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ACADEMIC SUCCESS IN COLLEGE GENERAL CHEMISTRY

By

Steven P. Poulios

A DISSERTATION

Submitted to
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ACADEMIC SUCCESS IN COLLEGE GENERAL CHEMISTRY

By

Steven P. Poulios

ABSTRACT

Research on the link between student learning and success in higher education is extensive and includes many perspectives, most of them highly focused and pertinent to the researcher's field. However, few, if any, studies have been performed from a more 'holistic' or well-rounded approach, that is, incorporating both cognitive and non-cognitive factors in examining academic success.

Six factors leading up to and continuing through general chemistry courses in college are likely to affect academic success. These factors include a variety of cognitive and non-cognitive variables (Astin, 1968, Pascarella & Terenzini, 1991, Tinto, 1986, Weidman, 1989): pre-college characteristics and experiences, college experiences in the classroom, college experiences out of the classroom, instructional resources, student-focused variables, and instructor-focused variables. These factors, ordered sequentially from high school through college, form the components in the development of a student-learning model (Pascarella & Terenzini, 1991).

Data from 2,247 students enrolled in general chemistry at Michigan State University during the 2002-2003 academic year were analyzed using standard multiple regression analysis. The model significantly predicted that in-class experiences and pre-college factors explained a large portion of shared variability with the final grade in the course ($R^2 = .398$).

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CHAPTER 1

INTRODUCTION

The Importance of Chemistry

Chemistry is considered "the central science" (Brown, LeMay & Bursten, 2003, p, 3). It is the universal language used to describe the understanding of the structure of matter that is essential to studying biology, agriculture, engineering, geology and other sciences. The importance of knowing chemistry has led to enormous advances in health care, conservation of natural resources, energy, increased food production, and many other environmental concerns.

An excellent example of this is the awarding of the 2005 Nobel Prize in Chemistry to three scientists (one of whom, Robert Grubbs, was a student at Michigan State University) for utilizing metathesis in a process for simplifying the synthesis of complex molecules used to make new compounds for industrial and medical use.

> This year's Nobel Prize Laureates in chemistry have made *metathesis* into one of organic chemistry's most important reactions. Fantastic opportunities have been created for producing many new molecules - pharmaceuticals, for example. Imagination will soon be the only limit to what molecules can be built!
>
> In 1971 **Yves Chauvin** was able to explain in detail how metatheses reactions function and what types of metal compound act as catalysts in the reactions. Now the "recipe" was known. The next step was, if possible, to develop the actual catalysts.
>
> **Richard Schrock** was the first to produce an efficient metal-compound catalyst for metathesis. This was in 1990. Two years later **Robert Grubbs** developed an even better catalyst, stable in air that has found many applications.

> Metathesis is used daily in the chemical industry, mainly in the development of pharmaceuticals and of advanced plastic materials. Thanks to the Laureates' contributions, synthesis methods have been developed that are: more efficient (fewer reaction steps, fewer resources required, less wastage); simpler to use (stable in air, at normal temperatures and pressures); and environmentally friendlier (non-injurious solvents, less hazardous waste products).
>
> This represents a great step forward for "green chemistry," reducing potentially hazardous waste through smarter production. Metathesis is an example of how important basic science has been applied for the benefit of man, society and the environment. (Royal Swedish Academy of Sciences, October 5, 2005)

Over the years, the study of chemistry has developed from a training ground for scientists to a complex application for a much more diverse group of students and citizens in a highly technical economy. Knowledge of chemistry has become essential for a technically literate society.

Many of the greatest scientific discoveries in the twentieth century resulted from the work of chemists and chemical principles. The discovery of the double helix structure of DNA by Watson and Crick in 1953 would not have occurred without the understanding of the relationship of the oxygen, sugar and phosphate molecules that make up deoxyribonucleic acid.

The knowledge of chemical principles, in conjunction with biology, was also instrumental in the discovery of the anti-cancer drug, Cisplatin. In the early 1960s, Barnett Rosenberg, a physicist at Michigan State University, was investigating the influence of electrical fields on bacterial cell division. Platinum electrodes were used to introduce electrical current into a medium of *E.coli* slurry. During the experiment, the cell division in the *E.coli* bacteria was arrested to the point of stopping altogether. It was determined that the platinum leaching from the electrodes stopped the cell division in the bacteria. The researchers concluded that if platinum compounds could stop the cell division in *E.coli*, then perhaps it would have the same influence on cancer cells. The development of Cisplatin and other metallic chemotherapy drugs has saved the lives of many cancer victims (Kotz &Treichel, 1996).

The study of general chemistry assists in making essential life decisions. Almost every day there is a feature on the television news or in the newspaper regarding health issues. For example, one feature story may report that drinking a moderate amount of alcohol (especially red wine) is beneficial for cardiac health while another feature will report on the dangers of alcoholism. Alcoholic beverages have been around for centuries. Distilling alcohol is one of the oldest chemical procedures used by humans. Learning the properties of alcohols is an integral part of general chemistry.

Another example is the warning label on common household bleach and ammonia products instructing users not to mix the two products in the washing machine or cleaning bucket. The source of the noxious gas produced from the acid-base reaction and concept of chemical equilibrium becomes obvious after the first course in general chemistry.

Another important aspect of the study of general chemistry impacts public policy decisions made by politicians and the general citizenry. For example, holes in the Ozone layer are believed to increase the risk of skin cancer. Automobile exhaust and smoke from coal fired electric generating facilities are purported to aggravate the problem. There are agreements and ongoing discussions from the leaders of the largest industrialized countries to limit these pollutants. In the case of developing countries, however, there is a different case scenario: They are just beginning to enjoy the benefits of reliable electric power for manufacturing, internal combustion engines for farming, and transportation and refrigeration to keep food safe to eat. Knowledge of the interaction of chemicals and the atmosphere is essential to the development of rational and equitable policy decisions on these issues.

The study of chemistry is also important in disciplines other than the physical sciences. Recently, student interest in the study of forensic science has increased. This may be partially due to television shows such as "C.S.I. Miami" and "C.S.I. Crime Scene Investigation," which have popularized the role of the forensic scientist in crime scene investigation. The life of a forensic scientist looks exciting, but television shows do not fully explain that crime scene investigation is really about collecting samples and performing quantitative analysis using procedures and principals learned in general chemistry.

Demographics of University General Chemistry Courses

Students entering four-year colleges and universities are a diverse group in terms of race, ethnicity, maturity, intelligence, socioeconomic background, and academic preparation for study in higher education. However, what they all have in common is that they have met the minimum requirements for admission to college, including required coursework, grade point average (GPA), and standardized test scores. These entrance requirements are believed to indicate ability to succeed in college.

While in college, many students choose, or are required to enroll, in a chemistry course. Typically, general chemistry is the first chemistry course taken by college students, as chemistry courses are vertically integrated, moving from basic chemistry to more advanced levels. As in mathematics, students must have an adequate foundation in the principles of chemistry to be successful in upper-level chemistry courses. For students in the natural sciences and other majors, general chemistry is a prerequisite for organic chemistry, analytical/physical chemistry, and advanced inorganic chemistry. It is defined as the study of matter and its changes and provides grounding in basic chemical principles and problem solving (Brady & Holum, 1996).

General chemistry is also an important service course, which means that is it offered to students who are not majors in the department; it is recommended or required by a student's major; it is an introductory course to the discipline of chemistry; or it is a single course without pre-requisites. Therefore, general chemistry includes students with varied backgrounds, interests and abilities. At Michigan State University, all students in the colleges of Natural Science, Engineering, Agriculture, and Natural Resources must enroll in at least one semester of general chemistry. Successful performance in general chemistry can also serve as an equalizer for students who enter higher education less prepared than their peers. This is especially true for students from economically disadvantaged backgrounds. If these students do well in general chemistry they then have access to stimulating and financially rewarding careers in the sciences, medicine and engineering.

Most students enrolled in college general chemistry have successfully completed high school chemistry. However, despite earning good grades in high school and scoring well on their college entrance examinations, many students do not do well academically in college general chemistry. An example of this tendency can be found in the distribution of final grades in Chemistry 141 for fall semesters 1996-2001 at Michigan State University: approximately 20% of the students in the first semester of general chemistry earned less than a 2.0 (or "C") for their final grade in the course (Hunter, 2003).

Introductory chemistry courses often have the reputation of being difficult to master. For the science major, general chemistry is often perceived as an essential first step in the chemistry curriculum. For the non-science major, it is a course to be endured in order to progress in their chosen major. The concepts and principles learned in general chemistry, however, are an essential part of future coursework in all of the physical sciences (Hunter, 2003).

General chemistry also serves as a "gatekeeper" course for many chemistry majors (Ditzer and Ricci, 1995), which means that they need to take it as a pre-requisite to upper-level chemistry courses.

Pre-professional students are especially concerned because their entry into scientific or health-related careers might be impeded by failure to succeed academically in college general chemistry. Students who apply to medical school must have completed general chemistry, organic chemistry, and physical chemistry.

In many colleges and universities such as Michigan State University, the Department of Forensic Science is housed within of the College of Social Science, not in the College of Natural Science. Students in the College of Social Science, interested in earning a Master's degree in Forensic Science, must have a strong background in chemistry and must complete coursework in general chemistry, organic chemistry, and physical chemistry. These courses are essential for the understanding of DNA mapping and quantitative analysis of crime scene evidence.

Whether or not students are science majors or choose other areas of study, they should have the opportunity to learn about scientific inquiry and develop the critical thinking skills taught in general chemistry. The scientific method is the basis for inquiry in general chemistry and other sciences. It allows students to construct a reasonable, accurate, and non-arbitrary meaning of the world around them.

In all the natural sciences and social sciences, researchers follow some variation of the scientific method. They observe and describe phenomena, formulate a hypothesis to explain the phenomena, collect data, and perform some type of analysis to accept or reject certain hypotheses. If the hypotheses are accepted after repeated tests, a theory may be proposed.

Statement of the Problem

Colleges and universities usually work hard to recruit and retain students, especially women and minorities. Many students choose the sciences and engineering because they can be academically engaging and financially rewarding. However, the transfer rate from sciences to other majors is very high. Nationally, approximately 35% of all students majoring in math, science, or engineering change majors or drop out between their first and second year of college. For minority students the rate is 50 – 65%.

Many of the students who do remain in the sciences express their dissatisfaction with their experience (Gainen, 1995). One of the reasons for this is that many of the students enrolled in college general chemistry usually did well in high school chemistry classes, which led to high expectations for success in college. Many had positive experiences in high school chemistry after an enthusiastic teacher ignited their interests in the sciences. Yet, interestingly enough, many of these students perform poorly in college general chemistry courses and are disturbed by their performance (Deal 1984).

The majority of students enrolled in general chemistry are required to take the course for another major (Oliver-Hoyo & Allen, 2005). Of the students that major in chemistry, few go on to become chemists. The B.S. chemistry program is intended to prepare students to go on to graduate school in chemistry. The B.A. chemistry majors typically apply to a professional program, such as medical school, dental school, or forensic science program. Still, others go on to receive a teaching certificate for teaching high school chemistry.

Nearly all of the movement out of the field of chemistry along with the mathematics, sciences, and engineering fields usually occurs after the first-year of study. This is primarily due to the gatekeeper effect of these courses (Gainen, 1995). General chemistry is a difficult course. In some colleges and universities competition can be fierce due to large numbers of pre-med students and course grade distributions skewed to the lower end of the grading scale. The curriculum is fast-paced and requires aptitude in mathematics and logical reasoning. Students must weigh "the profit-to-grief ratio" (Gainen, 1995, p.12) to determine the future payoff in jobs and material benefits. (Gainen's term refers to students who weigh the difficulty in studying the sciences against the eventual payoff in monetary and career rewards). Many students, especially women and minorities, have switched to other majors, after determining that the instructional culture of chemistry (or the other sciences) due to its hostile, alienating, and impersonal nature, has dissuaded them from remaining the field.

This phenomenon has been evident in past MSU summer academic orientations where more students declared a major in the College of Natural Science, for example, than in the College of Communication Arts. The academic advisors for natural science, especially the pre-professional advisors, were very busy working with first-year students, while the Department of Communications Arts and Sciences did not usually have an advisor in attendance. After two years, however, the reverse became true and the students who failed in the sciences either dropped out of college or migrated to other major areas of study.

Higher education is a huge public and political investment. In times of shrinking funding and public support, it is politically and fiscally irresponsible to squander resources on recruiting students only to have them leave the sciences or do so poorly that they drop out completely. Moreover, the potential loss of scientists in the United States' educational system, because of students' failure in general chemistry is an important academic and national security issue. Colleges and Universities in the United States may be "the envy of the planet" (Axtell, 2003, p.1) but they are not keeping up with the rest of the world in terms of emphasizing and endorsing the sciences. Moreover, higher education, as a whole, is not keeping up with advances in technology.

Most institutions of higher education in the United States offer a variety of courses that satisfy the requirement for general chemistry. The required courses usually depend on the student's major area of study. In general, there are courses for chemistry majors and courses for non-chemistry majors. Non-chemistry majors enrolling in general chemistry typically include students majoring in engineering, agriculture, human ecology, and pre-professional studies (pre-medical, pre-dental, nursing, teacher education, etc.).

In contrast, chemistry majors, chemical engineering majors, and biochemistry majors are usually enrolled in a general chemistry course with a higher mathematics prerequisite under the assumption that these students have all had at least one year of high school chemistry.

At Michigan State University, enrollment in non-major general chemistry courses (CEM 141 and CEM 142) is always greater than the courses designed for chemistry majors. These two courses enroll approximately 4000 students a year. The enrollment in the courses for Bachelor of Science degree (B.S.) chemistry majors, biochemistry majors, and chemical engineering majors (CEM 151 and CEM 152) is approximately 400 students.

Very few students enrolled in CEM 141 and CEM 142 are chemistry majors. Consider the number of chemistry majors for the academic year of 2004-2005. There were approximately 100 declared B.S. chemistry majors but only 11 spring semester 2005 graduates. For Bachelor of Arts (B.A.) chemistry majors, there were approximately 125 students with 32 graduating spring semester 2005.

Research Questions

The objective of this study was to investigate the factors that influence academic success in college general chemistry. Most students are inquisitive about their world and everyday phenomena and few students inherently dislike studying chemistry and other sciences.

Each semester, a new group of students enrolls in college general chemistry. Many of the students enrolled are first-year students with good grades in high school chemistry, good (high) ACT and/or SAT scores, and a desire to succeed. All have had a mathematics placement examination, or the necessary mathematics prerequisite course to enroll in general chemistry. Despite good high school grades, competent standardized test scores, and tests for math placement criteria, some students do not succeed in college general chemistry. All of the elements for academic success appear to be in place, yet some students earn a poor grade in the course.

The subject of chemistry is not new to most students who attend college, especially those majoring in the natural sciences. Most of the material in college general chemistry is included in the high school chemistry curriculum. Although the pace of instruction in college is accelerated, compared to high school, much of the material looks familiar. Moreover, those students coming from an accelerated high school program may have experienced a more intensive level of chemistry instruction than is offered in the first semester of general chemistry in college. Occasionally, students enrolled in college general chemistry may not have had any high school chemistry, especially if they are from a small high school and had to choose between taking physics or advanced biology instead of chemistry.

However, for most students coming into the university for the first time, the large lecture format of general chemistry is much different from the high school instructional format. Whereas in high school, teachers have had formal teacher training, in the university, the instructor may have had extensive training and experience in research, but usually not a formal course in pedagogy. He or she may have a strong desire to be an effective teacher, but is often perceived by the students as uninspiring and unimaginative.

Therefore, this study examined the following major research questions:

1. What is the description of the sample and independent variables?
2. What is the relationship between key student demographics and control variables on the final grade in general chemistry?
3. What is the relative importance of pre-college characteristics, in-class experiences, out-of-class experiences, instructional resources, student-focused variables, instructor-focused variables, and the final grade in general chemistry? (r-square change by block).
4. What is the relationship between individual indicators within pre-college characteristics, in-class experiences, out-of-class experiences, instructional resources, student-focused variables, instructor-focused variables, and the final grade in general chemistry? (The significance of individual predictors by block)

CHAPTER 2

LITERATURE REVIEW

Introduction

The literature and research on student learning and success in higher education is extensive and encompasses many research perspectives. Learning theorists, investigating academic success in college, focus primarily on in-classroom and instructional variables. Student affairs researchers, interested in retention, diversity, and equity issues, examine admissions criteria and out-of class experiences. Admissions personnel collect data on student demographics test scores and other pre-college characteristics. However, no studies have been performed from a more 'holistic' approach, that is, to incorporate both cognitive and non-cognitive factors, such as pre-college characteristics and college student experiences in and out of the classroom, instructional resources, student-focused variables, and instructor-focused variables, as they relate to academic success.

More specifically, the purpose of this study has been to use this more 'holistic' lens to determine the influences that affect student academic success in general chemistry courses at Michigan State University, namely CEM 141 and CEM 142.

There are two lines of literature on college success included in this literature review: One studies the influence and effect of college on students (college impact studies) and the other looks at the effects of college on students in specific subject areas (in the case of this study – chemistry and other natural sciences).

College impact studies include literature on student retention (Tinto, 1986), student socialization (Weidman, 1989), student involvement (Astin, 1984), and student change through the college experience (Pascarella & Terenzini, 1991, 2005). The literature is important because it suggests generic models for investigating factors that influence success in college, models which became the basis of the conceptual framework for this study.

The literature, which looked at the effects of college on students in a variety of courses, addressed some of the factors that influence academic success in college general chemistry, but there was little consensus across the studies. In the end, this study's review of the literature demonstrates the need for research that casts a wide net into the variables potentially influencing academic success in college general chemistry.

College Impact Studies

In 1969, Feldman and Newcomb synthesized the results of 45 years of research on the impact of college on students. They determined that the students' values orientation changed considerably during their college years, i.e., students became less authoritarian, less dogmatic, and more liberal. They discovered, too, that those students who became more involved in college life tended to do better in their classes than those who did not become involved. These students were often not satisfied with their intellectual and other experiences in college, such as feeling that they had little contact with faculty members outside of the classroom and that the faculty had little concern for their welfare. Situations like these often increased college withdrawal and dropout rates.

Research has also determined that all students learn at some level in college. Some may not learn as much as others but they still learn (Pace, 1979). Most students increase their verbal and quantitative skills and become more competent and knowledgeable in their major area of study (Pascarella & Terenzini, 1991). Using test scores as an outcome variable, Pace (1979) found that seniors, as a group, know more than sophomores. Also, Pace discovered that the more credit hours a student had had in a specific subject area, the higher his/her achievement in that subject: "Students learn what they study, and the more they study, the more they learn" (Pace, 1979, p. 18).

Astin (1968) identified and studied a variety of college environments. In his study, Astin collected data on more than 30,000 students at 247 higher education institutions. He utilized the Inventory of College Activities (ICA) consisting of 275 "stimuli" covering four different areas: the peer environment, the classroom environment, the administrative environment, and the physical environment. His most salient conclusion was that undergraduate students' acquisition of knowledge or philosophical on life, might be highly dependent on the institution he or she attends. He referred to the college environment as "an array of potential stimuli" consisting of "any behavior, event, or other observable characteristic of the institution which is capable of changing the student's sensory input, and whose existence or occurrence can be confirmed by independent observation." (Astin, 1968, p. 118)

Astin's 1968 survey reflects many issues affecting today's college students even though the research is more than 40 years old. Of course, there were some very outdated questions in the ICA, such as "danced the twist" or "students were permitted to smoke in class" (Astin, 1968, p. 148), but other questions, including "drank beer" (p. 148) "felt homesick" (p. 148) and "the instructor was enthusiastic" (p. 149) are all generic and pertinent issues for today's students and are included as variables in this study.

In 1971, Astin completed another comprehensive study and produced a book, *Predicting Academic Performance in College*, intended primarily for high school students moving on to some form of higher education upon graduation. In the chapter "Who succeeds in college?" Astin illustrated that high grades in high school translated to high grades in the freshman year of college: "Of all of the information available about the high school student, his record of academic performance is the best single indicator of how well he will do in college" (Astin, 1971, p.4).

Also included in Astin's 1971 study were variables such as gender and academic ability as measured by standardized tests (American College Test (ACT), the Scholastic Aptitude Test (SAT), and the National Merit Scholarship Qualifying Test (NMSQT)). He found that male students were twice as likely to receive borderline or failing grades as college freshmen, than were female students, and he reported a positive relationship between how well a student performed on standardized tests of academic ability and his or her grades as a college freshman.

College Impact Models

As early as 1979, Pace proposed a model for college student learning and development. He used the term "impress" rather than "impact" to explain the effects of college because of the characteristic mark, stamp, or impression made on students. Pace said that the question for evaluating student development is simple, "given the students who come here, what happens to them and what they are like when they leave" (Pace, 1979, p.125).

His *Path for a Student Development and College Impress Model* (1979) had three basic propositions: the first is that students coming to college bring a basic set of experiences, beliefs, knowledge, personal traits and other pre-college characteristics. The second is that the college environmental factors and quality/quantity of student effort influence these pre-college characteristics. Examples of environmental factors include classroom experiences, interaction with peers and faculty, and participation in clubs or organizations. The third component of the model is the outcome, which he labeled student development and college impress.

This component in Pace's model was seen by him as a result of the combined influences of the normative effects of the college environment and student effort exerted on the student's background and characteristics. Pace refers to development as the difference between before and after scores on criterion referenced metrics collected at the beginning and end of college. Impress is the mark or impression left on the student as a result of the college environment. The impress may be academic achievement or personal feelings, such as satisfaction with college or progress to desired goals. The impress is a lasting mark that can be measured after a student leaves college in terms of interests, successes, outlook, philosophies, or other aspects of the college experience.

In 1991, Pascarella and Terenzini performed an extensive compilation of the research in the 1980s which investigated how and why students change in college. When explaining change in college, they differentiated between developmental change models and college impact models. Developmental models tend to identify *what* changes as students progress through college. Examples of developmental issues are socio-emotional development and identity formation.

College impact models focus on *how* the changes occur and the sources of the change. This includes interactions with other students and faculty, programmatic issues and sources of instruction or support. *What* versus *how* is the most important distinction between developmental and college impact models for explaining student change.

Fifteen years later, Pascarella and Terenzini (2005) did a follow-up of their original work. In their new book, they reviewed the research in the 1990s conducted since the publication of the initial volume in 1991. They concluded that while there were hundreds of studies done since their original *How College Affects Students* was published in 1991, their original college impact model continued to explain how students change in college.

Building on their earlier work with college affect studies and college impact models, Pascarella, Edison, Nora & Terenzini (1996) investigated the experiences of first-generation college students. In this study, using much of the recent literature on how college experiences shape educational outcomes for college students, they proposed a "causal sequence" model of student success. The assumption of this model is that student success in college is dependent on factors that begin pre-college and continue throughout college, both in and out of the classroom. They maintained that the major impact of college on students is the "cumulative result of a set of interrelated experiences sustained over an extended period of time" rather than the result of any single experience (Pascarella, et al. 1996, p. 749).

Another variation on the college impact model is Astin's (1991) input-environment-outcome (I-E-O) model for assessing educational outcomes in higher education. His I-E-O model was originally used to assess Ph.D. productivity in educational institutions. He found that by simply measuring the number of Ph.D.s produced by an institution, or the correlation of student characteristics such as sex, major, or academic ability to Ph.D. productivity, did not completely explain the phenomenon. Although student ability was the most important factor for attaining a Ph.D. there was some discrepancy between institutions. Some of the institutions that should have been highly productive were not and some with less potential to produce Ph.D.s overproduced.

Astin also determined that outcomes, such as Ph.D. production at educational institutions, could not be determined by single input measures. He found that simply having input and outcome data was not enough. One needed to identify the environmental forces of college acting upon students to influence Ph.D. production. Input and outcome variables look at students at two different times in their educational careers. Environmental experiences are the intervening factors that affect change. More importantly, environmental experiences often can be controlled, changed, or otherwise manipulated.

Astin (1984, 1993) also proposed a college impact model with his theory of involvement. He contended that the more students are involved in college the better they would succeed academically. He referred to involvement as the quality and quantity of interaction students invest in the college experience. He deduced that two of the most important factors of involvement are student interaction with peers and with faculty. He also included place of residence as a factor in college involvement. Students who live on campus tend to have more student friendships, a better social life with more involvement in extracurricular activities such as athletics, and also assumed leadership roles more frequently. They also become more liberal, social, hedonistic, and less religious.

College impact models were also used to explain student withdrawal from college. Perhaps the most famous is Tinto's theory of student departure (1986). His longitudinal model of student departure included student pre-entry attributes, goals/commitments (T_1), institutional experiences, integration, goals/commitments (T_2) and outcomes.

Much like Astin's theory of involvement, Tinto's underlying theme is integration into the college environment. The premise of his model is that students enter college with disparate family backgrounds, academic skills, and abilities. As the student experiences the college environment, these pre-college attributes are influenced by interactions with the academic and social systems of the institution. If the interactions are positive, the student integrates into the system and does not withdraw. If the interactions are negative and integration does not occur, the student may depart.

The college impact models by Astin, Pascarella, and Tinto dealt primarily with cognitive outcome variables, or outcomes that affect student academic success and retention. In contrast, Weidman (1989) proposed a college impact model that can be applied to non-cognitive variables to explain the theoretical underpinnings of college socialization, including career choices and lifestyles.

Similar to previous college effect studies, Weidman's model included student pre-college or background characteristics. In his model, forces exerted by the social and academic structure of the institution, influenced student pre-college backgrounds and experiences. Outside the normative social and academic structure of the institution were mediating and often conflicting effects of parental background and non-college reference groups (such as peers, employers, and community organizations). These external constraints could affect the student's experiences in the structural and organizational settings of college and influence socialization outcomes and development.

An additional line of research looked at both cognitive and non-cognitive factors that influence success in college. Ting (1997, 1998) examined low achieving, specially admitted, first-year college students. He found that data from composite ACT scores, high school rankings and non-cognitive psychosocial variables collected from a questionnaire were important in predicting success in college. When both cognitive and non-cognitive variables were regressed on freshmen year grade point average, ACT scores, high school rank, successful leadership experiences, and community service were significant predictors of freshman year academic success. He suggested that cognitive and non-cognitive variables might better predict academic success than cognitive variables alone.

Richardson and Sullivan (1984) also investigated non-cognitive factors that influenced academic success for college freshmen. They looked at 199 students with high school grade point averages of less than 1.7 who were considered "academically challenged" (p. 90). They found no relationship between SAT scores and end-of-year freshmen grade point averages. There was a small positive correlation between high school grade point average and college freshman grade point average. The other significant predictors of college grade point average were motivation-related variables as identified by the College Student Inventory.

Students spend much more time outside of class than in class. Two thirds of college students' waking hours are spent on activities other than attending lectures, recitations, and studying. Yet most studies of student achievement in college focus on the students' academic experiences. According to Kuh, Schuh & Whitt (1991), "It seems reasonable to assume that when out-of-class experiences complement the institution's educational purposes, they contribute significantly to student learning and personal development (p. 6).

Much of Kuh's work on seamless learning and involved colleges was related to student development issues and not specifically to teaching and learning. His basic premise was that out-of-class experiences provide more of a complete explanation of the role of college in students' lives than classroom experiences alone.

Other studies found relationships between student success and non-cognitive variables. Milem and Berger (1997) and Berger and Milem (1999), extending the work of Tinto (1986) and Astin (1993), found that early involvement of students with faculty members is significantly related to student persistence. Pascarella, Edison, Nora, Hagedorn & Braxton (1996) found a positive relationship between teacher organization/preparation and specific course achievement. Pascarella, et al. found that academic success for first-year students was influenced by the type of institution attended (two-year or four-year), total credit hour load, perceived teacher organization, preparation, and support, and other non-cognitive factors.

Other studies investigated the factors that predicted success for first-generation college students using cognitive and non-cognitive variables. Nauman, Bandalos and Gutkin (2003) looked at the differences in academic achievement between students who were first in their family to attend college versus second-generation college students. They found that first-generation college students did not have the same sources of support as second-generation students and had to rely more on their own motivation to succeed in college.

Nauman et al. used ACT scores, along with a questionnaire, that measured motivational and learning strategies for identifying the most important variables for academic success in college. They found that the variable related to expectancy for success was the most significant predictor of success for first-generation college students, closely followed by ACT scores. For second-generation college students, ACT scores were the most significant predictor. They concluded that ACT scores were a valid predicator of college grade point averages in college but should be used in conjunction with other variables, especially for first-generation students.

The majority of the studies reviewed used the final grades in courses or overall grade point average to quantify student learning or learning outcomes in college. Studies of learning outcomes, however, do not always employ grades as the dependent variable. A study by Anaya (1999) used self-reports of learning, total college grade point averages (GPA) and performance on a standardized test (the Graduate Record Exam) as outcome measures. Using the data from a national study of 2,289 students she regressed within-college factors, nonacademic activities, and learning environments on these outcome variables. Although there were mixed results, in general, college environmental influences and learning activities in the classroom were associated with some aspect of student learning.

An interesting finding from her study was that the gains in learning were "domain specific," (Anaya, 1999, p. 516) in that certain learning environments and activities promoted specific learning outcomes. For example, students who majored in the physical sciences and took courses emphasizing mathematics skills showed increased quantitative gains as measured by both self-reports and GRE scores. Conversely, environments or activities not associated with the learning outcome showed no association or a negative association. The two examples used in her study were that being a guest in a professor's home was positively correlated to verbal learning but not quantitative learning, and the number of foreign languages taken was negatively associated with quantitative learning. Overall, environmental factors had some influence on college student learning (although the influence may be either positive or negative).

In summary, college impact studies that include non-cognitive variables in addition to the traditional cognitive variables identify better the factors that contribute to academic success in college. Pre-college characteristics and academic background (such as standardized test scores and high school grades) may be reliable predictors of the effects of college on academic success, but are most likely not the only factors. However, including non-cognitive factors, such as experiences in the classroom and experiences outside of the classroom, and instructional resources as well as student and instructor-focused variables, is essential to a comprehensive model of student learning.

Research on Academic Success in Chemistry and Other Physical Sciences

Although many studies on college students and academic success exist, relatively few focus on students enrolled in college chemistry. Journals such as *The Journal of Chemical Education* publish articles on pedagogical issues and practices related to chemistry but rarely publish empirical studies on the factors contributing to academic success. The majority of the studies used standardized test scores in mathematics, high school grades, and math/chemistry pre-tests as predictors of success in college chemistry.

Few looked at other elements, such as course-related factors and student activities out of the classroom.

Fletcher (1978) collected archival data on 150 students at Tennessee Technological University. He determined that the best predictor of success in college chemistry was the composite score on the ACT. The next variable (albeit minor) that had the most influence on the variance accounting for (R^2) the dependent variable, the final grade in college chemistry course, was a student's grade in high school physics.

Prior to his 1978 study, Fletcher (1977) produced a summary of the research literature predicting student success in college chemistry. He found that high school chemistry has little effect on college chemistry, and sex, as a variable, was not a significant predictor of success in college chemistry. Fletcher noted one common theme throughout the literature, namely that students with strong backgrounds in math and science were more successful in college chemistry than those with weak backgrounds. Strong backgrounds included four years of math and a full science sequence (chemistry, biology, and physics).

Ozsogomonyan and Loftus (1979) looked at four independent variables as predictors of general chemistry grades. A simple regression model containing math SAT scores, chemistry pre-test scores, math pre-test scores, and high school chemistry grades indicated that 35% of the variance in the final grade in general chemistry can be explained by these four variables.

Other variables, such as the course lecture and major field (or field of study), are potentially important factors affecting success in college general chemistry. Armine Paul (1978) found that the course instructor was a significant factor for academic success.

Teaching assistants, however, had no effect. He also found that students in more highly selective majors tended to perform better than other students. In his study, pre-medical technology and pre-pharmacy students were the best performers in college chemistry.

One use of research on factors that influence academic success in college general chemistry is to make predictions of students' course grades. Predicting students' chemistry course grades is a useful tool for instructors and counselors. Students at risk of failure can be identified early (Deal 1984), and predicting course grades may be used as a motivating factor for students who are less prepared for college. If a student's predicted grade is less than the desired grade, she or he may understand the need to work harder in the course to achieve the expected or desired grade.

In his study of first-year chemistry students at the University of California at Riverside, Deal (1984) found that the average grade of students was one grade lower than her or his high school chemistry course. The best predictor of chemistry grades was a combination of math SAT scores and high school chemistry grade. He reported that 73% of students received a grade within 33 percentage points of his or her predicted grade. He also reported that teaching assistants and supplemental assistance had no effect on prediction of college chemistry grades.

Much of the research on factors that influence academic success in college chemistry includes the pre-college variable, high school chemistry. There is some inconsistency, however, in the literature regarding the variable of high school chemistry and its effect on college chemistry achievement. Some contend that high school chemistry has little influence on college chemistry (Fletcher 1977; Willingham, 1985).

Others found high school chemistry to be of some value for the study of college chemistry, although high school mathematics may be a better predictor (Ogden, 1976).

Prior studies on the relationship between high school chemistry, math, and other high school science courses and success in college were primarily based on correlating high school grades with college grades. Few non-cognitive variables were investigated. Yager (1989) found that for high ability students, prior high school courses in chemistry and physics had little effect on success in college chemistry and physics. He collected data on 60 students over a two-year period. One student group completed high school chemistry and physics while the other did not. At the end of the courses in college chemistry and physics, there was no difference between the two groups of students. He suggested that students with prior high school coursework might become less attentive and prone to poor study habits when compared to students without prior coursework who had to spend more time studying and using tutors.

J. Daniel House in 1995 conducted a study on the predictive relationship between initial student attitudes, including academic self-concept and expectation of academic performance, and years of high school math and college admissions test scores with subsequent success in introductory college chemistry. He concluded that student attitudes were significant predictors for success in freshman chemistry. Furthermore, students' initial attitudes were better predictors of course GPA than ACT composite scores or years of high school math completed. Background characteristic variables, such as family characteristics or prior academic achievement of students, were not part of the study. However, the author acknowledged that including such variables would provide better guidance for further research.

Although most of the literature reviewed for this study was from four-year institutions, some literature from community colleges was included as well. Boughan (1996) investigated the correlates of positive performance in Chemistry 101 at a community college. He found three primary factors for success in the course. The best predictor was cumulative college grade point average. The second was a scale he termed socio-educational maturity, which combined age, delayed entry into college, full-time employment, and whether or not the student transferred from another academic institution. He posited that students, who were adult learners and typically worked full-time, were older, had transferred or delayed entry into college, and had the maturity and real world experience to meet the demands of college. The third significant factor was whether or not students were placed in developmental reading courses; those that received reading support performed lower than those who were not in such support classes. Nevertheless, these three factors accounted for only 35% of the variance to the final grade in the course. He noted that future studies should include other factors such as motivation, study habits, and family background.

More of the recent studies on success in college chemistry use both cognitive and non-cognitive variables in their models. Burdge and Daubenmire (2001) looked at several variables for increasing success in college chemistry and reducing attrition. They found that older students tended to get higher grades. Also, students who took chemistry later in their college careers did better than those taking the course as first-year students. Higher verbal scores on standardized tests were also correlated with greater success in college chemistry. The composite test scores were better predictors than math scores alone, according to this study.

Burdge and Daubenmire also found that most students had the necessary math skills to answer test questions correctly (such as the ability to do ratios or solve for "x"), but had trouble gleaning the necessary information from the text to answer written test questions correctly and set up and solve exam problems. In addition, they found that repeating the course had a negative relationship with success. Students taking the course more than twice had a higher failure rate than those taking it for the first or second time. In their study, no student who took the course more than three times passed the class.

General chemistry in large research universities is traditionally taught in the large lecture format. New chemical compounds and analytic processes are discovered every year but the classic scene of the chemistry instructor standing in front of the room muttering to the chalkboard has not changed much in the past 100 years. The instructor stands in the front of the room solving problems on the chalkboard while the students feverishly take notes. Words travel from the mouth of the instructor to the ears of the student and on to the paper or note pad. Later, when the student attempts to solve a similar problem they find they are often unsuccessful. The solution to the chemistry problem the instructor worked on the chalkboard appeared straightforward while the student was taking notes during lecture, but a few hours later, the student discovers he or she is unable to solve the problem on their own.

One of the tenets of the information-processing theory (Gagne & Medsker, 1996) is that the body's sensory preceptors are constantly bombarded with stimuli (sights, sounds, smells, tastes). Immediately, the sensory register determines whether the information should be moved to the short-term working memory, or filtered out. In short-term working memory the information must go through rehearsal and then encoded for permanent storage before it is available for search and retrieval later on. The act of learning is the process of encoding information for later retrieval and use. That is the primary problem with taking notes and not processing the information. It is not enough to simply write down on paper what is heard in lecture. The information must be processed for later retrieval and use.

There are a variety of ways to encode information for storage and retrieval in long-term memory. Two examples are active learning and collaborative learning.

Active Learning

In active learning, students are engaged learners rather than passive learners. Active learning takes place when students are involved in the learning process. But more important than just simple involvement and activity is engaging students in the physical and mental activities that require students to think about what they're learning and how it becomes meaningful to them (Angelo, 1993).

One technique for promoting active learning is class discussions where learners answer questions for themselves and other students in class. Another is the use of response cards or finger signals (Paulson, 1999). With either of these two methods, the instructor can ask a question and get a response from the students. For example, the instructor can ask a true or false question. The students can hold up a red card for true, green card for false or a yellow card if they do not know. The same is true for fingers. One finger for true, two fingers for false, and/or a fist for "I don't' know".

A new and innovative variation on the response card technique is an electronic response system. This system uses a device similar to a television remote, except that it transmits the answers from the students to a computer screen. These electronic response systems or "clickers" may also be used for in-class quizzes or to take attendance. Each student has a personal code assigned to his or her clicker and their responses are registered as a group or individually.

Another method is the "one minute paper," (Harwood, 1993) which gives the students a few minutes at the end of class to reflect on a question. This approach gives the instructor a starting point for the next class session. In all cases, the instructor can get a relatively anonymous assessment of whether or not students understand the material presented and readjust it as necessary.

When using active learning techniques, there is less emphasis on the transmission method of the teaching. Active learning involves students thinking, discovering, processing, and applying what they have learned in the classroom. The transmission method of teaching is instructor-centered. The assumption with the transmission method is that there is a stable body of knowledge that must be learned by students and there is a specific and effective way to impart the knowledge (Pratt, 1998). The transmission method in some courses, such as chemistry, is an effective method of teaching when the new material is related to prior knowledge that students already possess.

Collaborative Learning

Collaborative learning involves students working together to achieve a common goal. Formation of study groups is a form of collaborative learning. Students can get help from other students. Explaining a concept is a good way to enhance learning. You have to know a concept very well in order to teach it to some one else. Moreover, with collaborative learning, students can ask questions of one another in a non-threatening environment.

An alternative form of collaborative learning is in-class activities and out-of-class group homework assignments. Students, who participate in group activities, whether in or out of the classroom, learn to work together to find a solution to a problem. This participation provides help for learning the course material as well as experience for the working world, where collaboration is the norm rather than the exception.

One final collaborative learning technique is to establish a fixed or absolute grading scale for the course. The competitive nature to earn high grades in gatekeeper courses is exacerbated in curved grading system. Some students may be motivated by the competition to earn a high grade. Others may be discouraged or turned off by the notion of competing for a grade in a course. A fixed grading scale theoretically allows every student in the class to earn a high grade in the course (or to fail the course). No student has to worry about raising the curve in the grading scale by helping his or her peers.

Chapter Summary

The literature on academic success in college is extensive. Some of the literature on factors that influence success in college is subject specific and includes research on the factors that influence success in college chemistry.

The earliest research consisted of correlational studies that focused on academic achievement as measured primarily by scores on standardized tests. Some of the studies investigating college chemistry found a relationship between standardized test scores and high school performance with overall academic success in general chemistry. Others looked at high school grades and coursework in math and science, in addition to overall high school grades.

Although many of the early studies found some correlation between cognitive variables and academic success in chemistry, there has never been consensus across the literature that academic achievement (as measured by standardized test scores) or performance in high school (as measured by high school GPA) is the best predictor of academic success in college chemistry. Furthermore, adding non-cognitive variables to the equation increases the accuracy of predicting academic success in college.

A perfect correlation between math ability, standardized test scores, high school grade point average, etc., with academic success in college general chemistry, would be neat and tidy. With prior academic data and a simple regression equation, the final grade of any given student could be predicted. The literature, however, maintains that there are other non-cognitive variables that influence academic success in college chemistry.

If cognitive variables were the only predictors for academic success in college chemistry then there would be little incentive to do further research. Educators and policymakers can do little to influence prior academic achievement and other pre-college variables affecting academic success in college without major societal changes over generations of students. The only variables policymakers can influence are non-cognitive variables related to college students' experiences inside and outside of the classroom, instructional resources, student focus variables, and instructor focus variables. From a policy perspective, non-cognitive variables are extremely important when investigating the factors that influence academic success in college general chemistry.

To obtain the most precise and general description of the factors that influence academic success in general chemistry both cognitive and non-cognitive variables were included in the research design. To date, there are no studies investigating success in general chemistry using both cognitive and non-cognitive variables in relation to a student learning model.

There was a large body of literature on academic success in higher education, and it cut across all areas of higher education from community colleges to public and private institutions. Some of the literature was subject-specific and some was not. With such a diverse body of literature it was difficult to limit the number of constructs for the conceptual model created for this study. The student learning model for this study borrowed heavily from other research on college student experiences.

The most comprehensive lens to use for viewing student learning is to integrate the cognitive and non-cognitive elements, including social-emotional behavior, by linking student in-class and out-of-class experiences (Cove & Love, 1996). This provides a broader view than viewing student learning from a single perspective.

Assessing student pre-college characteristics was an element to common to most of the previous studies on academic success in college. In some of the studies, pre-college characteristics were as simple as using SAT or ACT scores. Others were more elaborate using high school data and parental SES. I chose to use all of the pre-college characteristics suggested in the literature when constructing the model for this study.

Most of the studies in this literature review looked at some form of instruction as a construct. Some of the studies were experiments with various instructional methods. This study did not incorporate instructional methods as a construct in the model. In class experiences and instructor focused variables assessed student perceptions of their instructor skills. There was no or experimentation with specific instructional methods. The focus of this study was the influence of students' pre-college characteristics, experiences in the classroom and experiences outside of the classroom on the their final grade in the general chemistry.

CHAPTER 3

METHOD

Introduction

The research methods used for this study are presented in this chapter. They include the conceptual framework, the variables in this study, and the study design. The chapter also includes a description of the population and respondent sample, a discussion of the development and administration of the survey instrument and focus groups, and a description of the pilot study. There is also a restatement of the research questions and a description of the data analysis techniques related to each question. Finally, a summary of the study methods and procedures is presented.

Conceptual Framework

The conceptual framework for this study was derived from a variety of college impact models. College impact models look at the process and origin of student change (Pascarella & Terenzini, 1991). This approach is in contrast to other models that examine internal characteristics of students such as affective, social, and moral development. Models that focus primarily on internal characteristics of student change omit the environmental effect when investigating student change (Kuh, 1991).

College impact models have been utilized extensively for investigating a variety of outcomes related to college students such as learning, retention, and socialization. Astin's (1968) investigation of the college environment, Tinto's (1986) theory of student departure, Weidman's (1986) evaluation of college as a socialization process, Pascarella and Terenzini's (1991, 2005), *How college affects students*, and the investigation of first-generation college students by Pascarella, Edison, Hagedorn, Nora and Terenzini (1996) are all variations on a generic college impact model. Prior to these studies there was little research on academic success in college that considered both current academic conditions and prior life events on academic success.

Pascarella's (1991, 2005) general model for assessing change consists of five sets of institutional and environmental variables. These include structural/organizational characteristics of institutions, student background and pre-college traits, interactions with agents of socialization (faculty and peers), institutional environment, and quality of student effort.

The conceptual framework for this study is a college impact model. It is a variation of Pascarella's student learning model (Pascarella & Terenzini, 1991, 2005; Pascarella, et. al., 1996) and Tinto's longitudinal model of institutional departure (Tinto, 1993).

Pascarella's model was modified by removing the construct of "Quality of Student Effort" and "Structural/Organizational Characteristics of Institutions," such as enrollment, faculty-student ratio, selectively and percent residential students, which were not needed for this study. The balance of the constructs is similar except that the college impact model used for this study includes student out-of-classroom experiences that were not included in Pascarella's model. He included "Interactions with agents of socialization," such as faculty and peers, which is related to the college experiences outside of the classroom construct contained in the college impact model used for this study.

Tinto's model posits that students enter college with a specific set of skills, attitudes, and family background variables. The decision to stay or leave the institution is determined through a series of formal and informal interactions with individuals and the social structure of the institution. Tinto's model was originally designed to study student attrition, but was successful in predicting other student outcomes as well (Pascarella & Terenzini, 2005). Tinto included influences from the external environment, such as family and other commitments. Because this particular study was primarily concerned with the internal institutional influence of student academic success, the college impact model modified for this study omitted the external environmental effects.

The college impact model developed for this study consists of six basic constructs and an outcome. These are the result of a factor analysis conducted on the data collected on the General Chemistry Survey, given to a cohort of college students.

1. Pre-college characteristics including high school course/grades and parent education/income.
2. In-class experiences, such as course organization and satisfaction.
3. Out-of-classroom experiences including social adjustment and time management.
4. Instructional resources, such as usefulness and availability.
5. Student factors including study habits and time commitments.
6. Instructor factors, such as skills, attitude, and availability.
7. Outcome, which is the final grade in the course.

This student-learning model was used as the conceptual framework for investigating factors that contribute to positive educational outcomes in general chemistry. It served as a map for guiding the data collection and analysis (Ostrom & Rogers, 1996). Figure 3.1 presents this conceptual framework.

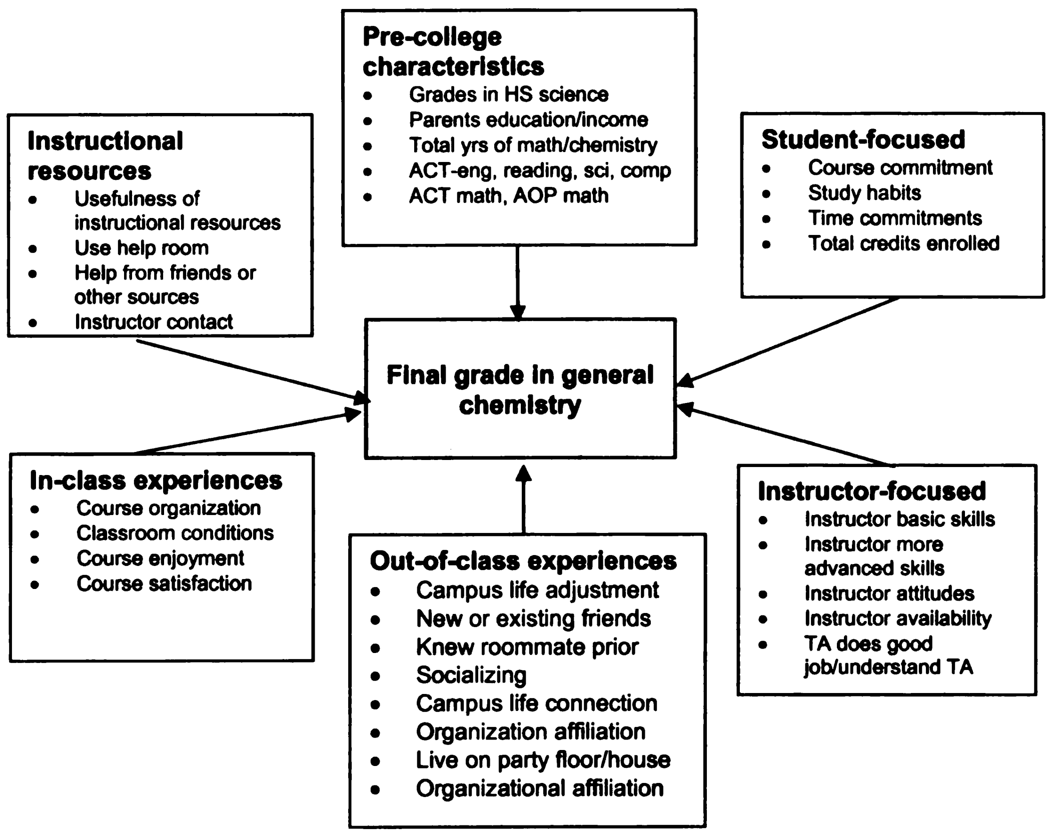

Figure 3.1. *Conceptual Framework- The College Impact Model*

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Components of the College Impact Model

The College Impact Model depicted in Figure 3.1 is a modified version of Pascarella's Student Learning Model. This model, which is the conceptual framework for the study, delineates six primary factors that influence academic success in college general chemistry. These factors are: students' pre-college experiences, college experiences in the classroom and college experiences outside of the classroom, instructional resources, student-focused variables, and instructor-focused variables. The six factors in the model are observed according to their relationship to each other and to the dependent variable, which is the final grade in general chemistry.

The final grade in the course was chosen as the dependent variable for this study because it was the most frequently used outcome variable in the literature on college academic success (Bauer & Liang, 2003, Broughan, 1996, Fletcher, 1978, House, 1995, Pascarella & Terenzini 1991, 2005, Pritchard & Wilson, 2003, Sanchez & Betkouski, 1986, Yager, 1989). One study (Anaya, 1999), advocated using student self-reported gain scores in lieu of final grades as an outcome measure. Anaya contested the validity of final course grades as an outcome measure because there were no pretests given for comparison with the final grade. She also questioned the reliability of grades because they are a non-standardized measure and 3.8 at one institution may not mean the same at another.

Pascarella's causal model for student success, (which was modified for this study) used grades to explain learning and cognitive development. In the 2005 follow-up of *How college affects students: Findings and insights from twenty Years of Research,* Pascarella and Terenzini (2005) note, "Our 1991 synthesis concluded that academic achievement indicated by grades, is among the most revealing indicators for students' successful adjustment to the intellectual and other demands of a course of study" (p. 618).

Using the final grade was also helpful for the data analysis and data collection for this study. Final grade was a ratio variable with defined zero value that was common to every case in the dataset. Moreover, it was a variable available to the participants and non-participants and was the only way to compare the two groups for any response bias.

To operationalize the conceptual model proposed for this study the factors that affect academic success in general chemistry were first looked at and then used to create the General Chemistry Survey. The General Chemistry Survey (GCS) was a 91-item instrument that corresponded to the constructs contained in the college impact model (see Appendix A). The questions on the survey were constructed from the literature on academic success in college and personal observations and experiences from the course structure of CEM 141 and CEM 142 at Michigan State University.

Factor Analysis

There were 91 questions on the GCS. In addition, ACT scores, AOP math scores and the final grade in CEM 141 and CEM 142 were obtained by signed informed consent from the Michigan State University Student Information System (SIS). There were other control variables obtained from the SIS that were not used in the factor analysis. These included, age, sex, ethnicity, course repeat status, residency, major, level (first-year, sophomore, junior, senior, graduate student) and Honor's College status. Some of the data obtained from the SIS were not used in the data analysis. However, it was easier to collect all the data available and discard any that were not needed.

When the Pascarella Student learning model was first modified for this study three overarching constructs were included that corresponded to the three possible influences on academic success in college. The first was pre-college factors, including academic achievement as measured by standardized test scores. The next two were relatively straightforward; students spent their time either in the classroom or out of the classroom.

The General Chemistry Survey (GCS) was then developed with the questions derived primarily from the literature on academic success in college and items unique to CEM 41 and CEM 142 at MSU. The GCS was constructed for data collection, which necessitated keeping three primary categories of questions in mind: pre-college characteristics and experiences, in-class experiences, and out-of-class experiences.

However, after some thought and consideration, the notion of only having three constructs in the model appeared too simplistic. The additional constructs of the instructional resources, student focus, and instructor focus needed to be added. This was because of noting how other models were differentiated in the literature and how they logically fit together from my own observations and experiences.

In addition, as a result of the factor analysis, the variables did not cluster neatly under each construct as intended with the original model. There were variables from distinct constructs clustered together in the factor analysis. For example, two questions on the survey related to attendance at lecture and recitation were originally grouped together under the in-class experiences construct. Another question asked about doing Learning On-line Computer Assisted Approach homework (LON-CAPA), was an out-of-classroom question. The factor analysis combined these three questions into one cluster that did not fit under the in-class or out-class construct so a new construct entitled *student focus* was created. Additional variables logically also fit under the *student focus* construct, such as commitment to the course and study habits.

The literature was very valuable in constructing the GCS. There was a high degree of consistency in the types of questions asked relative to academic success in college. The literature was inconsistent, however, regarding the categorization of the variables. This inconsistency was primarily because of the number and types of questions asked. Some asked very specific questions, while some were more global. I borrowed many of the questions contained in The College Student Experiences Questionnaire (CSEQ) and The National Survey of Student Engagement (NSSE) for GCS and applied them to the constructs in the conceptual model used for this study.

The 91 questions on the GCS were reduced to the 29 variables on the College Impact Model using factor analysis. Factor analysis is a data reduction method that looks at the correlation patterns of the data and attempts to determine the variables that account for most the variance in the data set. The data were reduced to summated scales that are an arithmetic average of the variables extracted from the structure matrix in the factor analysis.

The factor analysis extraction method for the data reduction of the questions on the GCS was principal component analysis with oblique rotation. The variables were entered according to each construct in the conceptual model.

The following six blocks contain the factor-derived scales from the data collected on the General Chemistry Survey. The questions on the General Chemistry Survey were determined primarily from the literature and The Inventory of College Experiences (ICA)

(Astin, 1968), The College Student Experiences Questionnaire (CSEQ) (Pace & Kuh, 1998), National Survey on Student Learning (NSSL, 1995) and The Non-cognitive Questionnaire (NCQ) (Tracy & Sedlacek, 1984). Some of the questions on the survey were specific to the chemistry courses at MSU (i.e., questions regarding LON-CAPA).

These blocks of data corresponded to the college impact models in the literature but were primarily a modified Pascarella College Impact Model. The six blocks of data collected and analyzed for this study are as follows:

Block One: Pre-College Characteristics and Experiences

- Grades in high school sciences
- Years high school sciences
- Parental education/income
- ACT-English/Reading/Science/Comprehensive scores
- ACT/AOP math

The first block of data represented student characteristics and experiences prior to enrolling in college general chemistry. These pre-college experiences included data related to high school coursework, performance in math and science courses, parental education/income, and standardized test scores.

The block of pre-college characteristics and experiences were included in the model because they were a part of all the models of student learning and college impact included in the review of literature. The models that were modified to construct the College Impact Model (Pascarella,1991, 2005; Tinto, 1996, Weidman, 1989) included pre-college characteristics and experiences as the first construct in their models.

Pre-college characteristics and experiences are an important construct because other studies have shown that variables, such as high school data and ACT (or SAT) scores, account for the largest variance when explaining college outcomes (Astin, 1971; Bauer & Liang, 2003; Pascarella, et al., 1996, Ting, 1997, 1998).

In addition, many of the variables in pre-college characteristics are relatively convenient data to collect. Pre-college data are usually archival data included on student's application records. Data, such as standardized test scores, are reported to the institution directly from the testing organization. Because they are not self-reported, there were fewer errors and missing data. Moreover, because most standardized test scores such as the ACT used in this study are norm-referenced the validity of the variable is increased and it is can be used as a control variable in the data analysis.

High school data was included on the survey, which contained self-reported data regarding the years of mathematics and chemistry taken and if students had completed a physics course. The data also included the grades from all high school math and science courses.

Other pre-college characteristics collected on the survey were factors related to parental education and income. The questions asked the students to choose the highest educational level attained by their mothers and fathers. The choices ranged from high school graduate to Ph.D. It also asked them to estimate their parents' combined yearly gross income.

The final group of variables presented in the pre-college characteristics block was data collected on ACT and AOP math scores from the SIS. Many of the students participating in the study took both the SAT and ACT tests. The majority submitted their

ACT scores (84.5%) so those data were used for this study. The ACT data included sub-scores in math, English, science, and reading, in addition to the composite score.

Along with ACT scores data were the scores from the math placement tests given during summer academic orientation at MSU. All students must have a math course as part of their general education requirement. Students are placed in a math course at summer academic orientation based on the score on their math placement exam. The math placement exam consists of a proctored test given at academic orientation, or a non-proctored test that students can take on the computer at home prior to attending the academic orientation session. The Michigan State University Department of Mathematics accepts the results of either test for placement purposes. The majority of students took the non-proctored math placement test (n= 510, 67.1.%).

Block Two: In-Class Experiences

- Course organization
- Classroom conditions
- Course enjoyment
- Course satisfaction

The second component of the student learning model involved the examination of college experiences in the classroom. Classroom experience data included student perceptions of course organization, the classroom conditions, and satisfaction and enjoyment of the course.

The questions on the GCS related to course organization were taken from the Inventory of College Activities (ICA) (Astin, 1968), College Student Experiences

Questionnaire (CSEQ) (Pace & Kuh, 1998), National Survey of Student Engagement (NSSE) (2005) and other studies related to academic success in college (Hagedorn, et al, 1999; Pascarella, et al, 1996).

The ICA was a 400-item questionnaire covering four broad categories including; the peer environment, the classroom environment, the administrative environment and the physical environment. The CSEQ asked students about how they spent their time at college in relation to faculty, friends, classes, extra curricular activities, employment and use of campus facilities such as the library. The NSSE asked the students to report on the frequency of their engagement in specific activities. These included hours per week doing schoolwork, extracurricular activities, employment, family commitments and study patterns.

Astin, in the ICA listed his course organization variables as part of the classroom environment. Pace and Kuh in the CSEQ listed the course organization variables (such as "course goals and requirements are clearly explained") under *Perceived Teacher Organization and Preparation*. Hagedorn, et al., using NSSL data, listed the course organization variables and instructor variables under the *Perceptions of Teaching* construct.

In the College Impact Model used for this study, the variables related to course organization were included under in-class experiences because there was a separate construct for instructor-focused variables. The items on the GCS related to *course organization* asked students if the course goals were clear and the syllabus accurate. They also indicated on the survey whether or not they understood how their grade was calculated in the course, if the course calendar was strictly followed, and if they perceived the course as well organized overall.

The classroom conditions variable was constructed of questions that asked whether or not students could see and hear the instructor in lecture, as well as being able to see the chalkboard or overhead projector. These questions were not included in any of the literature reviewed for this study but were added to the GCS, because the capacity of the lecture hall for CEM 141 and CEM 142 is 432 students, and it was important to know if seeing or hearing the professor effectively had any influence on academic success in the two courses.

Pace (1984) concluded, "Students who are the most satisfied with college put the most into it and get the most out of it" (p. 52). The CSEQ and most of the other questionnaires that collected data for national data sets included items on satisfaction with college as a whole but did not address individual college courses.

The course satisfaction variable asked students if they were satisfied with their performance in the course and if their scores on exams were about what they expected. There was also a question that asked about their satisfaction with the course overall.

The *in-class experience* block included a variable related to overall course enjoyment. This variable was composed of questions that asked if students enjoyed chemistry and if they would have taken chemistry if it were not a required course for their major.

Block Three: Out-of-Class Experiences

- Campus life adjustment
- New or existing friends
- Knew roommate prior
- Socializing
- Campus life connection
- Organization affiliation
- Live on party floor/house

The third component of the student learning model was college experiences out of the classroom. As much as 85% of an undergraduate student's waking hours are spent out of the classroom (Terenzini, 1991). Moreover, the transition from high school to college is a form of "culture shock" (Pascarella & Terenzini, 1991, p. 58). For some students this is the period in their lives when they begin to re-evaluate their goals and/or values through encounters with new ideas, new teachers, and new friends. College allows students to meet individuals with varied backgrounds and beliefs. College also provides students with opportunities for new freedoms, along with new academic, personal and social demands.

There were 18 questions on the survey related to out-of-class experiences (the most of any construct on the conceptual model). The CSEQ and NSSE asked questions regarding working for pay or volunteer work, and affiliation with clubs or organizations. The NSSE was a bit more specific and included one global question that asked the number of hours per week students spent in co-curricular activities such as student organizations, student government, fraternities or sororities, and intercollegiate or intramural sports.

Astin's ICA (1968) asked very detailed questions about students' out-of-class experiences in his peer environment construct. For example, regarding alcohol use, in addition to asking if students became intoxicated he also asked whether or not they drank beer, whiskey, or other hard liquor or drank wine. The GCS used in this study asked if students drank alcohol and went to parties but did not get specific about the type of alcohol consumed.

The ICA also included questions on student adjustment, such as homesickness and college roommates. It asked if the climate or weather of the university attended was different from that of the student's hometown. Although an interesting question, since 8% of the students in this study who completed the GCS were from Michigan, it was not included as a variable.

However, the GCS did include questions related to student adjustment such as whether or not students ever got homesick, if they would have liked to attend college closer to home, if they had considered leaving college, or thought it was a mistake to come to MSU in the first place. Similar to the ICA, there were also questions on socializing, which included drinking alcohol or going to parties and dating. Another variable asked if the respondent knew her or his roommate prior to coming to MSU, or if they were friends. The new or existing friends' variable on the GCS asked the same about their friendships and whether they made new friends when they came to college, or they knew their friends prior to coming to MSU.

The CSEQ included questions on living on or off campus and whether or not the students lived with parents. Pace (1984) concluded that living on campus had some influence on students' social and personal development as long as they were involved in activities while on campus. However, campus residence was neutral rather than positive with respect to general education and intellectual skills in college. The GCS included questions on whether or not students lived on campus or off campus, were commuter students, or lived at home with their parents.

Block Four: Instructional Resources

- Usefulness of instructional resources
- Use help room
- Help from friends other sources
- Instructor contact

Block four of the conceptual model included variables related to instructional resources for the course. The CSEQ and ICA asked about completing reading assignments but did not ask specifically about reading course textbooks. The CSEQ, ICA, and other instruments used to collect data for national data sets were not able to ask questions about specific courses. When they asked whether or not student do the assigned reading for the course, it may or may not mean reading the textbook because many courses use course packs, instructor produced handouts or media, other than textbooks.

In CEM 141 and CEM 142 there is a textbook and study guide available in the bookstores. Both are recommended for the course, but not required. However, most students purchase the textbook for the course. The same textbook is used for CEM 141 and CEM 142. The study guide that accompanies the textbook was written by one of the course professors. The GCS asked students about the usefulness of the textbook and accompanying study guide.

There were also questions about the help room and how it was used, in addition to questions about their sources of help with chemistry, such as friends or other students in the class. The literature reviewed for this study did not include information on student use of help rooms.

The instructor contact related variables were common in the literature. The ICA, CSEQ and NSSE asked whether or not students met with their instructors outside of class. The ICA asked if their instructor called the students by their first name. The GCA used for this study asked the students in CEM 141 and CEM 142 if they took advantage of their instructor's office hours and whether or not the instructor knew their names.

Block Five: Student-Focused Variables

- Course commitment
- Study habits
- Time commitments
- Total credits enrolled

The fifth component of the conceptual model was *student-focused* variables. The data collected for these were related to their commitment to the course, study habits, and time commitments, including the total number of credits enrolled.

Questions on the GCS that assessed course commitment included attendance at lectures and recitations. Interestingly, none of the questionnaires reviewed in the literature asked if students attended lecture or recitation. Attendance in CEM 141 and CEM 142 is not required. The question of whether or not students attended lecture and recitation was included on the GCS to determine whether or not there was a relationship between attending class and final grade in the course.

There were some questions on the GCS that were specific to students in CEM 141 and CEM 142. For example, CEM 141 and CEM 142 are large lecture courses. The only way to provide graded practice problems for the course is to use LON-CAPA homework. (LON-CAPA was developed at MSU to provide individual homework problems for students, especially in large lecture courses. Courses at MSU in mathematics, chemistry, physics and biochemistry are some of the departments that utilize LON-CAPA as homework).

One question common in the literature was relative to study habits. The ICA, CSEQ, NSSA and others (Hagedorn, et al, 1999; Kuh, et al, 1997; Milem & Berger, 1997; Pascarella, et al, 1996; Whitt, et al, 2003) included questions relating to when and how students study. The questions on the GCA that looked at study habits of students enrolled in CEM 141 and CEM 142 are the number of hours per week they study chemistry and whether or not they attempted to do practice problems other than the assigned LON-CAPA homework.

The total credits enrolled during the semester seemed to be an important variable. Questions on the CSEQ were very specific on the number and type of courses taken. Pascarella, et al (1996), utilizing the CSEQ, asked about the number of pre-professional/technical, arts and humanities, and science and engineering course taken. The GCS only included questions asking for total physical science credits enrolled and total non-physical science credits enrolled for the semester, because most of the students were first-year students and did not yet have the opportunity to take other courses related to their major.

Block Six: Instructor-Focused Variables

- Instructor basic skills
- Instructor more advanced skills
- Instructor attitudes
- Instructor available/office hours adequate
- Teaching Assistant (TA) skills

The sixth component of the conceptual model was instructor-focused variables, and there were 17 questions on the survey related to these. This component and out-of-class experiences accounted for more than one third of the questions on the 91-item survey.

Classroom instruction is an important part of the college student experience. As in high school, college students remember their best teachers fondly and worst teachers less so. Teaching excellence is the goal for most instructors. There are five characteristics that students attribute to excellent college teachers. These include enthusiasm, clarity, preparation/organization, stimulation, and love of knowledge (Sherman, T. M., Armistead, L. P., Fowler, F., Barksdale, M. A. & Reif, G).

The items in this construct were taken from the NSSE (in Hagedorn, et al, 1999; Whitt, et al, 2003), CESQ (and in Kuh, et al, 1997; Pascarella, et al, 1996) and the ICA. Questions relative to professors and instruction were numerous and varied. They ran the gamut from asking for assistance in coursework to discussing personal problems and career goals. There were also questions about instructor preparedness, skills/clarity, support, and feedback provided. The ICA asked about teaching assistants.

Questions on the GCS related to the instructor-focused construct included questions relative to student perception of their instructor's basic teaching skills, such as whether or not the instructor was prepared for lecture, if the instructor spoke intelligibly, and whether or not the instructor made mistakes in the lecture. There were questions about more advanced teaching skills including asking and answering questions during lecture, using good examples, and reviewing and summarizing the material at the close of lecture.

Instructor attitude was also an important part of the instructor focus component of the conceptual model. These questions asked whether students perceived that their instructor cared whether or not they learned chemistry, sounded excited, used humor and liked teaching chemistry overall. Instructor focus variables also included questions on instructor availability, adequacy of office hours, and availability during office hours.

Graduate students teach all the recitations in CEM 141 and CEM 142. Most of the teaching assistants are international students. There were two questions on the survey related to teaching assistants. One was whether or not the students understood their teaching assistant and the other was whether or not they thought their teaching assistant was doing a good job in recitation. None of the questionnaires reviewed in the literature for this study asked specific questions about international teaching assistants. Because issues regarding international teaching assistants were voiced in the focus groups, two questions were added to the General Chemistry Survey asking student perceptions of their teaching assistants in recitation.

The dependent variable in the College Impact Model used in this study was the assessment of academic success in general chemistry at Michigan State University as measured by the final grade at the end of the semester on a standard 0.0 to 4.0 scale. The final grade in general chemistry is based on a total number of points earned on exams and homework according to a fixed grading scale. The grading scale for CEM 141 and CEM 142 is fixed and unchanged for the past 5 years. It is as follows:

>800=4.0, >740=3.5, >680=3.0, >620=2.5, >560=2.0, >500=1.5, >440=1.0, <440=0.0

Other methods of assessment, such as authentic assessment or performance assessment based on genuine or real examples of students' work, are not used in general chemistry at Michigan State University. The only evidence that students have achieved the goals of the course is through multiple choice examinations and homework.

Research Questions

The objective of this study was to investigate the factors that influence academic success in college general chemistry. The major research questions of this study were:

1. What is the description of the sample and independent variables?
2. What is the relationship between key student demographics and control variables on the final grade in general chemistry?

3. What is the relative importance of pre-college characteristics, in-class experiences, out-of-class experiences, instructional resources, student-focused variables, instructor-focused variables, and the final grade in general chemistry? (r-square change by block).
4. What is the relationship between individual indicators within pre-college characteristics, in-class experiences, out-of-class experiences, instructional resources, student-focused variables, instructor-focused variables, and the final grade in general chemistry? (The significance of individual predictors by block)

Study Participants

The participants for this study were students enrolled in CEM 141 and CEM 142 - the general chemistry courses offered at Michigan State University. CEM 141 and CEM 142 are offered every semester during the year. The enrollment, however, is highest during the fall semester. For the spring 2003 through fall 2003 the enrollment was as follows:

Table 1.

Spring, 2003 – Fall, 2003 Enrollment in CEM 141 and CEM 142

	CEM 141	CEM 142
Spring semester 2003	927	626
Summer semester 2003	106	79
Fall semester 2003	1966	284

There are a total of 65 sections of the CEM 141 schedule during the fall semester. The maximum enrollment per section is 30 students. The lecture hall for CEM 141 has a capacity of 432 students, thus the 65 sections are divided into five 50-minute lectures per day, three times per week (Monday, Wednesday and Friday). There are 13 sections per lecture. In addition, each section has a 50-minute recitation per week for a total of four contact hours for the course. The lectures meet at various times during the day. Attendance is not required at lecture or recitation.

CEM 142 meets for two 90-minute lectures per week (Tuesday and Thursday). There is also a recitation that meets for one 50-miunion session per week. There are 14 sections of a maximum of 30 students per section. Attendance is not required in lecture or recitation.

Student Sample

This study drew on a convenience sample of students enrolled in CEM 141 or 142, who volunteered to complete the survey. As an incentive to participate, 10 points of extra credit in the course were given to the students who completed the survey (the course grade is based on a grading scale of 1,000 possible points).

All the students enrolled in CEM 141 and CEM 142 during the fall semester of 2003 had the option to complete the survey. The students who participated in the survey were not a random sample but a self-selected group. Because it was not a random sample, there was no way of sampling a specific stratum (such as female engineering majors) to reflect the target population. However, like a stratified random sample, pre-established quotas of the various subgroups could be designated to better reflect the population of students enrolled in general chemistry (such as sex, race, major, etc.). No special sampling techniques were used, but final grade data was collected on the non-participants to check for any non-response bias.

Data Collection

This was a cross-sectional study utilizing survey research and archival data. The survey was developed primarily from the literature on college effect studies. To determine the validity of items on the survey instrument, there were focus groups conducted with students enrolled in CEM 141. An email was sent to all students during the 10^{th} week of the semester inviting them to participate in a focus group to discuss the factors that influence academic success in general chemistry. The students who responded were assigned a time and place to meet. They were provided with pizza and soft drinks because the focus groups met in the early evening. The size of the focus groups was limited to eight or ten students. This size group is an optimal size for quality data collection in focus groups (Madhavi & Nelson, 2002)

The survey was comprised of a 91-item questionnaire utilizing a Likert-type scale for student responses. The five possible responses were: Strongly Agree -Agree - Neutral- Disagree Strongly Disagree. For data analysis, these interval data were coded as Strongly Agree=1, Agree=2, Neutral=3, Disagree=4 and Strongly Disagree=5.

To minimize the length of the survey instrument, some of the data were collected via a query from the Student Information System (SIS) maintained by the Office of the Registrar at Michigan State University. The SIS is a large database maintained by the university with information on every student enrolled. The data included are extensive.

All of the information on a student's initial application for admission, as well as all other pertinent information on students while they are attending Michigan State University are entered into the system. Through informed consent, overall high school grade point averages, composite scores, and subject sub-scores on the American College Test (ACT), scores on the Michigan State University Academic Orientation (AOP), mathematics placement scores, and final grades in general chemistry were extracted from the SIS. In addition, data on each student's major, class-standing (first-year, second year, third year or fourth year), honors college status, sex, ethnicity, and whether or not they repeated the course, were gathered from the SIS. Reducing the length of the survey increases the response rate (Rosenberg & Daly, 1993). Moreover, collecting archival data from university records eliminates the need for tabulating, coding, and entering data collected on surveys, thus increasing the validity of the data collected.

The objective portion of the survey instrument was comprised of 91 questions. The data from the 91 questions on the survey and other data college from the SIS were reduced to 24 subsets by employing a factor analysis.

A numerical coefficient of reliability of the survey instrument was calculated using Cronbach's alpha. Reliability or the internal consistency of an item measures the stability of the measuring device over time. Internal consistency is especially important for variables developed from summated scales because it is desirable to know whether identical items if re-constructed, will elicit the same responses if re-administered to the same respondent sample and to use insure they are measuring the same underlying construct. (Santos, Lippke, & Pope, 1998). In addition, summated scales, based on a greater number of questions, have higher reliability than single question variables (Mitchell & Jolley, 1988).

The 29 scales in the College Impact Model are a series of interrelated items designed to measure the constructs of student pre-college characteristics, college experiences in the classroom, college experiences out of the classroom, instructional resources, student-focused variables and instructor-focused variables.

The alpha's for each scale is included in Appendix A with the factor loadings. Some of the alphas were very low although the factors loaded on each other in the factor analysis. For example, variable entitled "time commitments" was as a summated scale consisting of the average hours per week of work for pay and average hours per week of volunteer or non-paid work. These two items seemed to hang together in the factor analysis but the reliability was .084. The same was true for "total years of math and chemistry". The reliability coefficient (as calculated with Cronbach's alpha) of this item was .124. This low alpha may be because of the high correlation between the number of years of math and chemistry in high school and the low variance between the items.

Pilot of Survey Instrument

A pilot study of the GCS was conducted during the spring semester 2003. The final data collection was completed in late fall semester 2003. The data collection for this study was originally intended for both semesters of the 2003 academic year (spring 2003 and fall 2003). Unfortunately, there was an undetected error in the Likert scale printed on the survey instrument. The "Disagree" and Strongly Disagree" responses were reversed on the survey.

The choices were listed as:

Strongly Agree -- Agree -- Neutral -- *Strongly Disagree* -- Disagree
1 2 3 4 5

instead of

Strongly Agree -- Agree -- Neutral -- Disagree -- *Strongly Disagree*
1 2 3 4 5

The student participants quickly pointed out this error. It was corrected and the instrument reprinted. Unfortunately, there was no way to know whether the students answered the questions according to the headings on the Likert scale, or if they ignored the text and marked option five as "Strongly Disagree."

One alternative was to recode the data into a 3-response Likert scale with responses 1 and 2 representing "Agree," response 3 representing "Neutral" and collapsing responses 4 and 5 into "Disagree." This idea was abandoned since the data collection was planned for the fall semester and the enrollment was typically sufficient to get and adequate sample of the CEM 141 and CEM 142 population without the spring semester data. With the data unusable, this first wave of data collection was used a pilot for the newly developed GCS.

There were also some questions that needed re-wording. For example, question # 44 originally asked, "I bought the book of old exams from the general chemistry office." The response choices were, Strongly Agree – Agree - Neutral - Strongly Disagree - Disagree," which did not make sense. The question was amended for the final version of the survey to read, "The book of previous exams from the general chemistry office was helpful for studying for exams."

Other than the errors on the instrument, the pilot of the survey went very well. The response was better than expected and the students answered the questions thoughtfully. There was some concern that students would mark every question on the survey with the same answer or leave most of them blank so they could receive the extra credit, because the informed consent said they could resign from the study at any time and still receive the 10 points. From a visual inspection of the surveys returned, there were only five or six with "Neutral" or another single response darkened in for every question on the survey instrument.

The pilot study was very helpful because it confirmed that five days was sufficient time to allow for the students to complete and return the surveys. Furthermore, the surveys were machine scored at the campus scoring office, but never tested in large numbers on the campus scoring machines. Because there were almost 2000 surveys scored, printing errors or any other problems that precluded the scanning of the surveys would have required manual data entry at considerable cost in time and money.

The pilot of the survey instrument was unintended but valuable nonetheless. It was costly in terms of time, money and unusable data but provided some reassurance that the actual study would occur without procedural errors. However, it did serve its purpose of detecting potentially devastating errors on the survey instrument.

Data Collection Procedures

With the approval of the University Committee on Research Involving Human Subjects (UCRIHS), the 91-item survey instrument was given to the students enrolled in CEM 141 and CEM 142 during the 13^{th} week of the fall semester of 2003.

An email message was sent to all students enrolled in CEM 141 and CEM 142 during the 13^{th} week of the 15-week semester informing them of the opportunity to participate in a study on academic success in college general chemistry. They were asked to complete a survey that would be distributed in lecture. As an incentive for participation, they would be able to earn ten points of extra credit upon completion of the survey and informed consent form. The students who missed lecture on the day the surveys were distributed and wanted to participate were instructed to go to the General Chemistry office to get a copy of the survey.

Each student who participated in the study was given a survey form and informed consent. There was a box in the General Chemistry office where students returned the completed surveys and consent forms. The survey was distributed on a Monday in all five lectures and the deadline for return was on Thursday of the same week at 5:00 p.m. No late surveys were accepted.

The students marked their responses to the questions on the survey with a #2 pencil. The completed surveys were scored at the Michigan State University scoring office. The students were very familiar with Optical Character Reader (OCR) type answer sheets and there were few errors on the surveys.

The only major problem when administering the survey was that several students failed to darken their Personal Identification Number (PID) on the top of the page or entered an incorrect PID even though they were reminded numerous times that the information was essential. This created a problem, because their PID was the only way to identify the student and credit the 10 extra credit points toward their grade. Moreover, the PID was the only way to match the students who completed the survey to their final grade in the course, which was the outcome variable for this study. Fortunately, there were fewer than 50 students with erroneous, incomplete or incorrect PIDs. Some of the surveys with incomplete PID's were salvaged because the student's were identified if the PID was darkened in incorrectly on the grid for scanning but written correctly on top of the survey form. The instrument was printed double-sided.

The students were reminded to complete all 91 questions because it was easy to overlook the questions on the back. There were approximately 25 students, however, who did not complete the back half of the survey instrument, which is a small percentage of the 1,891 that completed the entire survey

The survey was given to students in CEM 141 and CEM 142 during the fall semester 2003. There were 2,252 students enrolled in CEM 141 and CEM 142 during the semester. The response rate to the survey was 83.9 %. This was greater than expected, which was probably due to the extra credit given for participating, although the ten extra credit points were only 1% of the total points possible (1,000 total possible points) for the semester. Although this was a self-selected sample, an 83.9 % response rate was representative of the population studied.

The timing of the survey during the semester worked out very well. The 13th week of the 15-week semester was ideal. The students appeared to have enough time in the class to answer the questions accurately, yet it was not so close to the end of the semester that they were busy studying for final exams. It also was close enough to the end of the semester that the prospect of extra credit was very attractive, which may have increased the response rate.

The students were given four days to complete the survey. The survey was distributed in lecture on Monday and due by the following Thursday at 5 p.m. There were copies of the survey available in the General Chemistry office for students who missed lecture. The students also were instructed to take and sign an informed consent form (and keep a copy if they desired). No late surveys were accepted. There were boxes outside the lecture hall and in front of the General Chemistry Office where students could deposit the completed surveys and the signed informed consent forms.

The completed surveys were taken to the university scoring office on a Friday and the data returned the following Monday. The students did not wait long for their extra credit. The 10 points extra credit showed up on each student's total scores on Monday afternoon on the CEM-SCORES Web site, which is a web-based grade book for students to check their grades. The only complaints registered by students were from those who were not allowed the extra credit points because they did not turn in their survey by the deadline.

Data Analysis

The student learning model has six components that influence the outcome variable, which is academic success in college general chemistry.

- Pre-college characteristics and experiences.
- College experiences in the classroom
- College experiences out of the classroom
- Student-focused variables
- Instructor-focused variables
- Instructional resources

The research questions defined for this study all focused on positive educational outcomes in general chemistry in relation to a variety of student experiences and background characteristics. All data were analyzed using SPSS Graduate Pack 11.5 for Windows. Initial analysis included descriptive statistics on the dataset with an overview of each item in the survey instrument. Moreover, descriptive statistics provided an overview of the dataset for identifying any obvious errors or omissions.

Multiple regression analysis looks at the joint relationship between a dependent variable and two or more independent variables (Bohrnstedt & Knoke 1994). The dependent variable in this study was the final grade in CEM 141 and CEM 142. The independent variables included the demographic information and the 28 summated scales that made up the constructs of pre-college characteristics, student experiences in the classroom, student experiences out of the classroom, instructional resources, student focus variables and instructor focus variables.

Analysis Used for Research Questions

Research Question 1. What is the description of the sample and independent variables?

Descriptive statistics were used to describe the sample for this study. In addition, the responses to the survey and archival data were summarized.

Research Question 2. What is the relationship between key student demographics and control variables on the final grade in general chemistry?

- sex
- ethnicity
- participants and non-participants
- first-generation students
- physics in high school

- class (first-year students)
- honors student status
- major county of residence
- age of student at the time of study
- repeat status and final grade
- cohort group (CEM 141 or CEM 142)

Independent sample t-tests and ANOVA were used to compare the group means of data in relation to the final grade in general chemistry.

Research Question 3. What is the relationship between the blocks of variables related to pre-college characteristics, in-class experiences, out-of-class experiences, instructional resources, student-focused variables, instructor-focused variables, and the final grade in general chemistry? (r-square change by block).

Standard multiple regression analysis was used to determine the relationship between the blocks of variables labeled in-class experiences, out-of-class experiences, instructional resources, student-focused variables, instructor-focused variables pre-college characteristics and final grade in general chemistry. Particular attention was paid to the unique R^2 accounted for by each category of variable in predicting the final grade in general chemistry.

Research Question 4. What is the relationship between individual indicators within pre-college characteristics, in-class experiences, out-of-class experiences, instructional resources, student-focused variables, instructor-focused variables, and the final grade in general chemistry? (The significance of individual predictors by block)

Standard multiple regression was used to determine the relationship of the 29 independent variables contained in the conceptual model on the final grade in general chemistry.

CHAPTER 4

RESULTS

Introduction

This chapter presents the statistical analysis of the model of performance in the general chemistry courses of CEM141 and CEM 142 at Michigan State University. There are discussions regarding: data collection procedures; analysis of the data collected, including descriptive statistics of the data set; details of the factor analysis; reliability of the derived summated scales and a description of data transformations necessary for coding of raw data; and results of the regression analysis testing the components of the conceptual model. In addition, eleven key demographic and control variables were analyzed.

This is a cross-sectional study using survey research and archival data. The conceptual model is a variation of the college impact model by Pascarella and Terenzini (1991). All data collected were from students enrolled in general chemistry at Michigan State University during the fall semester of 2003.

The students who volunteered to participate completed a 91-item survey. They also completed an informed consent that allowed access to their final grade in the course and demographic data from the Student Information System (SIS) at Michigan State University. In addition, there were focus groups assembled early in spring 2003 to validate the items on the survey.

A pilot study was completed in the spring semester 2003 to test the final version of the survey. The pilot study quickly detected a small number of errors and omissions on the survey instrument. The instrument was corrected and a new version was printed for the data collected during the fall 2003 semester.

Analysis of Collected Data

The general chemistry survey included 91 questions that correspond to the six components of the conceptual model for this study. These include:

- Pre-college characteristics
- In-classroom experiences
- Out-of-classroom experiences
- Instructional resources
- Student-focused variables
- Instructor-focused variables

The respondents answered the questions by darkening a circle next to each question on an OCR answer sheet. The Michigan State University scoring office scored the answer sheets. The raw data were loaded into SPSS, Version 11.5. The descriptive statistics for each question are included in table 4.1

Research Question 1: What is the description of the sample and independent variables?

The sample was 55.2 % female (n=1,243), 44.8 % male (n=1,009) and predominantly Caucasian (n=1,685, 74.8 %). There were 144 Black students in the study (7 %) and 140 Asian/Pacific islanders (6.9 %). 30 students listed their ethnicity as Hispanic (1.3 %) and 15 as Chicano (.7 %). There were 29 students (1.3 %) listed under the "Not requested" category. These are usually international students that do not report ethnicity on their application for admission. There were no background data on 182 students (8.1%). Two thirds of the students in this study were first-year students (n=1440). Less than a quarter of the students were first-generation college students (n=440).

Pre-college characteristics. The majority of students had algebra II in high school and earned an “A”. Most also had physics and chemistry and earned an “A” or “B”. The students parents were well educated. Over two thirds of the students’ fathers had at least a bachelor’s degree. About 60 % of mothers had a bachelor’s degree or higher. About half of the students reported their parents combined income was between $80,000 and $120,000. About 15 % earned greater than $150,000.

In-classroom experiences. Approximately 90% of the students responded that the course was well organized and the classroom conditions were good (they could see and hear the instructor). They were generally neutral on whether they enjoyed chemistry but about 60% indicated that they would not take chemistry if it were not required for their major. About twice as many students were satisfied overall with the course compared to those who were not satisfied. This finding is consistent with other studies that found students were only moderately satisfied with their intellectual experience in college (Feldman & Newcomb, 1969).

The students’ responses basically responded neutral on the GCS in regards to their performance in the course. However, they were not happy about their grades on exams and approximately 60% reported that the scores on the exams were not what they expected. This finding may reflect that most of the students in this course did well in high school science and were accustomed to getting good grades. The mean final grade in the course was 2.56 (SD=1.13). This result is consistent with other studies, such as Deal (1984), who found that "Most students enter college with high grades and high expectations, but many have their hopes dashed by poor performance." (p.154). In his study the average grade in the freshman chemistry course at the University of California at Riverside was 2.52.

College experiences outside of the classroom. Seventeen questions on the survey assessed college experiences outside the classroom. Overall, 90% of the students thought they made the right decision to come to MSU and only about 7% regretted not attending a college closer to home. They essentially responded neutral on the GCS about getting homesick at times and only about 20% thought often about leaving MSU.

Students participating in the survey were a social group; two thirds of the respondents went to parties and on dates. Less than half belonged to a club or organization and only about a third attended religious services. The majority (over 64%) of the respondents drank alcohol even though most of them were minors at the time of the survey.

Most of the students lived in residence halls on campus. Only about 20% lived off campus. Very few students lived with their parents (less than 4%) and about 9 % were commuter students.

When asked whether or not they had made new friends since coming to MSU, 70% said they had made new friends when they came to MSU. About 30% knew their friends before coming to MSU. About one third of the students said they were friends with their roommate prior to coming to college and about 36% indicated they knew their roommate prior to living together on campus.

Instructional resources. Purchasing the textbook for the course was optional but highly recommended. The same was true for the study guide that accompanies the textbook. The students were neutral on the value of the textbook for the course. More than 50%, however, perceived the study guide that accompanied the textbook to be helpful. This may be because one of the instructors for the course was the author of the study guide and often referred to it in lecture (he was not the author of the textbook, however).

When students sought help with their chemistry, they were inclined to get it from their friends or other students and not from the chemistry help room or private tutor. Less than 20% of students reported using the help room or other resources such as a private tutor, but over two thirds sought help from friends or other students.

Student-focused variables. The questions on the GCS related to student focus indicated that over 70 % of students always attended lectures but only about 30% attended every recitation. An overwhelming majority (over 90%) of students did their Leaning On-line-Computerized Personal Approach (LON-CAPA) homework. Attendance at lectures and recitations for CEM 141 and CEM 142 is not monitored or required. However, LON-CAPA homework is due weekly and constitutes about 25% of their total grade for the course.

Regarding study habits, about half of the students did practice problems other than the assigned LON-CAPA homework, but reported studying chemistry only about two to four hours per week. Approximately 60% of the students studied on weekends.

Many of the students participating in the survey worked at a job or some type of non-paid work. If a student had a job, the majority (about 60%) worked one to five hours per week for pay and spent approximately one to two hours per week in volunteer or non-paid work. This result may not be an accurate representation of students' work commitments, however. The questions in the survey related to work read: "Average number of hours per week you work for pay" and "Average number of hours per week of volunteer or non-paid work." The first option was "(1-5)" and did not offer a choice for zero hours worked. Over 25% of the students did not respond to either question so it was not known whether or not the students that did not work simply skipped the question or chose the first option (which was 1-5 hours per week) since they did not have the option to choose zero hours worked.

Instructor-focused variables. Approximately 90% of the students agreed that their instructor was prepared for lecture, making few errors and speaking intelligibly. Teaching assistants did not fare as well. Only about 50% said they understood what was presented by their teaching assistant and that their teaching assistant was doing a good job in recitation. The students also perceived that their instructors were interested in their learning (approximately 50%) and asked/answered questions in lecture (70%). Over 90% perceived that their instructor liked teaching chemistry and most liked their instructor (almost 80%). Less than half of the students, however, agreed that the instructor had adequate office hours or was available during office hours.

Research Question 2. What is the relationship between key student demographics and control variables on the final grade in general chemistry?

Gender and final grade in general chemistry. The mean final grade for all students in the sample was 2.562 (SD=1.132). The mean final grade for male students in the course was 2.604 (SD=1.154). Females earned slightly lower grades (M=2.527, SD=1.112). Independent sample t-tests indicted that there was no difference between male and female students in the sample regarding the final grade in the course (t=1.588, p= .112).

This finding of no difference in the mean final grades between male and female students is consistent with previous studies (Fletcher, 1977, House, 1995, Sanchez & Betkouski, 1986). The ratio of male to female students in this sample (55.2 % female to 44.8 % male) was consistent for previous years of general chemistry courses at Michigan State University.

Table 2.

Ratio of Male to Female Students enrolled in general chemistry at Michigan State University

	2001	2002	2003	2004
Male	49.9	47.2	44.8	47.5
Female	50.1	52.8	55.2	52.5

The sample for this study is also consistent with national data for the ratio of fewer male students compared to female students attending college (NCES, 2003).

Table 3.

Ratio of Male to Female Students Attending College

	2001	2002*	2003*	2004*
Male	43.9	43.5	43.3	43.2
Female	56.1	56.5	56.7	56.7

*projected

Ethnicity and final grade in general chemistry. Student ethnicity was downloaded from the SIS at MSU. Ethnicity was categorized into nine groups as follows: Caucasian, Black, Chicano, Hispanic, American Indian, Asian/Pacific Islander, other, not reported, not requested. The "not requested" category was usually comprised of international students. Ethnicity on the SIS is taken from the self-reported information on applications for admission to MSU and the international students are not required to report ethnicity.

Independent sample t-tests compared the mean final grades of Caucasian students and all other students in the sample. The mean grades of Caucasian students (M=2.639) were greater than non-Caucasian students (M=2.330) (t=5.658, p<.001).

As stated previously, the sample for this study was 74.8% Caucasian (n=1685). All other students totaled 25.2% (n=569). There were 144 Black students (6.7 %) and 140 Asian/Pacific Islander students (6.2 %) in the sample. There were missing data on 8.2% of the sample (n=182).

A one way ANOVA was performed on the nine groups of ethnicity. This analysis indicated a significant difference across all seven ethnic groups (F=13.92, df=7/2057, p<.001).

A post-hoc test (Tukey's HSB) of the mean final grade in general chemistry and the nine ethnic groups revealed that Caucasian students (n=1682, M=2.64) did significantly better than Black students (n=143, M=1.82) and Chicano students (n=15, M=1.40), but not Hispanic (n=29, M=2.38), American Indian (n=12, M=2.13) or Asian/Pacific Islander (n=140, M=2.58).

The mean final grade of the group of students labeled "not reported" (n=15, M=3.0) or "not requested" (n=29, M=2.97) was significantly higher than the Caucasian students. These groups were primarily international students who do not normally include their ethnicity on their application for admission to the University.

Response bias between participants and non-participants. The study participants were students enrolled in CEM 141 and CEM 142 during the fall semester of 2003. For analysis purposes to investigate for any response bias in the sample, the data were re-coded into four groups: CEM 141 participants (n=1645), CEM 142 participants (n=246), CEM 141 non-participants (N=321) and CEM 142 non- participants (N=40).

There were no survey data collected on non-participant groups. However, the same archival data were collected on the participant and non-participant groups. These data included the final grade in the course and all other information available from the SIS.

The results from CEM 141 and CEM 142 were analyzed separately to determine differences in final grades between participants and non-participants. Independent sample t-tests indicted that the CEM 141 participant group earned a significantly higher mean final grade (M=2.71) versus the non-participant group (M=1.69) (t=15.8, p<001). The same was true with the mean final grades for CEM 142 participants (M=2.84) and non-participants (M=1.54) (t=7.1, p< .001).

CEM 141 and CEM 142 were analyzed separately to determine differences in final grades of the participant groups. Independent sample t-tests were used to compare the mean final grades of students enrolled in the CEM 141 and CEM 142. The mean final grade for the CEM 141 was 2.71 (n=1643) and the CEM 142 was 2.84 (n=244). The significance level for the testing the means was set at .05. The difference between the participants in CEM 141 and CEM 142, was almost, but not quite, significant (t= -1.89, p=.059).

First-generation college students and final grade in general chemistry. Independent sample t-tests showed that there was a significant difference in the mean final grade for the students who reported they were the first in their family to attend college (M=2.597, n=440) when compared to non-first-generation college students (M= 2.778, n=1430 (t= -3.333, p=.001).

This finding is consistent with the literature on first-generation college students (Reihl, 1994; Ting 1998).

Physics in high school and final grade. The 1,284 students who reported taking physics in high school were more successful in college general chemistry (M=2.84) than the 590 students who did not take it (M=2.51) (t=6.56, p<.001). This finding is consistent with Fletcher (1978), who found that a strong background in high school math and science, especially physics, translated into academic success in college chemistry. However, Yager (1989) determined that for high-achieving students, high school physics had little effect on college chemistry.

Class standing (first-year students) and final grade. It is common for first-year students to take general chemistry because it is a prerequisite for upper-level chemistry and biology courses. This sample included approximately 66% first-year students. Independent sample t-tests were used to compare first-year students with sophomores, juniors, and seniors.

The mean final grade for first-year students was 2.62. The grades for first-year students were significantly better than non-first-year students (M=2.43) (t=3.64, p<.001).

First-year student final grades (M=2.62) were significantly better than sophomores (M= 2.43) (t=3.295, p=.001) and juniors (M=2.42) (t=24, p<.05). There was no significant difference between first-year students (M=2.62) and seniors (M=2.6) (t=.433, p=.665). There were seven graduate or lifelong education students in the course but their grades were not included in this analysis.

Honors college status and final grade in general chemistry. There were 118 students in the sample who were in the Honors College. The mean final grade of Honor's College students was 3.45. This was significantly higher than the 2.51 for all of the other students in the sample (t=8.94, p<.001).

Major area of study and final grade in general chemistry. There were 112 majors listed on the SIS for the 2,252 students in the sample. The data were re-coded into the following 13 groups: human biology (n=92), education/kinesiology (n=90), Lyman Briggs College (n=175), mathematics (n=55), engineering (n=142), agriculture and natural resources (n=75), chemistry/biochemistry (n=35), no preference (n=196), pre-professional (n=413), psychology (n=63), natural science-no preference (n=22), pre-nursing (n=148) and other (n=746). A one way ANOVA indicated that there was a significant difference between major and final grade (F=1.835, df=12/2234, p<.05).

A post-hoc test (Tukey's HSB) of the mean final grade in general chemistry and the 13 majors revealed only one significant difference: the College of Engineering students had the highest mean final grade (M=2.82) and the students in the College of Agriculture and Natural Resources had the lowest (M=2.18).

This finding partially conflicts with Paul (1978) who found that the highest grades in chemistry courses were those students majoring in premedical technology. However, in his study, the final grades of engineering students were greater in comparison to students majoring in Agriculture and Forestry.

County of residence (if in Michigan) and final grade. Michigan State University is a land grant university and the majority of students in the sample are from Michigan (91.2%). The students in the sample represented 74 of the 83 counties in Michigan. The majority of the students (54.6%) were from six counties. Thirty-nine percent of the total, however, were from the tri-county area of southeast Michigan (Wayne, Oakland and Macomb counties).

The counties of residence data were re-coded into a single variable with seven categories that reflected the population of Oakland (n= 432), Wayne (n= 268) Macomb (178), Ingham (n= 142), Kent (n= 117), Genesee (n= 93) and Other (n= 1022).

The students from Macomb County earned the highest mean final grade in the course (M=2.73). The next highest grades were achieved by students from Oakland county (M=2.65). Students from Wayne county earned the lowest mean final grades in the course (M=2.39). A one way ANOVA indicated significant differences in final grades across the categories of ($F = 2.291$, $df = 6/2240$, $p<.05$).

A post-hoc test (Tukey's HSB) indicated a significant difference in the mean final grades for students from Macomb county and Wayne county (Mean difference =.338, $p<.05$) and from Oakland county and Wayne county (Mean difference = 2.26, $p<.05$). However, there was no difference in the mean final grades of students from Michigan versus non-Michigan ($t=.244$, $p=.807$).

Age of student at time of study and final grade in general chemistry. A one-way ANOVA indicated significant differences across the age groups of the students participating in the study ($F=3.640$, $df=2/2226$, $p<.001$).

The range of students in the sample was 18 to 47 years old. Ninety-eight and one half percent of the students were 18 to 23 years old. The data were re-coded into seven age groups: 18,19,20,21,22,23, and "all other." The 18-year-old group's (n=971) final grades (M=2.67) were significantly better than the 20-year-olds (n=293, M=2.38), 21-year-olds (n= 137, M=2.26), 22-year-olds (n=40, M=2.11) and the "all other" (n=50, M=2.17) age groups.

Again, this finding conflicts with that of Boughan's (1996), who found that age was a strong predictor for academic success in community college chemistry, with older students earning higher final grades. This may be because students in community college differ substantially from sample used for this study and therefore may be an irrelevant comparison. Boughan, however, was one of the few studies reviewed that included age as an independent variable.

Repeat status and final grade. Independent sample t-tests indicated that there was a significant difference in the mean final grades of student repeating the course and those taking it for the first time ($t= -7.795$, $p< 001$). The 112 students repeating the course earned a lower final grade (M=1.862) than those taking it for the first time (n=2071, M=2.669).

This finding is consistent with Burdge and Daubenmire (1991), who found that repeating a course was detrimental to academic success. They found that students, who repeated the course more than one time, earned lower grades than previous attempts and no student who repeated more than three times passed the course.

Financial aid and final grade in general chemistry. There were 1205 students in the sample who reported receiving some type of financial aid. Six hundred and fifty-nine students indicated that they did not receive any financial aid. Independent sample t-test confirmed that there was no difference in the final grades of students who received financial aid (M=2.75) and those who did not (M=2.67) (t=1.1, p=.269)

Research Question 3. What is the relationship between the blocks of variables related to pre-college characteristics, in-class experiences, out-of-class experiences, instructional resources, student-focused variables, instructor-focused variables, and the final grade in general chemistry? (r-square change by block).?

The data for analysis were tabulated from student surveys and archival information from students enrolled in general chemistry. The interval data from the survey were Likert-type responses to 78 questions related to student experiences in and out of the classroom. In addition to the 78 objective questions, there were 13 additional questions on the survey associated with parental background and socio-economic status for a total of 91 questions on the survey. The archival data were primarily demographic information, high school data and standardized test scores gathered from the SIS at Michigan State University.

The 91 survey items corresponded to the variables included in the six blocks in the conceptual model. Factor analysis was used to reduce and replace the larger set of variables by a smaller set which best summarized the data set and detected structure in the relationships between variables.

The data from the responses for the General Chemistry survey and archival data from the SIS were reduced to 30 summated scales corresponding to six blocks of data and using principal component analysis with oblique rotation and minimum Eigenvalue of one (Eigenvalue is the measure of variance explained by a factor).

The six blocks included: pre-college characteristics, in-class experiences, out-of-class experiences, instructional resources, student-focused variables and instructor-focused variables (Appendix A). The 30 scales contained in the six blocks were transformed in SPSS into new variables using the "recode" function. The 30 new scales were the arithmetic mean of the groups of variables derived from the factor analysis. A description of each factor and the variables included within each factor is explained in Appendix A. The variables that did not load and were omitted are listed below.

During the preliminary regression analysis, the coefficients for many of the variables were negative. This result was because of the way the survey instrument was designed and scored. The response choices to the questions on the survey instrument were "Strongly agree," "Agree," "Neutral," "Disagree," and "Strongly Disagree." They were scored as: "Strongly agree" =1, "Agree"=2, "Neutral"=3, "Disagree"=4, and Strongly disagree"=5. The negative regression coefficients were confusing when looking at the model. To put all scales in the same direction, all the variables were multiplied by a negative one. The recoded variables in the data set were all negative.

In-class experiences. The variables in the block under "in-class experiences" loaded onto five factors. Three variables were discarded. The variable, "The lecture room is comfortable," did not load on any of the other factors. It was not correlated positively or negatively to any of the other variables and was discarded. Two other variables related to lecture size were not used. The responses to, "I like the large lecture format for chemistry" and, "I prefer a small classroom environment for chemistry," were highly negatively correlated (-.751). They essentially measured the same response, did not load onto any of the other factors, and were discarded.

Pre-college characteristics. The variables in the pre-college characteristics block loaded onto three factors. There were no variables omitted.

Out-of-class experiences. The variables related to out-of-class experiences loaded onto six factors. The variable, "I get along with my roommate," did not load onto any of the variables related to out-of-classroom experiences and were discarded.

Instructional resources. Four factors emerged from the variables related to instructional resources. One variable, "The book of old exams is helpful for studying for exams" did not load onto any of the factors and was omitted as a variable in for the study.

Student-focused variables. The student-focused variables loaded onto three factors. One variable "I try to explain material to another student or friend" did not load onto any of the other variables. It was not highly correlated positively or negatively with any of the other variables and was discarded.

Another variable related to use of the ALLMSU web site for LON-CAPA homework, was also discarded. The ALLMSU web site is a non-MSU sponsored web site that student use to get help with their LON-CAPA homework. It is essentially a chat room that students use to, among other things, rate professors, buy and sell athletic tickets, and discuss LON-CAPA for chemistry and physics. Although LON-CAPA problems are randomized, students can post the algorithm to solve the problem on the ALLMSU web site. The students simply "plug and chug" the numbers assigned for their problems and get the answer

The other variable discarded was "I do CAPA alone (not with a group or with other students)." This variable did not load onto any of the other factors related to study habits and was not correlated, either positively or negatively, with the other variables.

Instructor-focused variables. Five factors emerged from the variables related to instructor focus. There were no variables omitted.

Model Tests

Standard multiple regression analysis was performed to determine the relative influence of the six blocks of independent variables and the dependent variable. The six blocks were pre-college characteristics, in-class experiences, out-of-class experiences, instructional resources, student-focused variables, and instructor-focused variables. The dependant variable was the final grade in general chemistry. Analysis was performed using SPSS regression (Appendix A)

The first block of variables was pre-college characteristics and experiences. These variables included; grades in high school science and high school math, parents education and income, years of math and chemistry in high school, ACT English, reading, science and comprehensive scores, ACT math score and math scores from tests at summer academic orientation (AOP). The variables in block one contributed to 19.8 percent of the total variance in the model ($R^2 = .198$, $p < .001$).

Controlling for all other variables in the block there were two significant variables. One was students' scores on ACT math and AOP math tests ($t=7.380, p<.001$) and the other was grades in high school science ($t=7.048, P<.001$).
The variables parents education and income ($t=1.370, p=.171$), total years of math and chemistry in high school ($t=.177, p=.860$) and ACT English, reading science and comprehensive sub scores ($t=1.910, p=.056$) were not significant in the pre-college characteristics and experiences block.

The second block of variables was in-class experiences. This block included student perceptions of course organization, classroom conditions, course enjoyment and course satisfaction. This block accounted for largest portion (20 percent) of total variance in the model ($R^2 = .200, p<.001$).
There were two significant variables in this block, course enjoyment ($t=2.341, p<.01$) and satisfaction with the course ($t=19.45, p<.001$).

The third block of variables entered was out-of-class experiences. These variables included issues such as campus life adjustment, making new friends, whether they knew or were prior friends with their roommate, socializing, campus life connection, whether they lived on a "party" floor or not. This block accounted for only .2 percent of the total variance in the model ($R^2 = .002, p>.01$). Controlling for all other variables in the block all were significant except the one that asked if they knew their roommate or they were friends with their roommate prior ($t=1.345, p=.179$). The other variables in the block, campus life adjustment ($t=-5.138, p<.001$), friendships ($t=4.067, p<.001$), socializing ($t= -4.109, p<.001$), campus life connection ($t= -3.521, p<.001$) and live on a quiet floor or party house ($t= 3.111, p< .01$) were all significant.

The fourth block of data were variables related to instructional resources. These variables included; usefulness of instructional materials, use of the help room, sources of help and instructor contact. Instructional resources contributed to 1.2% of the total variance in the model ($R^{2=}$ .012, p=.054). All four of the variables in this block were significant. Instructional resources (t=7.82, $p<.001$), use for the help room (t=2.581, p=.01), sources of help (t= -9.572, $p<.001$) and instructor contact (t= -2.436, $p<.05$).

The fifth block consisted of student-focused variables. These variables were students' answers to questions related to course commitment, study habits, time commitments and total credits enrolled for the semester. Student focus variables contributed to 6.9 percent of the total variance in the model ($R^2 = .069$, $P<.001$). All of the variables in this block are significant. These include, course commitment (t=8.491, $p<.001$), study habits (t=2.346, $p<.01$), time commitments (t=4.168, $p<.001$) and total credits enrolled for the semester (t= -5.586, $p<.001$).

The sixth block of variables was instructor focus variables. These variables included students perceptions of instructor basic skills, instructor more advanced skills, instructor attitude, instructor availability, and teaching assistants (TA). Instructor focus variable contributed 1.3 percent of the total variance in the model ($R^2 = .013$, $p<.05$). Only instructor attitude (t=2.014, $P<.05$) and teaching assistant (TA) performance (t= 3.540, $p<.001$) were significantly related to final course grade.

As a predictor of final grade in general chemistry all six of the blocks of variables the regression model were significant except out-of-class experiences. The full model accounted for 49.4 percent of the total variance. Two blocks of variables, however, in-class experiences and pre-college characteristics, accounted for the largest portion of the shared variance (39.8 percent).

Research Question 4: What is the relationship between individual indicators within pre-college characteristics, in-class experiences, out-of-class experiences, instructional resources, student-focused variables, instructor-focused variables, and the final grade in general chemistry? (The significance of individual predictors by block)

Standard multiple regression analysis was performed between the dependent variable (final grade in general chemistry) and the 28 independent variables. Analysis was performed using SPSS regression.

Regression analysis indicated that the model significantly predicted the final grade in general chemistry (F=15.626, df=28/448, p<.001). The R^2 for the model was .494 and the adjusted R^2 was .462. Table 4.4 depicts the Y-intercept, unstandardized regression coefficients (B) and standardized regression coefficients (beta) for each variable.

Nine individual variables in the model significantly predicted the final grade in general chemistry. The strongest predictor was course satisfaction (β= .481, t=11.172, p<.001). The next most significant variable was course commitment (β= .225, t=6.625, p<.001). The third variable was ACT math sub scores and AOP math scores (β= .202, t=5.081, p<.001). The fourth was students' grades in high school science courses (β= .169, t=4.57, p<.001). The fifth was instructor contact (β= -.126, t=-3.44, p=.001). The instructor contact coefficient was negative. The sixth significant variable was the variable composed of ACT sub scores in English, reading, science and their comprehensive score

(β= .108, t=2.86, p<.01). The seventh significant variable was the total number of credits enrolled for the semester (β= -.085, t= -2.46, p=.014). The regression coefficient for total credits enrolled was also negative. The eighth significant variable was if the students used the help room for help with their LON-CAPA homework or other problems (β= .085, t=2.36, p=.019). The last significant variable was study habits (β= .077, t=2.11, p<.05).

Summary

This chapter looked at the analysis of the data collected from student responses on the general chemistry survey and archival data collected from the SIS. All data were collected from students enrolled in CEM 141 and CEM 142 at Michigan State University during fall semester 2003.

There were some initial problems with the survey that were detected during the pilot study and corrected for the final data collection. There were no problems with the final administration of the survey and the response rate was 83.9%.

The first analysis was a description of the sample and independent variables in the conceptual model. The ratio of men to women students in the sample reflected prior years in general chemistry courses at Michigan State University, as well as national data. The descriptive statistics of the independent variables did not show any outliers.

There were eleven key demographic and control variables in the dataset. There was no difference in the final grades between male and female students. White students earned higher mean final grades than did non-white students.

There was a response bias in the sample. The survey participants earned significantly higher final grades in general chemistry than non-participants. However, the non-response rate was so low (16.1%) that it was not a concern.

Less than a third of the students in the sample were first-generation college students, but they did not do as well in the course as non first-generation college students. The mean final grades in general chemistry for first-generation college students were significantly lower than non first-generation students.

Taking a physics course in high school positively influenced students' final grade in college general chemistry. From the data analyzed in this study, students who took a physics course in high school earned significantly higher final grades in general chemistry than those who did not.

There was a wide range of student ages in the sample. Moreover, first-year students through seniors were represented. Age and class were important factors for academic success in college general chemistry. First-year students earned higher final course grades than sophomores and juniors. However, there was no difference in first-year students and seniors. Age was also an important factor. The 18-year-old students earned higher final grades than any other group.

There were students in the sample representing 74 of the 83 counties in Michigan. The greatest number of students was from Wayne, Oakland and Macomb counties. Of these three counties, students earned the highest final grades from Macomb County and the lowest from Wayne County.

Other important control variables were that students who repeated the course earned significantly lower final grades than those who took it for the first time. Honors college students earned higher grades than non-honors college students. Students in the College of Engineering earned the highest final grades of all majors. Students in the College of Agriculture earned the lowest final grades.

The conceptual model for this study was a variation of the College Impact Model (Pascarella & Terenzini, 1991, 2005). The model included six blocks of independent variables, which were: pre-college characteristics, in-class experiences, out-of-class experiences, instructional resources, student-focused variables and instructor-focused variables. The dependent variable was the final grade in college general chemistry.

Standard multiple regression analysis was used to analyze the relationship of the six blocks of independent variables to the final grade in college general chemistry. Two blocks of independent variables, pre-college characteristics (R^2 = .198) and in-class experiences (R^2 = .200) explained a large portion of the variance. Together, those two variables contributed to 39.8% in shared variability with the final grade in general chemistry. The remainder of the change in R^2 was attributed to out-of-class experiences (R^2 = .002), instructional resources (R^2 = .012), student-focused variables (R^2 = .069) and instructor-focused variables (R^2 = .013).

There were 28 independent variables in the model. A standard multiple regression analysis was performed with the dependent variable (final grade in college general chemistry) and 28 independent variables. There were nine significant predictors of final grade in college general chemistry. The strongest predictor was satisfaction with the course. Students who were satisfied with the course earned higher final grades. Other significant predictors were ACT math sub scores, AOP math score, ACT English, reading, science and comprehensive scores.

Another significant variable was instructor contact. However, the regression coefficient was negative so the students with high instructor contact earned lower final grades in college general chemistry. Components of the instructor contact scale asked if students attended the instructor office hours and if the instructor knew their name.

CHAPTER 5

DISCUSSION AND CONCLUSION

The origin of this investigation of the factors that influence academic success in college general chemistry occurred when the researcher represented the Chemistry Department at summer academic orientation. The primary purpose during orientation was to meet with prospective chemistry majors or students who required general chemistry for their major.

The majority of the students enrolling in general chemistry did not want to become scientists. They were required to take general chemistry as a prerequisite for admission to medical school or another professional school, such as teacher education, forensic science, or chemical engineering. Thus, the majority of the students worked with would go on to graduate or professional schools, or apply for admission to the College of Education or College of Engineering in their sophomore year. Fewer were in the College of Agriculture, College of Nursing, and College of Natural Science. Although their final academic goals were different, they all had been placed into the minimum of College Algebra or higher on the mathematics placement test giving at AOP and all had a strong desire to succeed.

The researcher of this study was the Academic Program Coordinator for General Chemistry, and was able to follow many of the students from summer academic orientation through their first-year of General Chemistry. Some of the students did very well and some struggled in the course. Developing an understanding of why some succeeded and others did not became the motivation for pursuing this research.

A review of the literature revealed that college students bring disparate experiences and backgrounds with them when they matriculate. Once at the institution, they spend their hours both in and out of the classroom. The foundation of this study was Pascarella's (1996) assertion that the impact of college on students was the result of cumulative, interrelated experience, rather than any single event. There were a number of models created to assess and predict the impact of college on students (Astin, 1991; Pace, 1979; Tinto, 1993; Weideman, 1989). These models were adapted for this study to investigate the factors that influence academic success in college general chemistry.

The conceptual model for this study was a college impact model. This model was modified primarily from Pascarella's (1996) General Causal Model for Assessing the Effects of Differential Environments on Student Learning and Cognitive Development (2005) but also from Astin's I-E-O model (1991), Pace's Student Development and College Impress Model (1979), Tinto's Theory of student departure (1993) and Weidman's Model of Undergraduate Socialization (1989).

All of the models were similar. Astin's Input-Environment-Out (I-E-O) was perhaps the simplest but the basic tenets of all the models were similar. Students come to college with varied backgrounds and experiences and the academic and non-academic environments of college influence a variety of outcomes for students during their time at the institution. The various models assessed outcomes such as learning, retention, and socialization after college. The student-learning model created for this study focused on one simple outcome, which was academic success in college general chemistry as measured by the final grade in CEM 141 and CEM 142 at Michigan State University during fall semester 2003. This outcome variable was examined in relation to the six constructs of the student learning model modified for this study. The six constructs were student pre-college characteristics, in-class experience, out-of-class experiences, instructor-focused variables, student-focused variables and instructional resources.

To operationalize the student-learning model, a 91-question General Chemistry Survey (GCS) was developed. The questions on the GCS were related to the six constructs that made up the student learning model. Some of the questions on the GCS were unique to general chemistry at MSU, but most were borrowed from the College Student Experiences Questionnaire (CSEQ) (Pace & Kuh, 1998) and The Inventory of College Activities (ICA) (Astin, 1968).

An analysis of the data collected provided the following conclusions:

1. For the key demographic variables, Caucasian students earned higher final grades than non-Caucasian. First-generation college students earned lower grades than non first-generation students did. Students who had physics in high school earned higher final grades in college general chemistry. First-year students earned higher final grades than sophomores and juniors, but there was no significant difference between first-year students and seniors. Students in the Honors College earned higher grades than all other students in the study. Engineering students earned higher grades than other majors. Students from suburban counties earned higher grades than urban counties. Students who repeated the course earned lower final grades than students taking the course for the first time.

2. When looking at the r-square change by the six blocks of variables used in this study, the largest percentage of the variance contributing to the final grade in general chemistry was student experiences in the classroom and students pre-college characteristics. Instructor-focused variables, student-focused variables, and instructional recourses were also significant, but to a lesser extent. The out-of-class experiences block was not significant.
3. When analyzing the significance of individual predictors within each block, the significant variables were: grades in high school science, total years of math and chemistry, ACT English, reading, science and comprehensive sub scores, scores on ACT math and AOP math, course satisfaction, instructor contact, course commitment, using the help room, study habits and total credits enrolled during the semester.

Conclusion 1

The key demographic variables in this study were analyzed primarily by comparing one group to another in relation to the final grade in general chemistry. Depending on the type of variable, independent sample t-tests or one-way ANOVA were used to assess any group differences. This analysis provided little insight into the factors that influence academic success in college general chemistry. The key demographic variables were important, however, for looking at the sample and characteristics of the students participating in the study.

In the study design and conceptual model, the key demographic variables were collected and analyzed as controls but were not included as independent variables in the model. It turned out that not including the key demographic variables in the conceptual model was a flaw in the study design. Upon final analysis, there were some differences in the demographics of the sample, but they were not included as mediating variables and there was no analysis of their interaction with the dependent variable. The difference in the key demographic characteristics of the sample was interesting but did not serve to fully explain their influence on academic success in college general chemistry in relation to student experiences in and out of the classroom.

For example, Caucasian students earned overall higher final grades in general chemistry than all other groups of students. This finding is consistent with the literature on academic success in college (Hagedorn, et al, 1999; Mason & Mittag, 2001; Flowers & Pascarella, 2003). However, the model and analysis for this study did not control for any other variables such as ACT scores, parental education/ income, or county of residence to determine if the students were from urban, suburban, or rural high schools, or to see if simply being Caucasian influenced the final course grade.

The first-generation college students did not achieve as well as non first-generation students in relation to the final grade in general chemistry. This finding was also consistent with the literature. Ting (1998) found that first-generation students and those from disadvantaged backgrounds tended to be academically at risk in college. Hagedorn et al (1999) found that students with parents that completed some higher education had higher levels of college math achievement. Others (Naumann, Bandalos & Gutkin, 2003) found that ACT scores were a good predictor of academic achievement for first-generation college students.

This study only looked at the group differences between first-generation college students and non first-generation college students in relation to the final grade in general chemistry. It would be interesting to look at first-generation college students controlling for pre-college characteristics, such as ACT scores and parental income to see whether or not first-generation students with high standardized test scores and advantaged backgrounds do better than students with lower scores and lower parental income/education.

The analysis of the key demographic data collected for this study would suggest that the most successful students in general chemistry would be Caucasian and a first-year or senior student. She or he (gender did not make a difference) would be an engineering major in the Honors College taking the course for the first time, and coming from a suburban high school.

Other than Honors College status, the above description would include a large number of students in the course so there must be other factors that influence academic success in college general chemistry.

Conclusion 2

This study used the block method in the regression analysis. There were six blocks of variables that formed the college impact model used for this study. These six blocks included pre-college factors, in-class experiences, out-of-class experiences, student-focused variables, instructor-focused variables and instructional resources variables. The questions on the GCS corresponded to each of the constructs. The variables were entered into a factor analysis by construct. For example, there were 17 questions on the GCS related to the course instructor. The factor analysis identified a pattern of relationships within this block and five variables were created. These variables made up the block entitled "Instructor-focused variables." The five new variables were the arithmetic average of each cluster.

The data analysis for this study was two-fold. First, the blocks of variables in the model were entered into the regression equation to determine the contribution of each in relation to the final grade in general chemistry. Second, the individual variables were entered into a regression equation to determine their influence on the outcome, which was the final grade in general chemistry.

For discussion purposes, conclusion one and conclusion two will be discussed together. The discussion too, of the blocks of variables and the individual variables within each block will provide a clearer picture of their influence on academic success in general chemistry. This format is evident when looking at the in-class experiences block, which was the most significant block in the model. Upon closer examination, there is one highly significant variable, course satisfaction, whereas the rest of the variables in the block were not significant.

Looking at the blocks of data and the individual variables within each block helps make better sense of the data. It also reduces the need to keep referring back to the model to determine which variables were included in each block. Moreover, it illustrates the weakness of the block method of analysis (which will be discussed later in this chapter). Therefore, the discussion will include both the contribution of the blocks of variables and the individual variables within each block in relation to the influence on the dependent variable, which was the final grade in general chemistry.

In-Class Experience Block and Variables

The in-class experience block and variables had the greatest significance of the six constructs in the conceptual model used for this study. In-class experiences contributed to 20% (r-squared = .200) of the variance predicting the final grade in general chemistry. The in-class experience variables included: course organization, classroom conditions, course enjoyment and course satisfaction. The only significant variable within the in-class experiences construct was course satisfaction and it was quite large (t=11.172). The course satisfaction variable was made up of three questions on the GCS. These included whether or not students were satisfied with their performance in the course, whether or not their grades on exams were about what they expected, and their overall satisfaction of the course.

In this study, course satisfaction was an extremely strong predicator of academic success in general chemistry. This finding suggests that students who were satisfied with the course earned a higher final grade than those who were less satisfied. Unfortunately, from these data, it is unknown whether or not students were satisfied with the course because they earned a good grade, or whether or not they earned a good grade because they were satisfied with the course. The influence of course satisfaction on the final course grade was an important predictor of the final course grade in this study and requires further investigation.

Pre-College Characteristics and Experiences - Block and Variables

The next most significant block was pre-college characteristics and experiences. This block included standardized test scores, parental educational and income, and high school coursework and performance. This block of variables contributed 19.8% (r-squared = .198) of the variance to the final grade in general chemistry.

It can be hypothesized from this study that an individual's innate intelligence and high school performance will translate into academic success in college general chemistry. Students who earned good grades in high school math and science will be more successful in college general chemistry.

In this study, student grades in high school science influenced their final grade in college general chemistry. The variable of the grade in high school science was composed of self-reported grades in algebra II, chemistry and physics. This is consistent with the literature (Astin, 199; Deal, 1984; Ozsogomonyan & Loftus, 1979) that high school performance and standardized test scores were predictors of academic success in college.

Fletcher (1977) reported that students with four years of math and a full science sequence were more successful academically in college chemistry. This particular research found that the number of years of high school math and chemistry was not a significant predictor of academic success in college general chemistry. However, earning good grades in high school math and chemistry was a significant predictor. Therefore, earning good grades in high school math and science was more important than the number of years of math and science for academic success in college general chemistry. In addition, students who had a physics course in high school also were more successful in college general chemistry.

The literature on the relationship between high school chemistry and college chemistry was mixed. Some found a relationship between high school chemistry and college chemistry (Fletcher, 1977; Willingham, 1985) and some did not (Ogden, 1976). In this study there was a significant relationship between both earned grades and number of years of high school chemistry and academic success in college chemistry. Students who earned higher grades in high school chemistry and had more than one year of high school chemistry earned higher grades in college general chemistry

Higher ACT English, reading, science and comprehensive sub-scores translated into higher final grades in college general chemistry. This finding was also true for higher scores in ACT math and AOP math. In general, high achieving students as measured by standardized test scores, were more successful in college general chemistry. This result was interesting because it was not sub-score specific. That is, higher sub-scores in English and reading were as important as the sub-scores in science, math and their comprehensive score. Perhaps this relationship was a function of the type of questions on the general chemistry exams. Although all the exams were multiple choice, all the questions were story problems and required reading. Students must be able to read and understand the questions on the exam before they could set up the problem and do the necessary calculations. Understanding the math required to complete the problems was not enough to do well on the exams. Students were required to read quickly and understand the information presented in order to pick out the information necessary to answer the question correctly.

Interestingly, in this study parental education and income were not a significant predictor of academic success in college general chemistry. This finding was somewhat surprising because first-generation college students did not do as well as non-first-generation college students.

There may be one or more reasons for this discrepancy. One is that the variable that measured parental education/ income was a combination of the highest degree attained by each parent and the annual combined parental gross income. A high score on this variable could be from a high income, from highly educated parents or both. Parents that earned high incomes may not have had college degrees. An additional reason for the discrepancy may be a result of the data analysis because the regression equation did not control for first-generation college students.

The strong influence of pre-college characteristic has both positive and negative implications for educational practitioners. One negative implication is that all the pre-college characteristics and experiences occur prior to matriculation so colleges and universities have little influence on these factors once the student arrives at the campus gates. Still, understanding pre-college characteristics and experiences is valuable for higher education professionals. Deal (1984) concluded that predicting course grades was a useful tool for counselors and admissions professionals. Students at risk can be identified early for remediation. Moreover, understanding the relationship between pre-college characteristics may motivate students to work harder to achieve the grade they desire if they understand that their preparation for college is not as strong as many of their classmates.

Student-Focused Block and Student-Focused Variables

The third significant block in the conceptual model was related to student-focused variables. This block of variables contributed to 6.9 % of the variance to final grade in the course (r-square = .069). These variables included course commitment, study habits, time commitments and the total number of credits enrolled for the semester. The student-focused block was certainly not as robust as was expected although many of the individual variables included in the block were significant.

One of the significant variables within the student-focused block was course commitment. The course commitment variable was a strong predictor of the final grade in the course. Course commitment included attendance at lecture, attendance at recitation and completing the weekly LON-CAPA assignments. The students in this study reported attending lecture regularly and doing their LON-CAPA, however, they reported neutral rather than agree or disagree on the GCS when asked if they attended recitation.

Attendance at lecture and recitation is not required in CEM 141 and CEM 142. There were no points or any other credit given for attendance at lecture or recitation. Students must have perceived attendance at lecture valuable, however, because most attended. They responded neutral on the GCS on questions related to attendance at recitation although they reported that they understood their TA and their TA did a good job in recitation. This was somewhat interesting because the majority of the TA's teaching recitation were international students. In the past, students have commented that they had trouble understanding their TA but that was not the case in this study.

Most students reported completing their weekly LON-CAPA assignments. Completing LON-CAPA was not required but contributed to 24 % of the total points toward their final grade. Student had ten chances to answer each LON-CAPA question. With a little effort, these were essentially "free" points so there was a strong incentive to earn these points toward their final grade.

Another significant variable within the student focus block was study habits. The study habits variable included doing practice problems, studying on weekends and total number of hours per week the students studied chemistry. This variable was not as strong a predictor as course commitment. This finding was somewhat surprising because it would seem that the more practice problems students completed and more total hours studying would translate into higher course grades.

The students did not spend much time studying chemistry. The majority of the students in this study spent between two to four hours per week studying. This is less than half the two hours outside of class recommended for each course credit hour (CEM 141 is a four credit course).

The total number of credit hours enrolled during the semester was also a significant variable in student-focused variables block. The GCS asked students for the total number of credits enrolled and the total number of physical science credits enrolled during the semester. The students enrolled in more credits earned lower final grades than those with fewer credits. This finding is somewhat inconsistent with the literature. Szafran (2001) determined that students who enrolled in more credits per semester earned higher grades than those who enrolled in fewer credits, however, he concurred that those who enrolled in more difficult courses tended to earn lower grades.

The results of this study conflict with Szafran (2001) partly because of the data collected on the GCS. In this study, the total number of credits enrolled and the total number of physical science credits enrolled were asked as two separate questions on the GCS but were combined into one variable ("Total credits enrolled") for the data analysis. The decision to combine both questions into one variable fit the characteristics of the students in the sample. If a student enrolled in the general chemistry course (CEM 141 or CEM 142), the general chemistry laboratory course and a college algebra and trigonometry, he or she had 10 credits out of a normal 15 credit hour load for the semester. This was also true for the students in this sample. The analysis of the data indicated that the mean number of physical science credits enrolled was greater than the mean number of non-physical science credits enrolled for the semester. This may partially explain why students enrolled in more credits during the semester did not do as well as students enrolled in fewer credits. When the data were analyzed in relation to physical versus non-physical science courses the results of this were consistent with Szafran (2001) regarding the relationship between grades, number of credits enrolled and difficulty of courses.

The data also revealed that the total number of credits enrolled per semester influenced academic success. Students in a large number of physical science courses tended to be less successful academically. This outcome poses a difficult problem. Students majoring in the physical sciences are usually required to enroll in traditionally difficult courses. Furthermore, most upper level math and science courses require sufficient prerequisites that may add to the total course load per semester.

Advisors must be aware that enrolling in a large number of difficult courses has a negative effect on academic success. Advisors and academic program directors must look at the sequencing of courses in the total academic program. How many courses are too many? That is probably up to the individual student but they should be made aware that in case of difficult courses, less is probably better and they must be prepared to budget their time accordingly.

Instructor-Focused Block and Instructor-Focused Variables

The instructor-focused block contributed to 1.3% of the variance toward the final grade in the course (r-square = .013). None of the variables in the block were significant. This was very surprising because 19 questions on the GCS were related to student perceptions of their course instructor with the anticipation that the course instructor would be a significant factor that influenced academic success in the course. In the case of this study and these data, the instructor did not appear to be a significant factor. Again, more research is required into the relationship between course instruction and other instructor-focused variables, and course satisfaction.

Instructional Resources Block and Instructional Resources Variables

The instructional resources block accounted for 1.2% of the total variance in the final course grade (r-square = .012). The use of the help room to LON-CAPA and other chemistry assistance had a positive influence on final course grade.

The only other significant variable in the instructional resources block was instructor contact. Instructor contact had a negative association with final grade. The instructor contact variable asked students if they attended the instructor's office hours and if the instructor knew their name. Very few of the students indicated they visited their instructors during office hours and fewer reported that the instructor knew their names. It appears that the students who visited their instructor for help were in dire straits and needed more help than the instructor could provide to assist them in the course.

Out-of-Class Experiences Block and Variables

The out-of-classroom experiences block was not significant and no individual variables within the block were significant. These findings are particularly interesting. A student's time outside of the classroom is significant. When Terenzini noted that over 85% of a student waking hours are spent out of the classroom, there was some expectation that that out-of-class experiences would be a significant factor for academic success in general chemistry. Perhaps out-of-class experiences are contributing factors for overall student learning and retention but not in specific courses, which was the focus of this study.

In summary, when looking at the six blocks of variables in the student learning model used for this study, approximately 40% of the variance contributing to the final grade in college general chemistry could be attributed to student pre-college characteristics and their in-class experiences. Out-of-class experiences, instructional resources, student-focused variables and instructor-focused variables contributed to only 9.4%.

The results of this study suggest that efforts to increase academic success in college general chemistry must be concentrated on two specific areas: students' pre-college characteristics and their experiences in the classroom. The bad news, as previously discussed, is that influencing students' pre-college characteristics and experiences are beyond the control of higher education professionals. In addition, the relationship between course grade and the most significant individual variable, course satisfaction, may be specious. It cannot be determined whether or not students earned a good grade in the course because they were satisfied or whether or not they reported strong course satisfaction because they were earning good grades in the course.

The good news is that there were a number of variables that can be influenced that will help students succeed academically in college general chemistry. One is instructor contact. Instructors often lament that the students they see during their office hours are the ones that need it the least. From the data in this study, students who attend their instructor's office hours needed help badly. Therefore, if it appears to an instructor that a student is simply not "getting it," they are probably correct. Instead of simply going over a few problems, answering a few questions, or reiterating concepts covered in lecture, the instructor should ask some questions to assess the knowledge level of the student. If it is not possible or practical to help the student during limited office hours, then the student should be referred to an alternate source of assistance such as their teaching assistant, the help room, or private tutor.

Another way to make students more successful is to increase their commitment to the course. Students who reported stronger course commitment earned a higher grade than those who did not. Course commitment included attending lectures and recitations, and completing their LON-CAPA. Instructors must make course lectures worth attending. Required attendance may be one way of making lecture attendance more attractive. Attendance was not mandatory for the sample used for this study. It would be interesting to conduct an additional study with randomly assigned students to lectures with required attendance to see if attendance at lecture had any effect on the final course grade or if students who did not want to be there would not do well anyway.

Doing homework was also essential for academic success in general chemistry. In this study, students were assigned LON-CAPA that served as computerized homework. Students need to practice chemistry problems through guided homework. Whether or not giving credit for homework problems is an effective method to induce students to practice chemistry problems is another good question for further research.

From the results of this study, students who used the help room were more successful in general chemistry. Again, more research is required to determine why students who visit the help room were more successful in the course. Perhaps it is because they are able to get questions answered on an individual basis in a less threatening environment. Students may be intimidated by asking a "dumb" question in lecture or recitation, but feel more comfortable working one-on-one with a teaching assistant. There is also some informal peer tutoring and collaborative learning in the help room. Students may speak with each other while they are waiting to meet with the next available help room tutor and learn from the interaction. In this study student success was negatively influenced by attending instructor office hours but positively influenced by visiting the help room. An explanation of why one source of remediation appears to be more efficacious for academic success in college general chemistry than the other will require further research.

Suggestions for Model Revision

The framing of the study to look at academic success from a cognitive and non-cognitive perspective was sound. Collecting data on student pre-college characteristics and their experiences in the classroom and experiences out-of-the classroom captured most of the desired variables. The block analysis is useful in identifying the overall importance of distinct student characteristics and behaviors.

Future studies should use more complex models to study the interchange between the blocks in the model. For example, the in-class experience block had the highest r-square in the model, but it was most likely a function of one variable, course satisfaction. When all the variables were entered into a regression equation, course satisfaction was an extremely important factor while the rest of the in- class experiences variables were not significant. When each block was added to the regression equation, in-class experiences became significant when in reality the only significant variable was course satisfaction.

Further research might consider course satisfaction as an additional outcome variable, one that precedes course grade. It is difficult to tell whether students were satisfied with the course because they earned a good grade, or they earned a good grade because they were satisfied with the course. Moreover, because course satisfaction emerged as such a strong influence, it would be interesting to investigate the factors that influence course satisfaction.

The third consideration is to look at some of the bi-directional influences of the variables in the study. In the model used for this study the direction of the analysis was all in one direction. Each block of variables was analyzed in relation to the final grade in the course. A revised model would include a look at the relationship between pre-college characteristics and final grade without controlling for all other variables. In addition, the relationship between the individual blocks of variables would be investigated. For example, student study habits and the student focus block may influence use of the help room or other instructional resources.

Further Research

The data collected for this study examined factors that influence academic success in college general chemistry. The GCS collected data on students enrolled in general chemistry at Michigan State University during fall semester 2003. The strongest predictor of academic success in general chemistry was course satisfaction ($t = 11.172$, $p < .001$). The more satisfied students earned higher final grades. This finding suggests that further research on the relationship between satisfaction and performance is warranted.

In this study, the course satisfaction variable was constructed from three questions on the GCS that asked the students whether or not they were satisfied with their performance in the course, if their grades on exams were about what they expected, and if they were satisfied with the course overall. To gain a greater understanding of the relationship between course satisfaction and academic success, developing and testing a new two-stage least squares model with course satisfaction, first as a dependent variable and then as a predictor of academic success, seems worthwhile. Using course satisfaction as a dependant variable requires eliminating from the satisfaction scale the item on exam grades and satisfaction with performance.

Another consideration for further research would be to collect data on instructor perceptions of the course. The instructor focus block was significantly related to academic success but less so than the student pre-college characteristics and in-class experience blocks. Two of the variables in the instructor focus block - the instructor attitude variable and the instructor availability variable - were most significantly related to academic success and justify further investigation. This investigation is especially important because of the negative relationship between instructor contact and final course grade. The data from this study indicate that students who attended their instructor office hours earned a lower final grade in the course. It would be interesting to investigate this finding from the instructor's perspective and compare it to the perception of the students in relation to instructor attitude and instructor contact.

In this study, the student pre-college characteristics and experiences block of variables was a strong predictor of academic success. Student pre-college characteristics and experiences contributed 19.8% in shared variability with the final course grade. It would be beneficial to do further research incorporating student demographic data in addition to other pre-college variables in relation to course final grade. Such data would include creating a dummy variable for gender and ethnicity in the regression equation.

In addition, it would be interesting to include whether or not a student was from an urban, rural, or suburban high school. The students in this sample represented almost every county in Michigan in addition to non-resident and international students. The data set included county of residence (if from Michigan) but it was not possible to determine the type of high school attended (such as urban, rural, or suburban) from county of residence data alone. For example, approximately 12% of the students in the sample were from Wayne County, Michigan. Wayne County includes the Detroit Public Schools (an urban school) and the Grosse Pointe Public Schools (a suburban school), representing two very different demographics. One way to collect data on the type of high school attended would be to include a question on the GCA asking students to classify their high school. Another would be to contact the Admissions Office to see whether or not they code the type of high school attended when they enter the student application information on the admissions database.

As mentioned earlier, general chemistry is a service course for many other majors. Therefore it is important for students to earn good grades in the course to be admitted to the nursing, engineering, medical, and veterinary schools, or other professional programs. It would be interesting to follow up with the students in this sample to see where they are now. Did a poor grade in course impede them from achieving their vocational goal? Did a good grade facilitate achieving their aspirations? Or did their grade make no difference in the pursuit of their educational goals? There is much written about the "gatekeeper" effect of courses such as general chemistry. Failing the course or dropping out of college would certainly interfere with a student's entry into medical school or engineering but does earning a barely passing grade have the same restrictive effect? It would be beneficial to investigate the impact of the "gatekeeper" effect of general chemistry on the future academic, career, and economic lives of students.

Scope and Limitations

"One of the more seductive dangers in the development of a body of knowledge is the temptation to seek premature closure; to think that we have learned enough." (Pascarella, 1985, p. 53). This study investigated the factors that influence academic success in college general chemistry. The data and conclusions contained herein pertain only to the students enrolled in CEM 141 and CEM 142 at Michigan State University during the fall semester of 2003. Year after year, however, the population of students enrolled in CEM 141 and CEM 142 is very consistent. Whether these factors generalize to other chemistry courses at Michigan State University or general chemistry courses at other institutions is beyond the scope of this study.

APPENDICES

APPENDIX A

MSU General Chemistry Survey Data

2003

Regression coefficients for blocks of variables in conceptual model

	Total R^2	Block ΔR^2
Block 1: Pre-college characteristics	.198	.198**
Grades in high school science		
Parents education/income		
Total years of math and chemistry		
ACT English, reading, science, comprehensive.		
ACT math/AOP math		
Block 2: In-Class Experiences	.398	.200**
Course organization		
Classroom conditions		
Course enjoyment		
Satisfied w/course		
Block 3: Out of class experiences	.399	.002
Campus life adjustment		
New or existing friends		
Knew roommate or were friends		
Socializing		
Campus life connection		
Live on quiet floor or party house		
Block 4: Instructional resources	.412	.012*
Usefulness of instructional resources		
Use help room for CAPA and other		
Help from friends or other sources		
Instructor contact		
Block 5: Student focus	.481	.069**
Course commitment		
Study habits		
Time commitments		
Total credits enrolled		
Block 6: Instructor focus	.494	.013*
Instructor basic skills		
Instructor more advanced skills		
Instructor attitude		
Instructor avail/office hours adequate		
TA does good job/understand TA		

**p<.001
* p<.05

Regression Coefficients for the Variables in the Conceptual Model

	B	Std. Error	Beta	t	Sig.
(Constant)	1.199	.805		1.490	.137
Pre-college characteristics					
Grades in high school science	.308	.067	.169	4.573	.000**
Parents education/income	.022	.042	.019	.535	.593
Total years of math and chemistry	.007	.053	.005	.126	.900
ACT-English, reading, science, comprehensive	.016	.006	.108	2.856	.004**
ACT math, AOP math	.053	.010	.202	5.081	.000**
In-class experiences					
Course organization	-.038	.092	-.020	-.415	.678
Classroom conditions	.010	.064	.006	.156	.876
Course enjoyment	-.049	.036	-.056	-1.373	.171
Satisfied w/course	.451	.040	.481	11.172	.000**
Out-of-class experiences					
Campus life adjustment	-.018	.044	-.016	-.416	.678
New or existing friends	.021	.035	.024	.602	.547
Knew roommate or were friends	-.006	.020	-.011	-.292	.771
Socializing	.034	.099	.012	.338	.736
Campus life connection	.261	.221	.041	1.180	.238
Live on quiet floor or party house	-.028	.037	-.026	-.755	.451
Instructional resources					
Usefulness of instructional resources	-.027	.052	-.020	-.518	.605
Use help room for CAPA and other	.135	.057	.085	2.362	.019*
Help from friends or other sources	-.021	.036	-.021	-.567	.571
Instructor contact	-.169	.049	-.126	-3.438	.001**
Student focus					
Course commitment	.309	.047	.255	6.625	.000**
Study habits	.125	.059	.077	2.114	.035*
Time commitments	.015	.051	.010	.287	.774
Total credits enrolled	-.170	.069	-.085	-2.461	.014*
Instructor focus					
Instructor basic skills	.022	.060	.017	.367	.714
Instructor more advanced skills	-.063	.066	-.046	-.960	.338
Instructor attitude	-.123	.066	-.085	-1.867	.063
Instructor available/office hours adequate	.093	.050	.069	1.875	.061
TA does good job/understand TA	-.047	.030	-.059	-1.588	.113

***p < .001, **p < .01, *p < .05

Descriptive Statistics for General Chemistry Survey Items

	N	Min	Max	M	SD
Course organization					
Course goals clear	1884	1	5	1.71	0.67
Syllabus accurate	1887	1	5	1.45	0.58
Understand grade calculation	1881	1	5	1.67	0.83
Course calendar followed	1873	1	5	1.68	0.74
Course organized	1882	1	5	1.83	0.84
Classroom Conditions					
Can hear instructor	1879	1	5	1.5	0.59
Can see instructor	1884	1	5	1.6	0.67
See board or overhead	1877	1	5	1.69	0.76
Course enjoyment					
Enjoy chemistry	1878	1	5	3.08	1.16
Take CEM if not required	1878	1	5	3.66	1.25
Course satisfaction					
Satisfied w/performance	1876	1	5	3.12	1.18
Grade about what expected	1877	1	5	3.53	1.18
Satisfied with course	1864	1	5	2.76	1.12
Seating preference (not used)					
Prefer sit in front	1884	1	5	2.53	1.22
Prefer sit in back	1884	1	5	3.53	1.21
No seating preference	1879	1	5	3.35	1.22
Campus life adjustment					
Get homesick	1865	1	5	3.15	1.24
Consider leaving	1866	1	5	3.76	1.27
Go home weekends oft	1864	1	5	3.56	1.29
Attend closer to home	1864	1	5	4.11	0.98
Mistake to come	1873	1	5	4.46	0.81
New or existing friends					
Made few friends	1874	1	5	3.84	1.18
Knew friends before	1870	1	5	3.62	1.23
Knew roommate or were friends					
Knew roommate before	1840	1	5	3.36	1.64
Roommate friends before	1838	1	5	3.46	1.58
Socializing					
Go on dates (1=yes, 2=no)	1869	1	2	1.38	0.48
Go to parties (1=yes, 2=no)	1869	1	2	1.23	0.42
Drink Alcohol (1=yes, 2=no)	1852	1	2	1.36	0.48
Campus life connection					
Commuter Student (1=yes, 2=no)	1878	1	2	1.91	0.28
Live off campus (1=yes, 2=no)	1878	1	2	1.79	0.41
Live at home (1=yes, 2=no)	1875	1	2	1.96	0.19

	N	Min	Max	M	SD
Organizational affiliation					
Belong to club/org (1=yes, 2=no)	1873	1	2	1.59	0.49
Attend religious services (1=yes, 2=no)	1874	1	2	1.73	0.45
Usefulness of instructional materials					
Textbook helpful	1874	1	5	3.02	1.04
Study guide helpful	1867	1	5	2.57	1.00
Use help room for CAPA or other					
Help room for CAPA	1882	1	5	3.5	1.26
Visit help room	1885	1	5	2.35	1.23
Help from friends or other sources					
Help from other sources	1888	1	5	3.98	1.15
Help from friends	1890	1	5	2.47	1.19
Instructor contact					
Attend Instructor office hrs	1880	1	5	4.06	0.85
Instructor knows name	1883	1	5	4.46	0.80
Course commitment					
Attend every lecture	1884	1	5	2.17	1.13
Attend every recitation	1880	1	5	3.34	1.38
Do all CAPA	1883	1	5	1.36	0.64
Time commitments					
Ave hrs work for pay/week (1=1-5, 2=6-10, 3=11-15, 4=16-20, 5> 20	1670	1	5	1.85	1.23
Ave hrs non-paid work/week (1=1-2, 2=3-4, 3=5-6, 4=7-8, 5> 9)	1639	1	5	1.26	0.68
Total credits enrolled					
Total physical sci cred enrolled (1=4-5, 2=6-7, 3=8-9, 4=10-11, 5> 12	1858	1	5	2.65	1.24
Total non-physical sci credits enrolled (1=1-2, 2=3-4, 3=5-6, 4=7-8, 5> 9	1839	1	5	3.11	1.23
Study habits					
Do practice problems-not CAPA	1873	1	5	2.83	1.19
Study weekends	1866	1	5	2.52	1.08
Hrs/week study chemistry 1=0-1, 2=2-4, 3=5-7, 4=8-10, 5>10	1872	1	5	2.23	0.78
Instructor basic skills					
Instructor prepared	1883	1	5	1.58	0.75
I like Instructor	1881	1	5	1.97	0.92
Instructor speaks intelligibly	1885	1	5	1.71	0.79
Instructor makes few errors	1883	1	5	2.01	1.00

	N	Min	Max	M	SD
Instructor more advanced skills					
Instructor uses examples in lecture	1888	1	5	1.79	0.78
Instructor asks questions in lecture	1881	1	5	2.24	0.95
Instructor answers questions lecture	1883	1	5	2.15	0.90
Instructor reviews/summarizes	1879	1	5	2.43	0.99
Instructor attitude					
Instructor sounds excited	1885	1	5	2.26	0.99
Instructor likes teaching	1882	1	5	2	0.85
Instructor likes chemistry	1878	1	5	1.6	0.67
Instructor uses humor	1881	1	5	2.32	1.03
Instructor cares if learn	1874	1	5	2.54	0.94
Instructor available/office hours adequate					
Instructor avail office hrs	1858	1	5	2.39	0.76
Instructor office hrs adequate	1859	1	5	2.41	0.79
TA does good job/understand TA					
Understand TA	1881	1	5	2.55	1.22
TA does good job	1871	1	5	2.57	1.19
Grades in HS science					
Grade in HS Algebra II	1857	0	4	3.6	0.65
Grade in HS Chemistry	1782	0	4	3.41	0.71
Grade in HS Physics	1371	0	4	3.38	0.80
Grades in high school science					
Years of HS math (1=0, 2=1, 3=2, 4=3, 5=4)	1876	1	5	4.84	0.44
Years of HS chemistry (1=0, 2=1, 3=2, 4=3, 5=4)	1871	1	5	2.17	0.59
Parents education/income					
Highest degree mom 1< HS, 2=HS grad, 3=BA/BS, 4=MA/MS, 5=PhD	1843	1	5	2.79	0.82
Highest degree dad 1<HS, 2=HS grad, 3=BA/BS, 4=MA/MS, 5=PhD	1816	1	5	3.03	0.98
Parents Income 1=0-39K, 2=40K-79K, 3=80K-124K, 4=125K-150K, 5>150K	1712	1	5	3	1.17
ACT-English/reading /science/comprehensive					
ACT English	1904	9	36	23.64	4.10
ACT Read	1904	10	36	24.57	4.77
ACT Science	1904	12	39	24.37	3.73
ACT Comprehensive	1904	12	35	24.51	3.38
ACT math/AOP math					
ACT Math	1904	13	36	24.86	4.02
AOP math unproctored	1510	2	28	14.85	5.13
Like large lecture	1881	1	5	3.14	1.22
Prefer small classroom	1882	1	5	2.29	1.14

	N	Min	Max	M	SD
Lecture hall comfortable	1875	1	5	2.89	1.02
ALLMSU for CAPA	1874	1	5	2.07	1.06
Do CAPA alone	1864	1	5	2.73	1.31
Seldom use helproom	1885	1	5	2.35	1.23
Old exams helpful	1877	1	5	1.69	0.93
Explains material others	1880	1	5	2.32	0.98
Get along with roommate	1850	1	5	2.01	1.01
Live on designated quiet floor	1858	1	5	3.82	1.39
Live party floor or house	1859	1	5	3.23	1.26
Chose residence college (1=yes, 2=no)	1871	1	2	1.84	0.37
Rushed fraternity/sorority (1=yes, 2=no)	1876	1	2	1.91	0.28
First-generation college student (1=yes, 2=no)	1874	1	2	1.77	0.42
Receive financial aid (1=yes, 2=no)	1868	1	2	1.35	0.48
Physics in HS (1=yes, 2=no)	1878	1	2	1.32	0.47
Final Grade in general chemistry	2247	0	4	2.56	1.13
Honors Student (1=yes, 2=no)	2252	1	2	1.95	0.22
Level (1=undergrad, 2=other)	2252	1	2	1	0.06
Class (1=first year, 2=sophmore, 3=junior, 4=senior)	2245	1	4	1.48	0.77
Sex 1=Male, 2=Female	2252	1	2	1.55	0.50
Ethnicity (1=cauc, 2=black, 3=chicano, 4=hisp, 5=native American, 6=Asian/PI 7=other, 8=not reported, 9=not requested	2070	1	9	1.65	1.69
HS grade point average	2039	0	4.8	3.60	0.33
SAT Verb	433	28	76	547.39	83.6
SAT Math	433	36	80	580.6	83.9
Group (1=141 fall part, 2=142 non part, 3=141fall non-part, 4=142 fall non-part)	2252	1	4	1.45	0.80
Total credit this semester	2252	0	20	14.2	1.53
Age at time of survey	2252	18	47	19.1	1.82

Factor Loadings

	Standardized rotated factor loadings*	Alpha
Course Organization		
Course goals clear	.690	
Syllabus accurate	.805	
Understand grade calculation	.614	
Course calendar followed	.722	
Course organized	.707	.738
Classroom conditions		
Can hear instructor	.849	
Can see instructor	.916	
See board or overhead	.863	.843
Course Enjoyment		
Enjoy chemistry	.845	
Would take CEM if not required	.789	.762
Satisfied w/course		
Satisfied w/performance in course	.899	
Grades on exams about what expected	.843	
Satisfied with course	.848	.829
Seating preference		
Prefer to sit in front	- .923	
Prefer to sit in back	.926	
No preference	.626	not used
Campus life adjustment		
Get homesick at times	.594	
Consider leaving MSU at times	.807	
Go home weekends oft	.629	
Attend college closer to home	.791	
Mistake to come to MSU	.746	.745
New or existing friends		
Made few friends	.886	
Knew friends before	.846	
Knew roommate or were friends		
Knew roommate before	.987	
Roommate was friend before	.987	.979
Socializing		
Go on dates	.601	
Go to parties	.840	
Drink alcohol	.799	.600
Campus life connection		
Commuter student	.860	
Live off campus	.670	
Live with parents	.711	.559

	Standardized rotated factor loadings*	Alpha
Organizational affiliation		
Belong to club or org	.750	
Attend religious services/meetings	.795	.306
Usefulness of instructional resources		
Textbook helpful	.824	
Study guide helpful	.804	.490
Use help room for CAPA and other		
Help room for CAPA	.774	
Use help room	.900	.708
Help from friends or other sources		
Help from other sources	.818	
Help from friends	.775	.431
Instructor contact		
Attend instructor office hours	.843	
Instructor knows student name	.881	.665
Course commitment		
Attend every lecture	.800	
Attend every recitation	.706	
Do all CAPA	.591	.470
Study Habits		
Do practice problems-not CAPA	.822	
Study weekends	.817	
Hours per week study chemistry	-.739	.526
Time commitments		
Average hours work for pay/week	.749	
Average hours non-paid work/week	.702	.084
Total credits enrolled		
Total physical science credits enrolled	- .912	
Total non-physical science credits enrolled	.915	-4.02
Instructor basic skills		
Instructor prepared	.856	
I like instructor	.634	
Instructor speaks intelligibly	.863	
Instructor makes few errors	.862	.8391
Instructor more advanced skills		
Instructor uses examples in lecture	.777	
Instructor asks questions in lecture	.795	
Instructor answers questions in lecture	.764	
Instructor reviews/summarizes	.698	.749

	Standardized rotated factor loadings*	Alpha
Instructor attitude		
Instructor sound excited in lecture	.863	
Instructor likes teaching	.874	
Instructor likes Chemistry	.768	
Instructor uses humor in lecture	.718	
Instructor cares if learn	.572	.827
Instructor available/office hrs adequate		
Instructor available during office hrs	.915	
Instructor office hours adequate	.912	.803
TA does good job/understand		
Understand TA	.962	
TA does good job in recitation	.962	.919
Grades in high school science		
Grade HS algebra II	.744	
Grade HS chemistry	.769	
Grade in HS physics	.720	.589
Parents education/income		
Highest degree mom	.755	
Highest degree dad	.816	
Parents combined yearly income	.776	.674
Total years math and chemistry		
Years of HS math	.731	
Years of HS chemistry	.731	.124
ACT-English/reading/ science/ comprehensive		
ACT English	.825	
ACT Reading	.869	
ACT Science	.787	
ACT Comprehensive	.985	.896
ACT math/AOP math		
ACT math	.798	
AOP math(un-proctored)	.908	.638

*Factor loadings- Principal component analysis and oblique rotation

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