand; That major is more equipped for industry; But I did switch out of spec chem to LAS because of the level of physics and math required"	Aligns with Career Goals	Chemistry (S&L)
66 (female)	"I had a really good chemistry teacher in high school and chemistry went fine when I took AP chemistry and my parents were making me choose a major on my college applications so I just went with chemistry because I had no idea what I wanted to do with my life and I thought chemistry was applicable to a lot of things"	"The chemistry major goes along with a lot of the career options I've thought of but now I'm not so sure; I don't regret choosing the major but I don't want to work in a lab all the time so I'm not sure; I do wonder what would have happened if I came in undeclared; I discovered that chemistry is not my passion and I hope to still get a lot of good things out of my chemistry degree but I decided a little too late that it's not my passion in life; With that said, when recruiters see that I'm a graduate from the University of Illinois, they know I'm smart; So how I'm viewed to potential employers as a chemistry major is that they know I can do a job"	Aligns with Career Goals	Chemistry (S&L)

PERSISTERS: Indicated That They Used Chemistry Study Groups/Had a Chemistry Peer Community in Their Classes

All Students		Female		Male		URM		Non-URM	
Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
19	4	9	2	10	2	8	0	11	4

PERSISTERS RESPONSES: POSITIVE ASPECTS

Student ID	*Classroom Instruction in Chemistry*	*Classroom Instruction in Math*	*Of Your Chemistry Major*	*Chemistry Department*
1 (male)	"Understanding hard concepts is rewarding; Using the fundamentals in research and other courses"	"Maybe getting a problem right"	"The research lab has been the most rewarding"	"We focus on specialized chem majors to go into a research lab; The Chem Department is doing a great job - gives scholarships and you help academically and financially"
4 (female) (interntl)	"Exposure to a research group for 2 years; Talking to graduate students has been most important because they've given me great advice including life attitudes; I learn how a research project works - writing and communicating; I also like statistical mechanics classes; My James Scholar project gave me a reason to talk to my professor – I don't like asking questions normally"	"I enjoyed calc 3 the most; It's best to learn math with the chemistry and physics - physics 225 makes the math come alive"	"We are academically strong in chemistry - both in courses and seminars; The professors and graduate students are high quality; Chemistry itself is great and interfaces with everything; Chemistry is a tool with underlying fundamentals"	"Good professors; research experience; a lot of courses to choose from - free electives; I appreciate the scholarship"
5 (female) (URM)	"Studying with my friends - one of my first friends was African American so we always teamed up and had a check system; Getting an "A" on a test was very rewarding"	"Math 221 was familiar from high school; I set aside time to go to the tutoring center for all my calculus; I like math a lot though"		"Keeping me updated about things"
6 (male)	"1) research opportunities - probably would have switched majors if I wasn't doing research, 2) going to seminars - didn't really know about except for my research group, 3) certain classes were incredible but only a few - professor dependent"	"I enjoyed my calc classes; They cover a lot of material and make sense in sequence (flowed well); The textbook chapters even aligned and it didn't matter the professor"		"For the better courses, I had more interactions with the professors – it's cool to meet with a professor"
7 (female)	"Getting into my chem 101 class - everyone was helpful"	"Math 115 – it's hands on too and the teacher involves the class; I talk to people because of clickers and I'm getting to know people"	"The people I've met in my class and the help along the way; If I need something, someone will help"	"Help is there; The resources available; Homework has tutors and office hours"
8 (male) (interntl)	"The chemistry professors are so nice and everyone is so nice; They reply to email quickly; Students can learn a lot here"			"The ranking of the chemistry department; Generous with scholarships (surprised that international students can get them); Patricia Simpson helped with resume lots of times and told me to network (but international students don't really know that)"
9 (male)	"Some professors are good (about 50% of them); Most are nice people"	"Math 225 was fine and the TA was helpful"		
11 (female) (interntl)	"Physical chemistry is the best - what I'm learning is really cool"	"Math 231/241/285/416/225 – interesting"	"The faculty here; The Chemistry Department has a strong reputation; Opportunities to do research"	
12 (female)	"Most professors care (but you have to get help); Good TAs	"Calc 2 and 3 - really good teachers and helpful; Exams were challenging but curved; I like math"	"The department is smaller than MCB; There are more opportunities to be involved - be a TA; Research is good; Faculty is good"	"The faculty; I like the small department (MCB is huge and there's more competition in MCB); The advising emails and emails from the department"

16 (male)	"All professors hold office hours in addition to TAs - professors put in time"	"I can apply math to physics and chemistry"	"It's fulfilling and good; Reminded that there are a wide variety of applications; Lots of research in the field now and we're reminded of this; It's fun to be in class and lab even though it's work with the reports and it's interesting"	"Consistent introduction of material; Expectations are clear; It's fair and you get what you give"
19 (male)	"Definitely the professors - they really care about the students; They put a lot of effort into students that come to them - I don't see that in other classes"	"I'm math oriented; I had some good professors but not as approachable as chemistry professors; I'm getting through them but I'm not really into it"	"The amount of knowledge I learn - goes so in-depth for understanding and I like to learn how things work; The problem solving; The interaction with professors"	"The overall feeling that we want us to do well and understand - even if it's hard and pushing us within reason; I have a good community - chemistry and chemical engineers; By select nature we are bonded"
22 (male)	"The challenging part - gets me to understand material on my own a lot; Helps me learn on my own; It forces me to"	"The material; Lots of practice with math topics"	"Exposure to other sciences and math application; I joined ACS to be more involved, network, and meet people in chemistry; I'm doing undergrad research to get extra perspective besides coursework and see what grad school is like"	"Challenges me to go past what I thought my limits were; Made me work harder to understand the material"
27 (female)	"The exam re-takes - learn a lot more from doing the re-take; I analyze and think about how I got the answers and how I think"	"I really like the homework because it's relevant to lecture; I really like math tutoring and the hours at night"	"I learn by doing so I learn a lot from lab; I like learning the reasons why; The problems are applicable (everyday problems)"	"The CLC is an amazing resource - good because it's in a different building; I feel embarrassed to go to professors and it's hard to ask for help; We do a great job of office hours; There is extra help outside of office hours (including professors); Office hours are not emphasized in the math department; I really like lon capa especially the video lectures"
42 (female) (URM)	"Chemistry labs - love the structure with the reports and writing; Labs are organized; In chem 202, the professor did cool experiments in class; It was very interesting and he enjoys teaching; He did exams and homework in lecture"	"I took calc 2, 3, 225, and differential equations - all of it was positive except for one professor"	"I think it's cool; I'm majoring in chemistry at a top-ranked school; The research opportunities; The scholarships (wouldn't be able to afford living here)	"Excellent advisors - if I'm struggling I can go to them; Good chemistry teachers, Merit Program, and scholarship"
43 (female) (URM)	"Experiments and how they relate back to what we're learning; They write on the board in general chemistry, not as much now"	"Calc 1 - practice exams correlated with the tests well"	"Makes me stand out; I know in the future I'll have a job; It's hard when my friends go out and I can't but I know it will pay off; I'm at a top-ranked school"	"All chemistry teachers are open and good - useful with office hours; Merit Program and Merit Fellows scholarship

PERSISTERS RESPONSES: POSITIVE ASPECTS (cont.)

45 (male) (URM)	"The accent of these teachers because our p-chem teacher is British and for 104 my professor had a cool accent so it makes the lectures more interesting; I also really like the way a lot of these teachers teach; They make it interactive and it helps to keep you very awake in class; A lot of the teachers take a genuine interest in their students when it's a big class; They actually care for the well being of students; For example, professors would ask me by name "How are you doing? How are your medical school applications doing?" It makes you feel a lot better as a student"			
46 (male) (URM)			"I kind of like the fact that when I tell people I'm a chemistry major they have a face like "WHAT?" - really like their expression; happens so often; so sort of a superficial reason"	
48 (male) (URM)	"Some of the professors that I've had are really enthusiastic; It seems like they really like teaching and they love what they're doing; It makes the whole lecture funner I guess"		"My research lab - my PI is really smart, funny, easy to talk to and very supportive; All of the grad students that work for him are a lot fun; The faculty in the department in general is very helpful"	
50 (male) (URM)			"The research lab - you think you're working by yourself on your own project but if you need help you ask your partner; You ask if they ran into that problem before or how they go about it so it's a lot more interaction than I thought at first; I really enjoy lab; Sometimes I don't really understand it at first but as I learn more chemistry and they are really friendly and explain how they do it and ask if I get it; So I actually really enjoy that about lab"	
51 (male) (URM)	"The professors are really good and they really know their stuff; The courses are organized well; especially gen chem - it was a good organized system and you always knew when homework was due way in advance"	"In terms of discussion sections, Merit for calc 3 was extremely helpful and for calc 2 I didn't take it and I struggled the whole time; I recommend Merit for anyone taking math here; It helps a lot"	"I got the chance to do undergrad research and it's been awesome - I wish everyone got the chance"	
53 (male)	"I'm in a Merit section for Chem 102 and that really helps being in a group; If I can teach it well enough, then I know it well enough"			
54 (male)	"I've had all good classes so far along the way and the teachers; For me I just I got lucky I guess in my classes because I enjoyed all of them"			"The order of the courses are good"

PERSISTERS RESPONSES: POSITIVE ASPECTS (cont.)

55 (male)		"My calc 2 professor I really enjoyed - he made me love math; He was awake and would engage us; He was never condescending and if we asked a question he would explain it well; Just overall he was likeable and I could pay attention"		"The professors (besides 232)"
62 (female)	"I've had a different experience with research professors; I'm in an advanced lab now and my professor is very approachable; My professor wants us to get something out of the class and I've learned more chemistry in this class than I've learned in any of my chemistry classes as far as application and teaching goes"	"I took calc 1 with a professor and he was really good; I enjoyed him a lot more than my calc teacher from high school; I really enjoyed the Math Merit program; I feel like I learned a lot from working in a group setting and having other people work on the same problem and having a TA make sure we were working together and if we got stuck, we asked the TA for guidance; Math Merit was the most helpful for me; Math Merit was most impactful because of the students I was working with and I was forced to bounce ideas back and forth with them because my TA didn't give us the answers"		
66 (female)	"I had a professor tell us that we had to work with other people; He said that if you work in a group, you will get a whole letter grade higher in this class; He wanted us to work together and share ideas"	"My math 220 professor was the best math professor I've ever had; He explains himself so well and I had him after taking math 221 and not doing well; He was clear about what he wants us to understand but then again I did take 221 the semester before so I already had some foundation"		

PERSISTERS RESPONSES: CHALLENGING, NEGATIVE, AND/OR FRUSTRATING ASPECTS // IMPROVING EXPERIENCE

Student ID	***Classroom Instruction in Chemistry***	***Classroom Instruction in Math***	***Of Your Chemistry Major***	***What Chemistry Dept Can Do To Improve Experience***
1 (male)	"I like them all; I don't like physics and I'm not interested in it; A lot of hard math and slowly dislike math classes that I'm taking later on; When the physics helped pinpoint areas in chemistry classes, then I enjoyed it"	"Really boring"		"1) MORE SUPPORT for students going to PhD programs (help with applications because there are a lot of nuances like letters of recommendation); we need guidance and information to help with the process 2) MORE COMMUNITY in the specialized chem major (I only know 2 people in my specific major) and 3) this is minor but free printing"
4 (female) (interntl)	"First semester of my junior year was a bad semester for me - I crashed and burned out and had depression; Chem 315 that semester was very hard for me because there was so much to write (20 hours per week for one lab report); I recovered over the summer"	"Math 285 - bad professor"		"In specialized chem, we barely know other majors in spec chem (only know 3 others) so I interact mostly with graduate students; We need mental health help - need peer and grad student support; For the lab courses - TAs grade differently from 203/205 to upper level labs - they take a lot of time and mark off for too much or not enough...conflicting messages"

PERSISTERS RESPONSES: CHALLENGING, NEGATIVE, AND/OR FRUSTRATING ASPECTS // IMPROVING EXPERIENCE (cont.)

5 (female) (URM)	"Classes where no one cares; Classes where students assume I don't know anything because I'm Black; I don't like how there's no Black people in my classes; Advisors are so disconnected and don't care; There's not much communication with the Chemistry Department except with [person X] and it makes me wish I went to Applied Health Sciences"	"I cannot pass calc 3; The worksheets were too hard in discussion and there wasn't enough time and they were complicated; We were just rushing to get points; I learned more from other parts like homework, lecture, and tutoring"		"More representation of the demographics in classes!; Break down material in lectures; Chem 232 online is bad - worst thing the department has done because it shows we don't care; Organic chem is the reason I became a chemistry major from high school but this class turned me away; Other colleges on campus make their students feel special - we need that!; We need more people of color - there is no one to look up to because they switch to other majors"
6 (male)	"Classes are professor dependent (some are incredible and some are poor) - there are exam average differences and the material covered even varies; When I took Chem 420/315/442 at the same time I was overwhelmed - that was too many to do together"	"I'm not a fan of online homework, especially math (lack of feedback because only entering a final number); The discussion with worksheets - no instruction was present - lazy way to do discussion; The introduction was given by the TA and then didn't help much during the rest"		"More regulation of courses (certain parts all students should learn) then professors can do other stuff differently; Change discussion - never did anything for me and I never enjoyed going (I liked the classes without a discussion in later classes and I had to go out of my way to ask questions); I would like more opportunities to have the same professors in other courses (whereas in math it seems more likely); Most of my issues came from how courses were scheduled (442/315/420 at the same time) - have more details listed on each class to see if we can take them together"
7 (female)	"Time management on the exams - didn't do as well; Labs - think beyond an easy answer and you have to fully explain everything"	"The written homework - I have a lot of questions"	"Classes will get harder; exams; time management"	"Going to the CLC for lab help - the people didn't know what I was asking"

PERSISTERS RESPONSES: CHALLENGING, NEGATIVE, AND/OR FRUSTRATING ASPECTS // IMPROVING EXPERIENCE (cont.)

8 (male) (interntl)			"1) I transferred from China as a junior so there were transcript problems because syllabi don't really exist in China like in the U.S. and I had a problem with my advisor - switched to LAS chem because of these transfer issues and I wanted to graduate; 2) undergraduate research - hard to get in as a junior or senior but I'm a transfer student so I can't start earlier (now I'm in a lab); 3) taking Chem 437 made me decide that I don't want to get a PhD anymore and want to do MS instead - so hard with lab report writing; 4) didn't write lab reports in China like what they want here; writing style is different for labs (transfer students don't take 203 and 205 and aren't prepared)"	"It's hard for international students to get internships; Have more open courses like on cosmetics or medicine"
9 (male)	"Professors here don't care and shrug you to the TAs; The homework is supposed to build a skill set but mine has no logical progression and they're like another test; How are the textbooks chosen? They're awful; There's an expectation to use Google but that's hard in chemistry; I hate it when professors curve at the end of the class - how do I know if I should drop or switch out of the class?"	"Math 285 was a nightmare - teacher did not give a conceptual understanding"		"Transfer students don't know about research; Advising isn't good at course sequencing (I just get a sheet); Advising is BIG - need a skeleton of do's and don't's for class structure especially for transfer students; Some of the classes skip all around in the chapters and that's super hard; Chem 312 was super disconnected"
11 (female) (interntl)	"I don't really like experimental; Chem 420 - not really science to me (just memorize a ton of things); Others have said it's the worst class they've ever taken (class itself, not really the professor)"			
12 (female)	"Chem 104 was frustrating because the teacher would go into a tangent"	"calc 3 - fast paced"	"I don't know many chemistry majors because there's a divide between chemical engineering, specialized chem, and LAS chem; The advising situation is in limbo because of the turnover"	"Normalize the curriculum (I get negative comments because I'm in LAS chem) - normalize to middle ground between the two because spec chem is too rigorous; Online chem 232 is an issue (videos are passive; have to look at other sources; maybe provide supplemental notes or outline); Create a more tight knit community in the department and make it more cohesive (in MCB everyone knows each other - have more social things during freshman year"

PERSISTERS RESPONSES: CHALLENGING, NEGATIVE, AND/OR FRUSTRATING ASPECTS // IMPROVING EXPERIENCE (cont.)

16 (male)	"The quizzes are rough (master material in a short amount of time)"	"The online section of Math 285 - don't recommend; The amount of personal instruction is limited and it's hard to find the professor; It's hard to look up other lectures online and read the book; It's hard to see the application and be motivated to study"	"Long nights and long papers but I'd rather be doing chemistry than English"	"More professors talking about their research and what they do"
19 (male)	"LABS are so frustrating – in Chem 203/205 a lot is expected but we don't know what we're doing; I have to write a lab report and we don't know what to write for completeness; This year in Chem 237 more is outlined on what's expected in reports but the lab lecture doesn't correspond to lab (the lecture is off)"	"Nothing bad but nothing great; not the same curiosity level as chemistry"	"Labs - the structure; grades frustrate me"	"Lab - work out the kinks; Labs themselves are fun but the structure of the class is frustrating"
22 (male)	"The pace - fast and a lot of material"	"I'm not very good at math so the subject itself is challenging - the pace"	"The lecture course and lab course don't always align well (e.g. like in Chem 436/437 and 420/315)"	"Make the lab courses align better with lecture; Focus more on quality than quantity of material (they pack in a lot); The lab report stuff - have to Google a ton because the text and notes don't have the answers like reactions and mechanisms which is different than the research literature"
27 (female)	"The effort I put in is never reflected in my grade (even though professors say it will); I perform well on other stuff but not exams (in high school you can self assess better and I can't self assess here); I can't demonstrate what I've learned well on a multiple choice test; You tell us to worry about learning but actually we just have to study for the tests - we have to choose"	"After 2-3 weeks into my calc courses, I feel like courses are geared towards engineering majors - but they think differently and yes, they're bright, but what about us?; The way the instructors even speak about the "engineers out there…"; Calc is so abstract; Why not calc for the rest of us that aren't in business or engineering? How does this apply to chemistry? How do these classes affect females? I feel alone because it's mostly males; ugh...calculus, why can't this math be offered through the chemistry department?"	"When I'm very discouraged I think of switching majors especially before midterms; Other majors (not science or engineering) seem more care free and not as worried about quizzes and exams"	"Re-evaluate exams - make them more doable for more students versus just the bright few; Make chem 103 and 105 labs more challenging; More general lab electives (they are all higher level right now); More support on an individual basis, especially after a bad exam"
42 (female) (URM)	"Freshman year I studied with a friend and then I lost who I studied with so it's hard - we would work on problems and motivate each other to go to class"	"Visualizing vectors in calc 3 - I could do the math but didn't conceptually know what it meant; I still love math but I'm scared to do more if I don't do well (don't want to risk it and set time aside for math)"	"Classes are really big so it's hard to just talk to someone; No discussions in upper level classes - no Merit sections"	"Bring back discussion sections in upper level classes - it's intimidating to raise my hand and ask a professor a question…easier to ask questions of a TA and others"
43 (female) (URM)	"Even though I study hard, I don't always do well on exams; I tend to struggle on them; I'm not a fan of power point slides - not very engaging and it's easy to tune it out"	"I'm worried about calc 2 because I struggle with understanding the concepts; If a professor did a problem a specific way, I had problems because I couldn't do it a different way"	"All of the classes I have to take (as I go up in classes, I struggle); I have to balance it all with classwork, clubs, and social life; In higher level classes, there are less minorities and it's discouraging in a sense - seeing other people that look like me and push me from similar backgrounds that I can relate to"	"Discussions are really helpful and it's hard to ask questions in large lectures"

PERSISTERS RESPONSES: CHALLENGING, NEGATIVE, AND/OR FRUSTRATING ASPECTS // IMPROVING EXPERIENCE (cont.)

45 (male) (URM)	"It's hard to get help in office hours when you show up and there's like 20 people; There aren't even enough chairs for you"	"Web Assign is so annoying sometimes; I feel like the way that the curricula is setup could be a lot better in terms of discussion, Web Assign, lectures; The curricula could be a lot better, more like chemistry; At least what I remember from discussion, the answers had to be correct to get the points; whereas it's not like that in chemistry or even in MCB you do the worksheet before class and go over answers in class"		"I agree with the peer tutoring service because you have someone there that has already taken the class and someone to give you advice, especially on future classes; If you have someone there, they can really help you a lot but also to help themselves because they can put it on their resumes/application; I think people would volunteer to do this"
46 (male) (URM)	"I did chem 202 my freshman year, I had this TA that for the life of me I could not understand her whatsoever; She was from China and I'm sorry I did not know what she said and she tried to write stuff out on the board I was just lost especially because I wasn't understanding lecture to begin with and then for her to come in and try to explain more just made me more confused and it gave me more questions than answers; TAs are a really big thing"	"I don't think I've had a calc professor I've actually liked because they allow very little room for questions in the actual class and they're always writing and keep writing and keep writing; The take home notes and they never help for the Web Assign homework and in discussion we're always learning new concepts which are different than concepts in lecture and I can't ask about lecture; It's confusing me even more and the worksheets are 10 times harder than anything on Web Assign and you got to get the worksheet done in an hour so that you can turn it in and get your points so there's no time to talk about lecture; I've had really bad experiences in math on this campus...ugh"		"If the exam average is higher for the first exam, why do professors make the second exam really hard to bring the average down? Isn't that what you want? A higher average? If someone could break it down and explain it to me, that would be appreciated; The reasons are unknown to us"
48 (male) (URM)			"The exams in chemistry - I've compared the 102 and 202 exams (102 is multiple choice and in 202 we get free response and those are really hard); I was not prepared for exams because they were like the challenge problems and not the suggested problems"	
49 (female) (URM)		"What I notice is that the math class here is combined with the engineers so that just makes it 10 times harder...it's just frustrating and scary; I think the average GPA for the engineering school is like a 3.1 and most of us are premeds and pre-healths so we don't want a 3.1; The fact that you try and try and try and go to TA office hours; One time I went to my professor's office hours and he could not solve the problem and he called himself stupid but if he's calling himself stupid, how am I supposed to feel? It was not a pleasant experience"		"A peer tutoring service where you are matched with someone that has already taken the class; or a mentoring service - students to students; but faculty to students would be even better; a lot helpful for research"

50 (male) (URM)	"Professors are just going to keep teaching and will try to stay on course; Halfway through the course in my orgo I class you started seeing a curve where good students are getting better and the students falling behind were progressively getting worse; In a big lecture this professor already had to start a bit behind so he was trying to get back to where he usually is during the year"	"I feel like those classes are to first weed out those engineers; Some of those problems were rigorous and you were expected to know them, even though you had discussion it was still hard if you didn't understand it to catch up with those discussion worksheets"	"Writing labs - I wasn't used to writing labs in high school and it was so challenging; the most challenging parts especially if you want to be a chemist"	
51 (male) (URM)			"People don't think you're that great anymore just because you're not a chemical engineer"	"There is too much information on registration day to understand the difference between spec chem and LAS chem; We need a better way to get into undergrad research; We need a better website - hard to find things and navigate (SCS website - not pleasing to look at)"
54 (male)		"I didn't like calc 2 but mostly for the content; They were both good teachers; I took calc 2 as a freshman and I don't know but for whatever reason I did bad in it; Part of the reason could be I don't like it; I'm not too sure what could have changed it to make it better but there was some kind of poor transition there where I got a bad grade; Maybe I didn't have enough base knowledge or something"		"The biggest concern is when I came up I took spec chem major with premed - I only got one slide about how I shouldn't do it if I'm premed but there was no explanation of why; I didn't know what I was signing up for and advisors said it was cool; I got destroyed by chem 202 because I never had AP chem in high school; I had to drop it which almost cost me an entire semester of college and I was upset about that; There was a weird lack of communication in many points along the way that shouldn't have happened; I know a few other people that had the same thing; They didn't know what spec chem was and how intense it was and it should be emphasized that spec chem is for people who want to go to grad school; I really emphasize the difficulty of spec chem; I feel like advisors are good in their field but if it's not in their field, then it's not very good because they're not knowledgeable in the field; The peer advising in MCB is really good - would be cool if we had that here in chemistry"

PERSISTERS RESPONSES: CHALLENGING, NEGATIVE, AND/OR FRUSTRATING ASPECTS // IMPROVING EXPERIENCE (cont.)

55 (male)	"Every single course I've taken in chemistry I've liked except for one - that's online orgo I; I consider it just advanced arrow drawing; I didn't learn anything; The setup was God awful and I didn't learn anything in that course; I just studied for exams and relied on the curve to get the grade I wanted in that class; In orgo 2 you actually understand the way things went and it prepared me; In orgo I I was just guessing and hoping I'd get it right"	"In calc 3 both professors were just God awful - one professor just used slides and the other would just stand there and talk and one was condescending if you didn't understand it and would make you feel stupid; They just wanted to get through it and then go to wherever they needed to go next; They didn't want to be there to teach us; Although there is a plus side in that I did develop good study habits instead of trying to rely on the professors it forced me to do a bunch of practice problems to try and learn it on my own and then talk to another person to fill in the holes we didn't understand"		
60 (female) (URM)		"Math 220 merit, so I'm with freshman - certain concepts as a group we do not get and reading a math textbook isn't something familiar from high school so when we have to work together as a group and you ask the group next to you and nobody understands and the TA sees that people are struggling and just says to figure it out; how do you figure it out? What's the first step to push me along? The TA should facilitate; It has to do with who you have as a Merit TA but I also understand that it has to do with how long you've been teaching and understand student's learning styles"		"The advisors don't really give freshman a detailed description of the differences between the two majors; It's your first year and you don't really understand the difference between the two"
62 (female)				"Instrumentation classes should be required for LAS majors; It would be cool if the department required group projects because I have no experience with that other than my ATMOS classes; Inorganic should be spread over two courses like organic, p-chem, etc."

PERSISTERS RESPONSES: CHALLENGING, NEGATIVE, AND/OR FRUSTRATING ASPECTS // IMPROVING EXPERIENCE (cont.)

65 (female) (interntl)	"The research professors I've had don't take the initiative towards teaching; For example, taking inorganic, my professor missed a ton of lectures which hampered our learning; I didn't feel like I got anything out of the class; I don't feel comfortable going to their office hours because they're always by appointment; versus instructors that only cared about teaching and were only focused on that and I could go to them whenever I wanted"	"Having grades spread across different things - and I've taken linear algebra, stats 400 and calc - calc was the only one that had discussion worksheets that were graded and it forced everyone to come and spend the whole time in a group and only 1 paper in the group would be picked to be graded; In linear algebra you work on your own; but with calc 2 you keep in groups; Grades spread across quizzes, homework, discussions and exams keeps everyone on track; When you only grade exams you don't realize you're behind until you take the exam"		"Having two chemistry programs is very confusing and there's a huge discrepancy between the two - specialized is so rigorous and the other one is so lenient; You can graduate in LAS without instrumentation or tough classes; I think analytical classes are so important for industry, research, pretty much everything; Advising was not good - as a freshman, they put me in Chem 232, 233, and math 231; Regardless of my high school background, I'm coming from far away and you need a group to work with for online chem 232 and I didn't know anyone; That kicked off college really bad for me; Chemistry majors should not have the same LAS 101 as the other majors - it's a huge issue when you're with all sorts of other majors and chemical engineers take their own 101 - chemistry majors need to be given important information like joining a research lab or whatever advice about what you want to do with your future career wise which is different than other humanities majors - STEM majors should have LAS sciences or something; I had to get the proper advice through joining AXE; this class for chemistry majors can learn about organizations this way too"
66 (female)				"The advising was not good with my first calculus - they should have seen that I struggled in AP calc and should not have put me in math 221; My dad was so mad that I had to retake calc 1 again; Then when I applied to the chemistry teaching minor, I didn't get in because I hadn't completed my physics classes but they didn't tell me (when I met with them before it just had to be in progress); and then this semester I was upset because I want to get into vet school and he said I needed inorganic chemistry and it turns out I do not because my gen chem classes count; and I could have taken biochemistry instead which is another requirement for vet school"