

EXAMINING THE RELATION BETWEEN HIGH SCHOOL SCIENCE  
COURSEWORK AND PERFORMANCE  
IN COLLEGE CHEMISTRY

by

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## DISSERTATION ABSTRACT

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Doctor of Education

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Recent studies have demonstrated a clear gap between the skills that high school graduates obtain by the completion of high school and those that are necessary for success in college as well as the workforce. Demands for more rigorous preparation at the high school level have prompted some states to make changes to state standards and high school graduation requirements. This dissertation used a prediction study to examine the course-taking patterns of high school students in science and their subsequent success in chemistry 1A at the college level. Analysis of obtained data using a two-way ANOVA was used to estimate the main effects of (a) number of semesters of science courses and (b) the type of science courses and (c) the interaction effect on college performance as indicated by the final course grade.

The results of this study indicate that the main effect of type and the main effect of number of semesters are both significant statistically. Taking more semesters of science in high school is positively associated with the final grade in first-year college chemistry. Taking higher level science coursework in high school is also positively associated with

final grade. The interaction of type by number of semesters is not significant, however.

Taking more semesters of higher level science coursework does not increase the likelihood of doing well in college chemistry, as there is no observable significant influence on final grade in chemistry, beyond the main effects described previously.

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# CHAPTER I

## INTRODUCTION

The need to address high school graduates' preparation for the rigor and expectations of higher education is clear. Multiple studies have demonstrated the gap that exists between skills students have when graduating from high school and the skills that are needed to be successful in college (ACT, 2007; Adelman, 2006; Allen & Scoring, 2005; and Conley, 2003). This study examines the relation between science coursework taken in high school and their success in first-year college science courses, a relationship that merits close examination.

High school students entering the workforce in the 21<sup>st</sup> century are encountering new challenges. According to the 2005 report by the Commission of the States, students now need at least two years of postsecondary education to be successful in a working environment requiring advanced skills. At the same time that they are looking for a more skilled and educated workforce, employers are reporting that high school and college graduates are not proficient in the skills they consider to be basic applied skills (Cassner-Lotto & Wright, 2006). These same employers are expecting high schools and colleges to prepare students to enter that workforce. Cassner-Lotto and Wright (2006) report that employers find that 25% of workforce entrants with a four-year degree, and 46% percent of those with a two-year degree are considered to be deficient in writing in English, with similar percentages existing in written communications. The percentage of high school graduates considered by employers to be deficient in these same skills is reported to be much higher, 72% and 81%, respectively. In addition, employers reported that high

school graduates are also deficient in mathematics (53%) and reading comprehension (38%). At the same time that employers are reporting deficiency in these essential skills, Planty & Provasnik (2007) find that more students are taking advanced coursework in high school than ever before. This apparent contradiction in student coursework and preparedness for the workforce bears more consideration and further study.

In addition to examination of the link between high school performance and preparation for the workforce, there is also increased research in the area of student preparedness for college success. Researchers have provided evidence that a more rigorous curriculum in high school is associated positively with college persistence (Achieve Inc., 2007; Adelman, 1999; Allen & Sconing, 2005; Horn, Kojasku, & Carroll, 2001; Seastrom, Hoffman & Chapman, 2007). At a time when there is increased demand for college graduates in the science, technology, engineering and mathematics (STEM) fields, the preparation that students receive to be successful in science and mathematics majors also has been under closer scrutiny (ACT, 2006a).

Research at the postsecondary level regarding student success in STEM majors has not been studied extensively, and published research is contradictory. The Higher Education Research Institute (2010) reported that, although significant variation has occurred over the years, the proportions of students interested in pursuing a major in a STEM career was approximately the same in 2008 as it had been in 1971, approximately 31%. While the Higher Education Research Institute study and others have examined the interest in STEM majors by race, ethnicity, and socio-economic status, limited research has been conducted on the persistence of these STEM majors to the attainment of a bachelor's degree in the field. The Higher Education Research Institute (2010) reported

only two studies that examined this topic, one of which found that only 38% of students who entered STEM major pathways had obtained a bachelor's degree in those same pathways within six years. At the high school level, there are also alarming patterns emerging. A 2006 report by the ACT reports that the number of students declaring interest in pursuing careers in the STEM fields has dropped from 7.6% to 4.9% in the last ten years.

While further research is necessary to understand the causes for the low number of students earning bachelor's degrees in the STEM pathways, research to examine the preparation that students receive before entering college is also needed. *College readiness* has become a phrase to describe the skills that students need to have in order to be prepared for the rigors of college coursework.

### **College Readiness**

Examining the factors that help to determine a high school graduate's preparedness for college can be difficult. A working definition of college readiness must first be established in order to develop valid measures for what a student must be able to do in order to be prepared. Conley (2007) defines college readiness as "the level of preparation a student needs in order to enroll and succeed—without remediation—in a credit-bearing general education course at a postsecondary institution that offers a baccalaureate degree or transfer to a baccalaureate program" (p. 5). Noble & Schnelker (2007) determine college readiness by the ACT benchmarks in the subject areas of English, Science and Mathematics. These cut-off scores being those that they determine mean that students are ready for college-level work. Baker, Clay, & Gratama (2005) further define college readiness as being the combination of college awareness, college

eligibility and college preparation. Although not identical, these definitions examine the skills that are needed for students to apply to, enroll, and persist in a postsecondary institution.

Previous studies linking college readiness to science coursework have been indirect. Allen & Sconing (2005) report that students receiving a score of 24 or above on the ACT Science test have a .50 probability of earning a B or higher in a typical college Biology course. ACT (2006b) reports that students who take a science sequence course including physics are more likely to reach College Readiness Benchmark on the ACT Science test than those students who take Biology or Chemistry only. Unfortunately, neither of these studies discuss course sequencing in great detail, and when referring to recommended numbers of science courses, ACT (2006b) only reports that 56% of ACT-test students took the recommended core curriculum that includes three years of science. These studies and others indicate a link between science coursework taken in high school and college readiness, but more investigation could further clarify whether that link is tied to (a) the type of coursework students take in high school, or (b) the numbers of science courses that are taken.

It is also unclear if graduation requirements for science positively correlate with higher achievement in science. Teitelbaum (2003) conducted a study that directly examined the influence of high school graduation requirements in math and science on course-taking patterns and achievement in that subject matter. He found that while students did in fact increase the science credits earned when three courses were required in high school, this difference amounted to only a 9% increase in subsequent science credits earned over those with a two-year science requirement. In addition, Teitelbaum

noted that, although students who take more and higher level math and science courses do achieve higher gains, achievement as indicated by national test scores was not associated with graduation requirement policies. Teitelbaum noted the paradox in these results, and was unable to develop an answer to his satisfaction, reinforcing my belief that this topic warrants more study.

### **Graduation Requirements**

In 2006, the graduation requirements specific to mathematics and science for high schools were collected and published for all 50 states (Zinth & Dounay, 2006). At that time, Alabama was the only state to require four years of science, although Mississippi was intending to increase to four credits beginning with the class of 2012. Illinois was the only state to require just one credit in science, but has increased that requirement to two credits starting with the class of 2011 (Zinth & Dounay, 2006). Of the 23 states that required at least three credits of science, 14 of them have been implementing this only recently with the graduating classes of 2006 to 2011 (Zinth & Dounay 2006). Oregon will join these states beginning with the class of 2012 (Evans, 2007).

While some states only set minimum science course credit, others also specify the types of science courses that must be taken to satisfy credit earned. Nine states specify that students must have at least one course in a life science and one in physical sciences, while nine other states require only that at least one course be a ‘laboratory science’. Fifteen states with minimum science requirements do not specify the type of science course taken. Oregon requirements for the class of 2012 specify that at least two science courses be laboratory experiences, and all must be “inquiry-based” (SBE 2007). Also, ten other states mention the necessity for at least one science course to be “laboratory-based”

(Zinth & Dounay, 2006). There are even differences in how states define science courses. Many states define science coursework as courses that study the life sciences, physical sciences, earth and space sciences, chemistry, and are inquiry- or laboratory-based (Zinth & Dounay, 2006).

In January of 2007, the Oregon State Board of Education voted to increase Oregon's graduation requirements. Beginning with the class of 2012, students will be required to earn a total of 24 credits to graduate, increasing the number of science classes from two to three classes, the number of Arts, or Second Languages, or Professional Technical Education from one to three credits, while reducing the number of electives from nine to six credits. The new reforms come in addition to House Bill 3129 (2005), which added a one credit requirement in science and one credit in math, and increased the overall credit requirement from 22 to 24. The Oregon Department of Education (ODE) claims that the new high school requirements will better prepare today's young people for postsecondary education and for the workforce by acting as a 'passport to college and workforce readiness.' It is the goal of the State board of Education, with the support of Oregon employers and universities, to improve the skills of all high school graduates in order to prepare them for today's high skill jobs and the rigorous coursework in college (SBE, 2007). In preparation for the credit requirement change, the Oregon State Department of Education broadened the definition of science courses to include applied and integrated science courses, such as Agriculture Science and Computer Science, but will require that at least two credits be earned in laboratory based courses (SBE, 2007). It remains to be determined whether or not computer science courses will be considered laboratory-based.

For Oregon, an increase in the science credit requirements corresponds to an increase in graduation requirements, which may affect graduation rates. A fear that high school students would drop out rather than meet new and more challenging requirements has led to some resistance to high graduation requirements (SBE 2007). Teitelbaum (2003), however, cites several researchers who have found that persistence in high school actually increased throughout the late 1980's and 1990's, a time when most graduation reforms and increases in requirements were occurring. These findings are consistent with those reported by the Oregon State Board of Education (2007). Seastrom et al. (2007) found that in 2003 and 2004, the United States graduation rates were approximately 73.9% and 75.0%, respectively. Oregon graduation rates are consistent with these findings, reporting average graduation rates of 73.7% and 74.2% in the same time period. Oregon ranked 34th in 2003 among the 51 states and the District of Columbia, and 29th of 50 in 2004.

**Review of Graduation Requirements.** Comparing graduation requirements among states is complicated. Unit discrepancies as well as content discrepancy exist between and within states. While most states report science achievement by credit expressed in Carnegie units, others do so by years completed. Idaho, Indiana, and New Jersey all have an independent unit policy, and some allow schools to report quarter- and half-credit options (Zinth & Dounay 2006). In addition, credit is assigned by course title, with little or no information provided about the content covered or course rigor.

Preliminary analyses of graduation rates and the possible relationship to graduation requirements have proved inconclusive. The five states with the highest graduation *requirements* (24 credits) were Alabama, Florida, South Carolina, Texas, and

West Virginia (Planty & Provasnik, 2007). When examining graduation *rates*, however, Texas and West Virginia both had graduation rates of approximately 75%, Florida averaged 67%, Alabama 65%, while South Carolina had graduation rates just under 60% (Seastrom et al., 2007). Of the fourteen states that had graduation rates above 80% in 2003, ten required 20 or greater credits to graduate, and three required a minimum of three credits in science. Of the ten states and one district that had graduation rates below 70%, all required a minimum of 20 credits to graduate, and required at least three credits. The next year, however, thirty-two states experienced an increase in graduation rates, while fifteen states experienced a decline (Seastrom et al., 2007). Only one state experienced no change. Due to the complicated nature in reporting graduation rates (i.e. student transfers in and out of the nation and between states, and students who complete high school early or late) it is difficult to draw reliable conclusions about a possible relationship between high school graduation requirements and student persistence.

While all states have specified graduation requirements, not all states implement requirements with fidelity. Schools, therefore, are under pressure to better prepare students for post-high school opportunities from such mandates as No Child Left Behind. Graduation rates are often used as a measure of school and state effectiveness, and are taken into account during AYP calculations (Adelman, 2006). Unfortunately, there is evidence that while graduation requirements may include rigorous science coursework, in some states students are allowed to graduate (i.e. receive a diploma) without having met those requirements. In schools that required three years of science, approximately 20% of students were able to graduate without fulfilling these obligations (Teitelbaum, 2003). In their 2007 study of high school course-taking patterns, Planty & Provasnik (2007) found

that 0.6% of high school graduates had completed no science courses, and 5.6% had completed only a low academic level science course. Although the reasons for these discrepancies is not explored, it may be explained by students who are eligible for alternate or modified diplomas, including students with individualized education plans that would modify the graduation requirements. It is also possible that states have a system by which parents may petition to have graduation requirements waved for their child under certain circumstances.

A trend toward satisfying requirements with only low level courses, some of which may lack rigor or not extend introductory science understandings, has been a concern raised in response to credit increase movements since *A Nation at Risk* was published. It is difficult, however, to examine the extent to which this has occurred given the availability of course titles only. Teitelbaum (2003) organizes courses into four groups: low level (basic biology, earth science or lower); middle-level science 1 (honors or general biology); middle-level science 2 (chemistry I or physics I); Advanced science (chemistry I and physics I or higher). This is adapted from Burkam & Lee's (1997) seven pipelines. Planty et al. (2007) considered only the highest level of coursework taken; general biology, chemistry I or physics I, chemistry I and physics I; or chemistry II, physics II and/ or advanced biology, also adapted from Burkam and Lee's organization system. Other variables may need to be used in transcript analysis to identify the rigor of science courses; math levels, for example to further investigate the prevalence of taking sets of only low level science classes in states with three or four science credits required for graduation.

Increased graduation requirements in math and science have had a positive influence on the numbers of science credits earned by students, although there is still no clear understanding of the correlation with the type, or levels, of science class students take (Teitelbaum, 2003). As mentioned earlier, there appears to be a positive correlation between rigor of coursework and college success. This would seem to indicate that more rigorous science coursework as part of graduation requirements would be more beneficial to the preparation of students for college coursework than just an increase in the number of science courses taken; however there is limited research currently available to investigate this hypothesis.

### **The Case for a More Rigorous Diploma**

Does the change to Oregon's graduation requirements create a more rigorous diploma? The American Diploma Project (ADP), of which Oregon is a member, has argued that in order to create a more rigorous diploma, states should require all students to take a rigorous core curriculum that defines specific course-taking requirements and specifies the core content for those courses (2004). While the ADP has developed and promoted the benchmarks for mathematics and English curriculum, it encourages college and workplace readiness expectations to be reinforced in all content areas. In addition, the ADP encourages graduation exams to ensure that students meet standards before earning a diploma. The recent changes to Oregon's graduation requirements include an assessment of "Essential Skills", where students will need to demonstrate proficiency in essential process skills deemed critical for success before they can be awarded a diploma (SBE 2007). In addition, the increase in math and science credits needed for graduation was designed to enhance analytic skills, a skill deemed by several reports to be important

in both college and the workplace (ACT 2006b, Cassner-Lotto & Wright-Benner 2006, Conley 2007, SBE 2007).

Will the increase in Oregon's science credit requirement encourage more students to take more academically rigorous science courses? Teitelbaum (2003) findings suggest that this would not occur, while Planty & Provasnik's 2007 study suggest otherwise. In their analysis, Planty & Provasnik (2007) found that the percentage of high school graduates taking at least one advanced science course (defined as a class more rigorous than general biology) has more than doubled in the years from 1982 to 2004. This trend in increasing levels of science coursework is confounded by the reports that large numbers of high school graduates are enrolling in at least one remedial course in colleges and universities (SBE, 2007; Adelman, 2004).

Given the few studies conducted in this area, and their conflicting findings, it appears that there is need for further research into the relationship that high school graduation requirements have on college performance. In concluding his research, Teitelbaum (2003) expressed a need for more examination of the relationship between graduation requirement policies and the likelihood that graduates enroll in a 4-year college or university. He noted in his research that "students who failed to meet their coursework requirements...were in the vocational or general track-the student population that this initiative was designed to help" (45). This appears to validate the concerns of opponents of graduation requirement increases that students may not be successful (Teitelbaum, 2003; SBE, 2007), and continues to warrant further study.

Science courses in particular may play a role in preparing students for post-high school opportunities. The "Key Cognitive Strategies" promoted by Conley (2010) include

such attributes as problem formulation, research, interpretation, communication, and precision and accuracy. Problem formulation attributes include the ability for students to understand and restate the problem in a given situation, develop logical questions, and to develop reasonable hypotheses regarding such questions. The strategy of research involves student engagement in developing and implementing procedures to investigate the problem, as well as to complete research on related information to aid in developing solutions to the problem, revising and repeating experiments to collect such information as necessary. Interpretation attributes include developing students' ability to correctly evaluate the results of their research, and to draw appropriate conclusions. In addition, the communication strategy emphasizes student decision-making on the best way to present information, including written work, and graphs or tables to display data and information. Students' ability to determine sources of error, and to use appropriate terminology specific to the discipline are all part of the fifth cognitive strategy, precision and accuracy, which students ought to apply throughout the process of investigation. All of these cognitive strategies are commonly associated with science, and may be skills developed particularly within science coursework.

The purpose of this study was to examine the relationship, if any, that exists between the type of science coursework students take in high school and their performance in college science courses. Is college performance in science courses associated with the number and type of science courses that students take in high school? The results of this study add to the literature base that examines the factors that will best prepare students to be successful in the transition from high school to college. As states look to strengthen graduation requirements and provide college- and work-ready high

school graduates, this study helps to highlight course-taking patterns that may lead to a higher likelihood of success in college chemistry.

## CHAPTER II

### METHODS

This study examined the relation that exists between student course-taking patterns in high school and the subsequent performance in first-year college chemistry. Specifically, this study estimated the effect of (a) the amount, and (b) the types of high school coursework on college chemistry performance, as determined by the final course grade. Furthermore, the interaction effect (number of courses by type of courses) on performance in chemistry was estimated. Do students need to take a minimum number of science courses in order to be prepared for college coursework, and does the type of courses taken in that sequence have an impact on performance at the college level?

#### **Design**

This study used extant data from a broader study for the National Science Foundation (NSF, funded under DUE-0737056), provided by researchers at University of California Berkeley (Claesgens, J., Scalise, K., Wilson, M., & Stacy, A., 2009; Scalise, K., Claesgens, J., Wilson, M., & Stacy, A., 2006). Participants were surveyed on three occasions, while progress on content is measured with a number of exams and other assessments throughout the term and a final exam. In the first survey, students were asked to self-report the total number of semesters of science courses taken, as well as to identify which courses were taken, in high school (see Appendix). Main effects on the independent variables along with the interaction effect were estimated using a two-way ANOVA.

## Participants

The sample in this study was the chemistry 1A class at UC Berkeley. All participants were surveyed on three occasions within the fall term of the 2009-10 academic year; (1) at the beginning, (2) midterm, and (3) end of the term about attitudes towards chemistry, future academic plans, and previous science coursework. After the term ended, grades that students earned were compared to the previous science coursework (number of courses taken in high school as well as types of courses taken) as reported by each student. Measures of attitudes toward science coursework were not used in this study, but were included as part of the larger NSF study being conducted (Scalise, K., Claesgens, J., Wilson, M., & Stacy, A., 2007; Scalise, K., Stacy, A., Douskey, M., Dabenmire, P., Lim, T., Sinapuelas, M. et al., 2010).

The data were collected through surveys administered online via surveymonkey.com (an online survey system). All students in the class were informed of the survey during the second week of classes and could access it from a link on their course webpage. 869 of the 1300 students enrolled in the course completed the survey, were 18 years of age or more at the time of the survey, and gave consent to participate in the study. The high participation rate (~67%) suggests that this may be a reasonably representative sample of the class, however unknown or known systematic variables may be present, including the known variable of systematic non-inclusion due to the survey frame design of students less than 18 years of age at the time of the survey.

Students who did not give consent to participate were excluded from the final data set. Students who were missing any of the three variables needed for this study were excluded from this study. Some students may have skipped some of the questions or

indicated “decline to state”; these students have some missing data. Students were identified by the principal researcher through student ID to link with course grades and lab section. This identifying information was then removed before the data were analyzed by this researcher.

Some students reported inconsistent information. For example, one student reported only taking only two semesters of high school science, but then listed that he/she had taken Earth Science, Integrated Science, Biology and Chemistry, although the reported coursework may not have fit into only 2 semesters of high school coursework, depending on the scope and sequence of the curriculum design, which is unknown. Such a discrepancy also may be explained by taking courses concurrently. A student may have taken Earth science and Integrated science courses during the same semester, and reported it as having only taken 1 semester of science.

### **Measurement**

The independent variables were classifications of type and amount of high school course work. The dependent variable was college freshman course performance. Measurement of the three variables was restricted largely to the extant data used in this study.

**Dependent Measures.** The dependent measure is student performance in Chemistry 1A course at University of California, Berkeley. Performance was measured by the final grade earned by students in the course, as determined by the course instructors. All instructors of Chemistry 1A at UC Berkeley use the same teaching materials and methods, including exams, and students may attend the lecture sessions of their choice or view webcasts. Laboratory sections are scheduled for each individual

student, depending on their selection of times and the availability of the choices, and the laboratory sections are facilitated by graduate student researchers, using materials created and used in common across all sections by the course instructors and staff.

The course grade was determined by averaging 4 exams given over the course of the term with the final exam, along with other assessment information and points awarded on project-based work such as laboratories and a literature investigation. The data sample included raw scores on each exam for each student, and a cumulative percentage earned for the semester. Exam 1 and Exam 2 were worth 80 points each, while Exams 3 and 4 were worth 120 points each. The final exam was worth 250 points. Other assessment and project-based information was included in the final percentage score for the course.

The percentage score was benchmarked into letter grade categories consistent with university grading standards of A+, A, A-, B+, B, B-, through F. Twenty-three students (2.65%) in the sample opted for Pass or No Pass grading option. Fourteen of these students (1.69%), earned a P grade which was then converted to the letter grade indicated by the percentage earned. The nine students (1.01%), who earned a NP were assigned the letter grade of an F as they would not earn credit for this course. The data available for these analyses were the letter grades, only.

To conduct an analysis of the main effects of type of course and number of semesters on the final course grade, letter grades were converted to numerical scores. A letter grade of F was assigned a value of one; a D- was assigned a value of two; a D, a value of three, etc., with a final grade of an A+ being assigned a value of thirteen. Values were assigned as displayed in Table 1.

**Independent Measures.** There are two independent variables, factor A (the number of courses taken), and factor B (the types of courses taken). Numbers of courses were self-reported number of complete semesters. Students reported a minimum of one semester up to “more than eight” as an option. The number of courses will be grouped into the following ordered categories, (1) three or fewer semesters recorded, (2) four or five semesters, and (3) six or seven semesters, and (4) eight or more semesters of courses selected by the participants.

Table 1

*Letter Grade Conversion to Numerical Values*

Letter Grade	Numerical Value
F	1
D-	2
D	3
D+	4
C-	5
C	6
C+	7
B-	8
B	9
B+	10
A-	11
A	12
A+	13

The variable "types of high school science courses" were classified into levels using the classification system of Teitelbaum (2003) and Planty et al. (2007). For the purpose of this study, Teitelbaum's interpretation of Burkam and Lee's pipeline serves as the guideline for the course grouping, with minor adaptations as described in the analysis section. Teitelbaum's (2003) model was adapted for the proposed research. Courses were organized into four levels of courses; lower level, middle level, middle level 2, and advanced level. Lower level coursework included courses listed as integrated science, biology, environmental science, or earth science. Middle level science coursework will include chemistry or physics courses. Honors chemistry, Honors physics, Honors Biology was categorized as Middle level 2. Advanced level coursework will include Advanced Placement courses taken in physics, chemistry, and/or biology, as well as International Baccalaureate courses. Students who identified taking coursework other than those identified above were sorted individually by the researcher into the category that appeared most fitting.

### **Analysis**

A two-way analysis of variance model was used to estimate the effect of (a) the number of semesters of high school science coursework, and (b) performance in Chemistry 1A on college freshman chemistry grades. The number of courses had four ordered levels, (1) representing three or fewer semesters recorded, (2) representing four or five semesters, and (3) representing six or seven semesters, and (4) representing eight or more semesters of courses selected by the participants. The type of coursework taken also had four levels, (1) will be Low level coursework, (2) Middle level 1 coursework, (3) Middle level 2 coursework, and (4) Advanced level coursework. The dependent variable

was the course letter grade transformed into a numeric equivalent. It is noted that the numeric scores associated with the letter grades are presumed to be continuously rather than categorically scaled.

### **Internal Validity**

**Strengths.** The large sample size used in the study supports the generalizability of any relationships found between the independent measures. This study uses data from 869 student responses, which limits the possibility of any one individual skewing the data. Any trends or patterns found in analysis of data could indicate that variance across high school coursework bearing the same title has less impact on student college readiness than previously thought. Conversely, if there is no discernable pattern found in the data, then this study supports further investigation in the effect that the aforementioned variability may have on student college readiness, however within the constraints of the limitations as described above.

**Weaknesses.** This study utilized a quasi-experimental design, with post-hoc self-reported observation data regarding what could be considered the treatment intervention (frequency and type of coursework). In addition to the self-report concerns mentioned above, such as conflicting self-reports for a few students and an inability to verify the self-reports for all students, another weakness in this design is the lack of random assignment of the participants of the study to the original intervention, of frequency and type. As such, there are numerous possible confounds at the student level that may have an impact on the results of this study, including ethnicity, gender, or socio-economic status of the participants. In addition, there are school level confounds that may also

affect the results of this study, such as school demographics and the type of secondary school of the participant (private or public).

Although all students enrolled in Chemistry 1A were invited to participate in the study, not all students agreed to participate. Almost 1300 students were enrolled in the course at the start of the fall term, but slightly fewer than 900 students met the criteria of age 18 at time of the survey, provision of consent, and completion of both the survey independent variables needed and the course itself to obtain a final grade. 869 respondents met these criteria for this survey, resulting in a 67% response rate. 174 of these participants (20%) were under 18, but obtained consent to participate. No information is available on the student profiles of the approximately 400 students who were not included in this survey. An unintended result of this self-selected participation may be sampling bias. It is possible that this reduces the heterogeneity of the student demographics in this study.

High school courses taken around the state and the nation will have high variability in the rigor and breadth of the coursework. It is unlikely that all 'Biology' courses are equivalent in scope and difficulty within a school district, much less within or across states. This same variance is highly likely to be found in all science courses, except Advanced Placement and International Baccalaureate coursework. AP and IB coursework has more rigid standards of accountability in order to maintain their status and accreditation by the respective governing boards. There is no way to guarantee that these advanced courses have similar teacher quality or course rigor, but it is likely that there is somewhat less variability between these courses. In 2008, the AP Course Audit was instituted, a process designed to ensure that high schools are aligning their course

curriculum to the college-level criteria set by the College Board (College Board 2010). In order for a high school to be able to list a course as Advanced Placement on transcripts, this audit must be completed. Such a process helps to improve consistency in curriculum in the advanced level courses.

The method for organizing the different courses into levels of rigor could be a source of error. These levels were adapted from studies conducted by previous researchers examining trends in science coursework (Burke & Lee, 2003; Planty, Teitelbaum). The data collection relies on student self-report regarding the courses that they have taken in high school, which is another weakness to this study. There is no apparent incentive for students to provide false reports, but a transcript analysis would be the only way to guarantee accurate reporting.

Finally, a major limitation of the study regarding generalizability is the one-case setting for the collection of the data, and the characteristics of this setting as extremely high-achieving students. In fall of 2009 when this data set was collected, UC Berkeley had an overall admissions rate of 29.5% (University of California 2010). The average weighted incoming grade point average in 2009, for example, was 4.34. Additionally those students enrolling and completing first semester chemistry at the case study site tend to be some of the highest achieving incoming students relative to an already select overall incoming class, and the UC Berkeley chemistry department itself is one of the highest ranking such departments at research institutions in the country. Therefore especially regarding high school graduation requirements, this population is not representative of those who would be influenced for instance by minimum high school

requirements in California schools, since most students have gone considerably beyond minimum graduation requirements in their high school achievements.

However some prior work on research studies by UC Berkeley researchers have indicated both in quantitative and qualitative findings that better supporting type and frequency of chemistry instruction does make a significant difference for student performance in high school more generally, including comparing what happens for (i) more typical schools and (ii) less served populations, with less served populations also making substantial gains in understanding through frequency and type interventions (Watanabe, M., Nunes, N., Mebane, S., Scalise, K., Claesgens, J., 2007).

### **External Validity**

**Strengths.** All freshman chemistry students in the department were included in the survey population. This study, therefore, had a sample size that is quite large- almost 1300 students were enrolled in the course, and close to 900 participated in the survey. After excluding incomplete or inconsistent surveys, there were still 869 student surveys to be included in the survey. Chemistry 1A is an early course in the science department sequence for science, technology, engineering, and mathematics majors (STEM) and is not the course sequence usually taken at the university by chemistry majors, so mostly represents other majors. In addition, chemistry 1A is one course that satisfies the general science graduation requirement for college graduation, so some student participants who do not intend to major in science. For this reason, college readiness indicators may be examined for all students, not only for students interested in pursuing a STEM major. Although study of this sample may not be easily generalized, an analysis of students with

strong academic profiles may produce effects that can be used to infer patterns in the academic profiles of students at other, less selective institutions.

**Weaknesses.** While Chemistry 1A is an entry level course at this college, without a transcript analysis it is difficult to determine if this course is similar to other entry level chemistry courses at colleges and universities of the same caliber. This will make it difficult to generalize any trends found in the data to entry level courses beyond this university setting. In addition, although a large sample size is used in this experiment, there may not be a wide range of high school experiences represented. The graduation requirements of the states the participants were from, as well as the characteristics of the high schools students attend (socio-economic status, size of the school, private or public school), may have an uncontrolled impact on the results of this study.

## CHAPTER III

### RESULTS

The primary research question in this study focused on what, if any, relation existed between student course-taking patterns in high school and their subsequent performance in first-year college chemistry. Specifically, this study examined the main effect of (a) the number of science courses, and (b) the type of high school courses, and (c) the interaction effect (number of courses by type of courses) on freshman final overall grade.

Eight hundred sixty-nine students participated in the survey. Of these students, 508 were female (58.5%), 356 were male (41%), and 5 students (.5%) declined to respond to this survey question (see Table 2). 92.8% of all participants were from California. 29.9% of the respondents identified their ethnicity to be White/ Caucasian, while 33.3% identified themselves as Chinese or Chinese American. Fourteen different ethnic identifications were claimed by the participants. A complete representation of the ethnic identification can be found in Table 3.

Table 2

*Gender of Study Participants*

Gender	N	%
Decline to state	5	0.5%
Female	508	58.5%
Male	356	41.0%
Total	869	100.0%

Table 3

*Frequencies of Ethnic Identification of Study Participants*

Ethnic Identification	N	%
American Indian/Alaska Native	4	0.5%
Chinese/Chinese American	289	33.3%
East Indian/Pakistani	62	7.1%
Japanese/Japanese-American	22	2.5%
Korean/Korean-American	83	9.6%
Filipino/Filipino-American	30	3.5%
Pacific Islander	5	.6%
South East Asian	45	5.2%
Other Asian	39	4.5%
African-American/Black	5	.6%
Mexican/Mexican American/Chicano	51	5.9%
Spanish-American/Latino/Latina	26	3.0%
Middle Eastern	28	3.2%
White	260	29.9%
Total	869	100.0%

The mean final grade of all students was a B. Three hundred of the participants (34.5%) earned a final course grade of an A-, A, or A+, while 409 students (47.1%) earned a B-, B, or B+ in the course. 130 students (15%) earned a C-, C, or C+ in the course, while only eleven students (1.3%) earned a D in the course. Nineteen students (2.2%) earned no credit for the course, earning an F or NP as their final grade (Table 4). Upon analysis, a significant relation between gender of the participant and final course grade was found. Male students tended to outperform female students ( $\chi^2 = 39.33$ ,  $df =$

10,  $p < 0.01$ ). There was no significant relation found between ethnicity and grade. Table 5 illustrates the final course grade distribution between genders.

Table 4

*Final Course Grades*

Grade	Total	
	N	%
A+	26	3.0%
A	148	17.0%
A-	126	14.5%
B+	150	17.3%
B	127	14.6%
B-	132	15.2%
C+	57	6.6%
C	33	3.8%
C-	40	4.6%
D	11	1.3%
F	19	2.2%
Total	869	100.0%

Of the 869 students included in this study, 550 students reported taking 8 or more semesters of science, 182 reported taking six or seven semesters of science, and 91 reported taking four or five total semesters of science. Only 46 students in the study reported taking three or fewer total semesters of science, 479 students in the study were found to have taken predominantly high level coursework, while 224 students predominately took Middle Level 2 coursework. There were 104 cases that had taken

predominantly Middle Level 1 coursework, and only 62 students took mostly low level courses (See Table 6).

Table 5

*Distribution of Final Course Grade by Gender*

Grade	Female		Male		Total	
	N	%	N	%	N	%
A+	10	2.0%	16	4.5%	26	3.0%
A	62	12.2%	84	23.6%	148	17.0%
A-	69	13.6%	57	16.0%	126	14.5%
B+	86	16.9%	64	18.0%	150	17.3%
B	78	15.4%	48	13.5%	127	14.6%
B-	91	17.9%	39	11.0%	132	15.2%
C+	36	7.1%	21	5.9%	57	6.6%
C	22	4.3%	11	3.1%	33	3.8%
C-	30	5.9%	10	2.8%	40	4.6%
D	9	1.8%	2	.6%	11	1.3%
F	15	3.0%	4	1.1%	19	2.2%
Total	508	100.0%	356	100.0%	869	100.0%

Note 1.  $\chi^2 = 39.33$ ,  $df = 10$ ,  $p < 0.01$ .

### Number of Semesters and Level of Coursework

Prior to testing the effects of number-of-courses and course-level on grade, the relation between number of courses and course level was examined. Table 6 provides the observed counts of students for number of semesters by course level. When tested statistically, the two variables are not independent ( $\chi^2=37.31$ ,  $df=9$ ,  $p \leq 0.01$ ).

As indicated in Table 6, students who take higher level course work, also tend to take more semesters of the course work. Of the 62 students who took predominantly low

level courses, 37 (59.7%) reported taking eight or more semesters of science coursework, 15 (24.2%) students reported taking six or seven semesters of science, eight (12.9%) students reported taking four or five semesters of science, while only two students (3.2%) reported three or fewer total semesters of science coursework in high school.

Table 6

*Predominant Type of Courses Taken by Number of Semesters Cross-tabulation*

Predominant Type of Courses Taken		Number of semesters				Total
		1,2,3	4,5	6,7	8 or more	
low level	n	2	8	15	37	62
	Percent within Predominant Type of Courses Taken	3.2%	12.9%	24.2%	59.7%	100.0%
middle level '1'	n	12	13	32	47	104
	Percent within Predominant Type of Courses Taken	11.5%	12.5%	30.8%	45.2%	100.0%
middle level '2'	n	14	21	60	129	224
	Percent within Predominant Type of Courses Taken	6.3%	9.4%	26.8%	57.6%	100.0%
high level	n	18	49	75	337	479
	Percent within Predominant Type of Courses Taken	3.8%	10.2%	15.7%	70.4%	100.0%
Total	n	46	91	182	550	869
	Percent within Predominant Type of Courses Taken	5.3%	10.5%	20.9%	63.3%	100.0%

Note 1.  $\chi^2 = 37.31$ ,  $df = 9$ ,  $p < 0.01$

Of the students who took predominantly middle level 1 coursework, 47 (45.2%) of them reported taking eight or more semesters of science coursework, 32 (30.8%) students reported taking six or seven semesters of science coursework in high school, and thirteen (12.5%) students reported taking only four or five semesters. Twelve students (11.5%) reported three or fewer semesters of science coursework.

Only fourteen (6.3%) students who took predominantly middle level 2 science coursework reported taking three or fewer semesters of science coursework. Twenty-one (9.4%) students reported taking four or five semesters; while 60 (26.8%) students reported taking six or seven semesters of science coursework. 129 (57.6%) students reported taking eight or more semesters of science coursework.

Of the students who took predominantly high level of coursework, only eighteen (3.8%) reported taking three or fewer semesters of coursework; 49 (10.2%) students reported four or five semesters of coursework, and 75 (15.7%) reported six or seven semesters of science coursework. 337 (70.4%) students who took predominantly high level science coursework reported taking eight or more semesters of science coursework.

### **Effect of Number of Semesters and Level of Coursework on Course Final Grade**

The primary question in this research pertains to the effects of amount and level of high school chemistry coursework on the students' freshman course grade. A two-way ANOVA was used to test the main and interaction effects of type and amount on freshman final grade. The interaction effect was not significant ( $F = 0.64$ ;  $df=9,839$ ;  $p=0.77$ ). The main effect of type was significant ( $F=10.89$ ;  $df=3,839$ ;  $p=0.04$ ), and the main effect of number of semesters was significant ( $F=7.02$ ;  $df=3,839$ ;  $p=0.02$ ). Tables 7,

8, and 9 and Figure 1 provide the cell descriptive statistics, and Table 10 provides ANOVA summary statistics.

Students who took predominately low level courses earned, on average, a grade of a 7.98 (B-). Students with predominately middle level 1 and middle level 2 also earned an average grade of 7.62 (~B-), and 8.35 (~B-), respectively. Students who took mostly high level coursework earned an average grade of a 9.43 (~B). As the mean final course grade increased, the standard deviation decreased, as indicated in Table 7.

Table 7

*Descriptive Statistics for Main Effect of Predominant Type of Courses Taken on Final Course Grade*

Predominant Type of Courses Taken	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
low level (n= 62)	7.98	.50	7.01	8.95
middle level '1' (n= 104)	7.62	.27	7.09	8.15
middle level '2' (n= 224)	8.35	.22	7.91	8.78
high level (n= 479)	9.43	.18	9.08	9.78

Similar results existed for the main effect of numbers of semesters on the final course grade (Table 8). Students who took three or fewer semesters of high school science earned a mean final grade of 7.60, which translated into approximately a B-. Students who reported taking four or five semesters of science coursework earned a mean final grade of 7.93, which also translated into a B-. Students taking six or seven semesters

of science coursework earned a mean final grade of 8.62 (approximately a B), while those students who reported taking eight or more semesters of science coursework 9.23 (also approximately a B).

Table 8

*Descriptive Statistics for Main Effect of Number of Semesters on Final Course Grade*

Number of Semesters	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1,2,3 (n= 46)	7.60	.49	6.63	8.57
4,5 (n= 91)	7.93	.30	7.33	8.52
6,7 (n= 182)	8.62	.21	8.20	9.03
8 or more (n= 550)	9.23	.14	8.96	9.51

Students who took high level courses earned a higher mean grade than their peers, Students who took only a few semesters of high level courses did not necessarily outperform those students who took more semesters of science, however (Table 9). As illustrated in Figure 1, students who took one, two or three semesters of high level courses earned a lower mean final grade than those students who took six or seven semesters of predominantly low level courses, as well as those students who took eight or more semesters of predominantly low levels of science.

Table 9

*Descriptive Statistics for Interaction of Predominant Type of Courses Taken by Number of Semesters*

Predominant Type of Courses Taken	# of Semesters	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
low level	1,2,3 (n= 2)	7.00	1.66	3.75	10.25
	4,5 (n= 8)	7.00	.83	5.38	8.62
	6,7 (n= 15)	8.73	.60	7.55	9.92
	8 or more (n= 37)	9.19	.39	8.43	9.95
middle level '1'	1,2,3 (n= 12)	7.50	.68	6.17	8.83
	4,5 (n= 13)	6.85	.65	5.57	8.12
	6,7 (n= 32)	7.59	.41	6.78	8.41
	8 or more (n= 47)	8.53	.34	7.86	9.20
middle level '2'	1,2,3 (n= 14)	7.29	.63	6.06	8.51
	4,5 (n= 21)	8.33	.51	7.33	9.34
	6,7 (n= 60)	8.53	.30	7.94	9.13
	8 or more (n=129)	9.24	.21	8.84	9.65
high level	1,2,3 (n= 18)	8.61	.55	7.53	9.69
	4,5 (n= 49)	9.53	.33	8.87	10.19
	6,7 (n= 75)	9.60	.27	9.07	10.13
	8 or more (n= 337)	9.97	.13	9.72	10.22

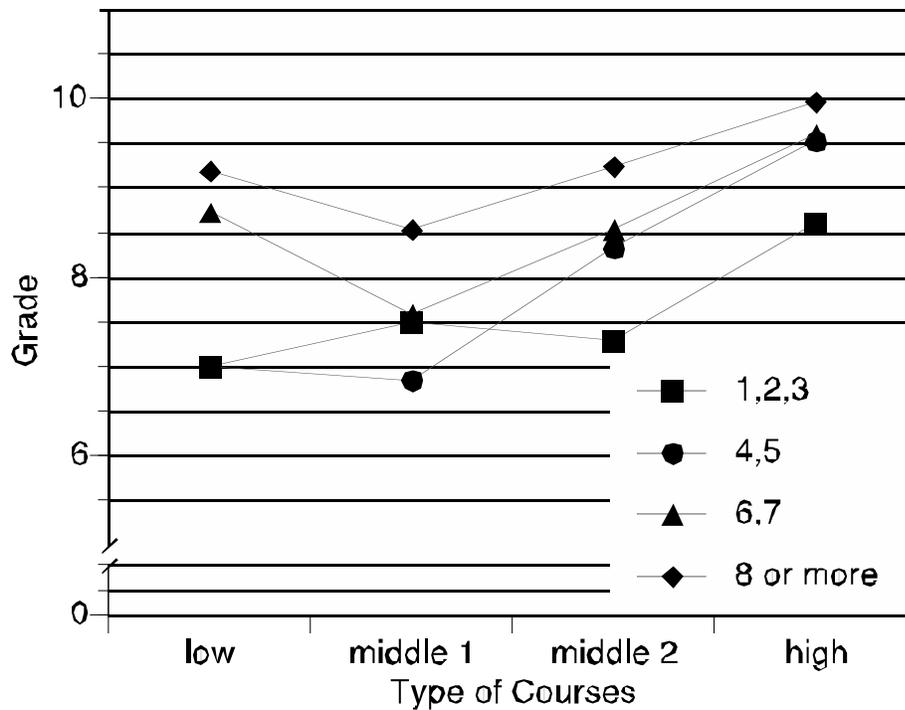


Figure 1. Mean Final Grades by Type of Courses and Number of Semesters.

Statistically significant main effects were obtained for type and the number of semesters on the final course grade as measured on a numeric scale (see Table 1). Though the main effects were significant statistically, there were no actual effects in terms of the letter grade (Table 10). The interaction effect was not significant statistically, indicating that the main effect of type is independent of the number of semesters (Table 10). Students who took more semesters of higher level coursework had higher final grades on average.

Table 10

*Type, Number of Semesters, Type by Number of Semesters ANOVA Summary Table*

Source	Type III Sum of Squares	df	Mean Square	F	Partial Eta Squared
Intercept	15269.607	1	15269.607	2786.70	.766
Type	205.188	3	68.396	12.48**	.042
Number of semesters	132.342	3	44.114	8.05**	.028
Type by number of semester	38.273	9	4.253	.78	.008
Error	4673.971	853	5.479		
Total	79786.000	869			
Corrected Total	5251.703	868			

\*\*  $p < 0.01$

The obtained significant effects were closely examined to identify the specific effects and to appraise the practical significance. Referring to Figure 2, though the main effect of course type is significant statistically, the means and confidence bands indicate that the effect is associated primarily with the high level course types. For all other types of courses taken, the confidence bands do overlap considerably. The pattern of means in Figure 2 explains in part the small effect size associated with course type, though the effect is significant, statistically. The lower three types of courses (low, middle 1, and middle 2) are not different with respect to freshman grade. The significant effect is associated with the high-level courses in contrast to the other lower types of courses ( $t = -7.35$ ,  $df = 723.31$ ,  $p \leq 0.01$ ).

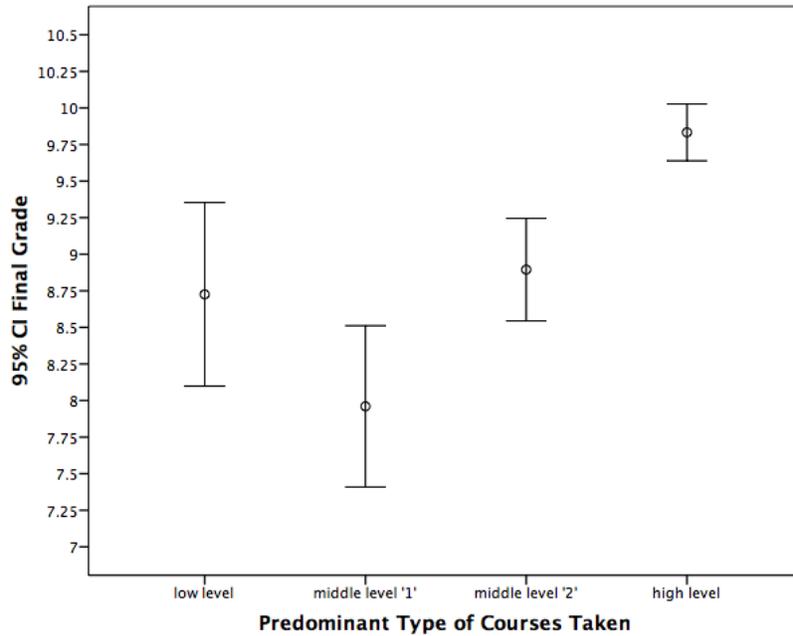


Figure 2. *Final First-Year Course Grade by Predominant Type of High School Science Coursework Completed.*

The graph of mean grade corresponding to each of the four levels of number of semesters illustrates the significant main effect of number of semesters is associated primarily with the 8 or more semesters resulting in higher final grades (Figure 3). Comparing the means for students taking 8 or more semesters with the mean for all other students collectively, the effect is significant statistically ( $t=-5.61$ ,  $df=853$ ,  $p \leq 0.01$ ).

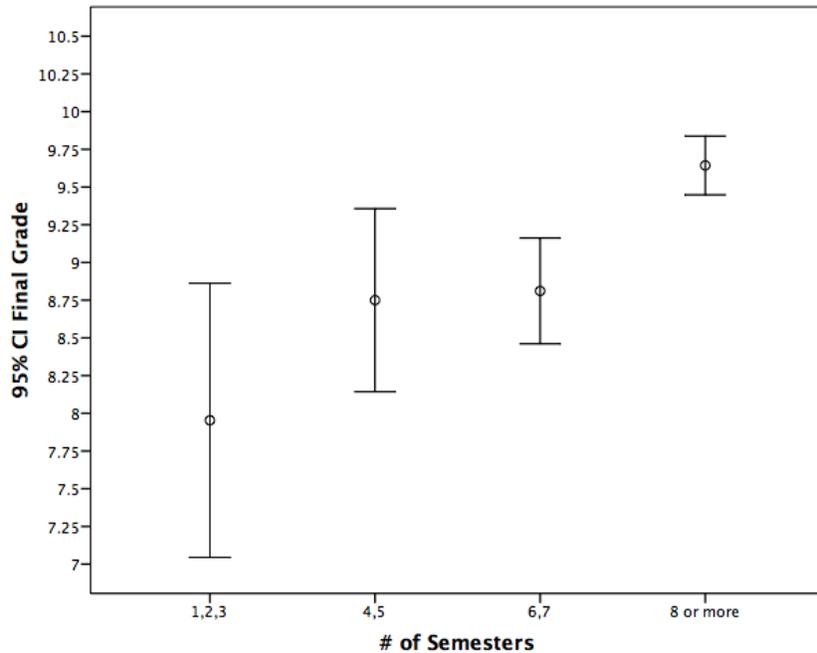


Figure 3. *Final First-Year Course Grade by Predominant Number of Semesters of High School Science Coursework Completed.*

### Summary

Taking more semesters of science coursework has a positive effect on final course grade. Students who took more semesters of science coursework in high school earned a higher final course grade, while decreasing the standard of error. Although the average final letter grade earned was the same for students who took three or fewer semesters of science coursework and those who took four or five semesters, a more complete picture can be obtained by observing the lower and upper 95% confidence bounds, as observed in Table 9. The lower bound grade for the former group of students was a 6.63 (approximately a C), while the lower bound for the latter group was a 7.33 (C+). The upper bound for both groups was an 8.57 and 8.52 respectively (B in both groups). The smaller confidence interval illustrates the difference in the mean final course grades within these two groups of students. The low sample size for students who took three or

fewer semesters of science coursework (n=49), however, also makes it difficult to make confident comparisons to the sample of students who took four or five semesters of science coursework (n=91).

Similarly, although students who reported taking six or seven semesters of science courses earned the same average grade as those students who reported taking 8 or more semesters, there was a wider confidence interval in the scores for the former group than for the latter. One confounding variable in this particular area of the study are those students who reported taking three or fewer semesters of science coursework. The possible implications of confounds are noteworthy with respect to interpreting the results, and are further explored in the Discussion chapter.

Students who took higher level science coursework in high school earned a higher final course grade, while decreasing the standard of error. Students who took predominately low level courses had an average final letter of a B-. Students who took predominantly middle level 1 courses also had a mean final grade of a B-, although the numeric average was actually lower than that of the previous group. This can be attributed to the upper and lower bound confidence intervals for each of the groups. Students who took predominantly low level coursework had a lower bound of a 7.01 (C+), as did those students who had taken predominantly middle level 1 coursework, with a 7.09. The former group had an upper bound of an 8.95 (a B), however, while the latter group had an upper bound of an 8.15 (a B-), despite having a much lower standard error. Those students who reported taking predominantly middle level 2 coursework also had a mean final grade of an 8.35 (a B), but there was a lower standard error in the scores. The lower bound was a 7.91 (a B-), while the upper bound was an 8.78 (a B+). Those students

who took predominantly high level coursework had a mean final grade of a 9.43 (a B). This group had the smallest standard error (.18). The lower bound of the confidence interval was a 9.08 (a B) and an upper bound of a 9.78 (a B+).

## CHAPTER IV

### DISCUSSION

The focus of this study examined what relation, if any, exists between the number of semesters and type of chemistry coursework that students take in high school and their performance in college. Is college performance related to the number of courses that students take in high school and to the types of courses that students take? Does the effect of one independent depend on the other independent variable interact? In this study, the hypothesis that there is a relation between the college performance and the type of coursework or number of semesters taken in high school is supported based on the data set used and the findings presented here.

The results of this study indicate that the main effect of type and the main effect of number of semesters are both significant statistically. Taking more semesters of science in high school is positively associated with the final grade in first-year college chemistry. Also, taking higher level science coursework in high school is positively associated with final grade. There are several reasons that the relations between number of semesters of science coursework and final course grade, as well as between the type of high school coursework predominantly taken by students and final course grade might exist. One reason may be the increased exposure to scientific processes and information. Laboratory and investigative procedures that contribute to critical thinking and problem solving skills are a significant aspect of all science courses, and are taught regardless of the specific science content taught in each course. Webb (1999) articulates four depth-of-knowledge levels within science and mathematics that addresses the ability of students to

successfully complete assessment activities. The first level is that of ‘Recall’, the ability to recall a fact, procedure or to apply a simple formula, while level two was that of ‘Skill or Concept’, and required students to make decisions about how to approach a problem or activity. Levels four and five, according to Webb (1999), include ‘Strategic Thinking’ and ‘Extended Thinking’, and require students to reason and plan using a higher level of thinking, solving complex problems, often over a long period of time. Students who take more science coursework are have increased opportunities to develop these skills, while those students who take higher level coursework are expected to develop those skills at a deeper or more sophisticated level, which would be consistent with the results of this study. Several studies report that these critical-thinking skills are positively associated with success in both post-secondary education institutions and in the workforce (Achieve 2004, Cassner-Lotto & Wright 2006, Conley 2007).

The results of this study indicate that students who have greater exposure to scientific information, as measured by number of high school semesters in which chemistry courses were completed may be better prepared to successfully complete college chemistry coursework. It is important not to overlook the simple fact that, in order to be successful in college chemistry, students must be able to demonstrate knowledge of the course content. Introductory college chemistry courses are often ‘gateway’ courses, which convey content knowledge that students need to master in order to find success in later college science courses. In this context, first-year college chemistry may not necessarily cultivate critical thinking skills, but serve as a type of ‘sorting’ mechanism by exposing students to content at the pacing and level of rigor expected of prospective STEM majors. Conley & Bowers’ (2008) study found that

college science courses are teaching many key content topics as though it was new material, despite the fact that the same content is taught in high school courses. In a previous study, Tai, Sadler, & Ward (2006) found that students who had a strong background in chemistry content- specifically in the area of stoichiometry- were likely to have higher grades at the end of first-year college chemistry. Based on the findings of these researchers and the results of this study, it is a reasonable hypothesis that students who take more science coursework have more exposure to chemistry concepts within a variety of contexts, while those students who take higher level coursework are exposed to a deeper level of content knowledge, thus increasing the likelihood of success in first-year college chemistry.

In addition, this study finds a direct link between high school course-taking patterns and subsequent performance in college chemistry, supporting other studies that have examined this subject indirectly (Allen & Sconing, 2005, ACT, 2006b). According to the results of this study, high school students increase their likelihood of being successful in chemistry if they take a high number of science courses, but can compensate for this if taking fewer, higher level science coursework. This may be due to increased understanding of the scientific information and processes mentioned previously. Students who take higher level of science coursework are exposed to a deeper level of content knowledge and critical thinking skills, and may learn this information after taking fewer courses.

Another possible reason for the results obtained in this study may be students' personal motivation. The higher level courses taken, or the increased number of science courses taken may be an indicator of a higher level of interest in science, perseverance, or

personal motivation on the part of the students. It is also possible that family expectations and support may influence students' motivations to be successful in science coursework. Students whose families expect them to pursue careers in STEM fields may have additional motivations to take more science courses, or higher level science coursework in high school, as well as to be successful in college courses. This study did not include information on student motivation, which might be an area of further research. It should be noted that additional studies on an extensive array of relevant variables in this data set, including performance, instructional, motivational, attitudinal and affective factors, is being conducted as part of the larger National Science Foundation study (Scalise, K. et al., 2007; Scalise, K., et al.2010). Connecting the results of this study with published studies that specifically examine student motivation within the area of science may be able to provide a more comprehensive picture of student course-taking patterns, as well as the implications for student success in college science courses. Such information may also help colleges identify students who are most at-risk of not-completing science courses, thus aiding in reducing the attrition of STEM majors.

The interaction of type by number of semesters was not found to be significant statistically. While the group of students who took more semesters of higher level science coursework completed freshman college chemistry with higher grades than their peers, the results of this study indicate that taking more semesters of higher level science coursework does not increase the likelihood of doing well in college chemistry, beyond the main effects, as there is no observable additional significant influence on final grade in chemistry.

This lack of interaction effect is interesting, as it could be hypothesized that if there is a relation between each independent variable (type of course and number of semesters) on final course grade, then an interaction would be present. As mentioned previously, student exposure to critical thinking skills and scientific processes, as well as exposure to important scientific content, may explain the main effects of number of frequency. It is possible that no interaction effect is observed because the critical thinking skills needed for both content and processes are equivalent. Once students have attained a certain level of skill, the likelihood of success does not increase with additional coursework. Students may attain that skill through sufficient numbers of coursework or by taking high level coursework, but after that, there is no additive benefit to taking more courses of higher type. Another possible explanation for the lack of interaction effect may be due to the sample distribution. Of the 869 participants in this study, 337 (~39%) took eight or more semesters of science coursework and predominantly high level courses. The unbalanced distribution of the participants may be masking an interaction effect.

Another interesting finding in this study was the performance of students who took predominately low level courses, but also took more semesters of science coursework. Students who took six or seven of semesters of predominantly low level coursework earned a mean final grade of 8.73 ( equivalent to a letter grade B), while students who took eight or more semesters of those same type of courses earned a mean final grade of 9.19 (equivalent to a B). Both of these groups of students outperformed those students who took a 3 or fewer semesters of higher level coursework, who attained a mean final grade of 8.61 (a B). Although this difference was not statistically significant, it does, however, merit closer examination.

As illustrated in figure 1, there is a general dip in performance among all students who took predominantly middle level 2 coursework, regardless of the numbers of semesters. A possible explanation for this may be the classifications of the courses included in each type category. This study organized coursework into type based on the work of Burkam & Lee (1997), Planty et al. (2007), and Teitelbaum (2003). Lower Level coursework included courses such as integrated science, biology, environmental science, or earth science. Middle level 1 coursework included chemistry and physics. The results of this study seem to indicate that classifying these courses as ‘low level’ may be inaccurate. It may be that physical science, earth science, and integrated science courses, often labeled as conceptual courses, are more rigorous than commonly thought. Although this is but one study, it adds to the literature base examining the factors that will best prepare students to be successful in the transition from high school to college. As states look to strengthen graduation requirements and provide college- and work-ready high school graduates, this study helps to highlight course-taking patterns that may lead to a higher likelihood of success in college chemistry.

By extension, students who find success in first-year STEM courses, such as chemistry, may persist in degree attainment in these fields. Approximately 30% of students who entered college with aspirations of attaining a degree in a STEM field attained that degree within 4 years (HERI, 2010). Eagan, Hurtado, & Chang (2010) found that prior academic preparation represented one of the strongest predictors of STEM students’ likelihood to complete a degree in STEM. Identifying course-taking patterns that provide such preparation in high school may improve student persistence beyond first year science courses.

The results of this study indicate the type of coursework and numbers of courses taken each have a significant positive association with final course grade. Though there are significant main effects, the effect size eta-square is small. Type of course predicts approximately 4% of the variance, while number of semesters predicts approximately 3% of the variance. It is important to note the lack of balanced sampling design, i.e., disproportionate numbers of students in each number of semesters by type of course classification group. Fewer students in this sample took lower level coursework and fewer semesters than the number of students who took higher level coursework and more semesters. Due to a relatively large sample, statistically significant effects were obtained, even though that effect is proportionally small. Graphic illustration of the group means and 95% standard error bands indicate that the main effects are associated primarily with one group differing from the others, rather than any pairwise group differences.

In this study, the significant relation found in the main effect of type and the main effect of number of semesters and final course grade is observed in the numerical values assigned. In several instances, even though there is a statistical significance between the numerical values, it results in the same letter grade. This raises an important question. Are the effects significant practically if the letter grade does not actually change as a function of the independent variable? Does this effect have a meaningful impact? Due to the method of coding, letter grades were assigned a number on a 1-point scale. This resulted in a letter grade of a C+ being assigned a value of seven, B- assigned a value of eight, and a B assigned a value of nine. As was discussed in the Results chapter, Students who took three or fewer semesters of high school science earned an average final grade of a B- , with a numerical value of 7.60. Students who reported taking four or five

semesters of science coursework also earned an average final grade of a B-, with a numerical value of 7.93. Students taking six or seven semesters of science coursework earned an average final grade of an 8.62, which is equal approximately to a letter grade of B, as did those students who reported taking eight or more semesters of science coursework (9.23). The mean numerical score was assigned a letter grade by rounding to the nearest whole number, even though the mean values varied greatly.

Rescaling the letter grade to a numerical scale for analyses does not necessarily invalidate the results, but does indicate the need to interpret the results cautiously. With a larger, more heterogeneous sample, the main effects may be amplified, and this there will be a more observable effect in the final letter grade earned in the course. Likewise, it may also be possible to better observe the main effects by utilizing a regression analysis and examining the raw points total rather than the letter grades for the study participants for a possible association with course type and frequency. The full point totals for participants were not available in this released data set; however, it should be noted that significant limitations would also be present utilizing such a methodology. It is a common practice to observe the practice of ‘curving grades’ in classrooms, at both the high school and college level, which could result in point totals indicating the presence of a main effect, although participants may not have earned credit in the course. The focus of this study is to determine if there is a relation between course type and frequency and performance in first year college chemistry, and performance is most commonly indicated by earning course chemistry. This supports the definitions of college readiness that include the successful completion of credit-bearing college courses (Conley, 2007).

To better analyze the main effects in this study, it may have been more beneficial if the numerical values were assigned to letter grades in closer approximation to realistic differences (a C+ was approximately a 65%, a B- was approximately a 70%, and a B averaged a 75%). Another possible numerical scaling of the letter grades would be to assign values of a 6.5 for a C+, a 7.0 for a B-, and a 7.5 for a B. It is possible that this may reduce errors in rounding numerical values to respective letter grades. It may also be a viable option to use percentages as the numerical values in statistical analyses, although this is not recommended; as mentioned previously, it is the final grade that is reported on college transcripts, and thus the value that must remain the focus of investigation, rather than the percentage values.

In this study, a significant relation between performance in college chemistry and higher level coursework was found. AP courses are more closely aligned across state and national level, and the curriculum is set by the College Board. The recent AP course audit conducted helps to ensure fidelity to the curriculum by high schools across the nation. This study included International Baccalaureate (IB) coursework as advanced coursework, which also includes an internationally aligned curriculum (International Baccalaureate). In addition, the results of this study support the published literature linking advanced coursework completion to college readiness (Achieve 2004, ACT 2006b; College Board 2010). The results of this study reinforce the relation found by Allen & Sconing's 2005 study linking the ACT science test to success in first-year college science courses, and adds to their report that studied this effect on first year college Biology. Although there is limited literature in this field, the literature that does exist supports the hypothesis that an aligned curriculum series of advanced coursework,

such as Advanced Placement courses, has a positive influence on preparedness for college coursework, as do the results of this study.

Despite the lack of alignment of science curriculum across the district, state, and national levels for this data set overall, a statistical significance association was found between the type of coursework taken and the final grade in chemistry. Labeling a course as 'Chemistry' on a transcript provides little information regarding the rigor of the course expectations, the breadth of content covered, nor does it indicate the depth to which content is covered. Without an analysis of course syllabi, it is difficult to discern the level of variability in student experiences within a science course. However, this study supports- at least for this data set- that those creating and instructing these courses are bringing about student outcomes positively associated with college success, in this context and based on this data set.

Several publications in recent years have argued for more course alignment, both at the state level as well as the national level (Achieve, 2004; ACT, 2007; American Diploma Project, 2004; Conley, 2007). This study appears to find a significant relation between success in college chemistry and high school coursework without such curriculum alignment, but does not explore the differences that might be made by more or less alignment in policies and practices. Even with published science standards adopted by at the state level, material covered in a standard chemistry course can vary significantly in depth and breadth of content between districts, schools, and even between teachers in the same building. This suggests implications for future research, as performance associated with curriculum alignment are out of the scope of this study.

One confounding variable in this particular area of the study are those students who reported taking three or fewer semesters of science coursework. While the University of California, Berkeley admissions process does not specify the number of science credits, the selective nature of the university raises questions regarding those students with low number of science coursework. There are a few possible explanations, however, for these students. First, UC Berkeley admissions office completes a comprehensive evaluation of all candidates. It may be that the strength of these students portfolio was such that meeting the minimum requirements of credits earned in science was sufficient for the student to be admitted, given other strengths and also the goals of the student, which may not have been a science major.

Another reason that students may have reported so few science courses could be the difference between semesters of coursework and credits earned. The state of California, the state from which most students in the study came, requires two credits of science coursework to graduate. Credit may have been earned after only one semester of class, depending on the school schedules. A final reason that students may have reported three or fewer semesters of science is that the survey question asked, “How many semesters of science courses, total, did you take in high school?” Some students may have interpreted this question to exclude any courses taken in an alternative environment, such as at a local community college.

Future research in this area could improve on this study by further clarifying survey questions to determine the number of science classes taken before entering first-year college chemistry courses at four-year institutions. A thorough transcript analysis of

participants in similar studies might also yield a more comprehensive profile of student course-taking patterns, strengthening the research in this field of study.

### **Limitations**

The lack of random assignment in the quasi-experimental design of this study, which used self-report data for the course frequency and type introduces many possible confounds. Clearly, self-report data may be unreliable or have unknown bias. The limitation is not so much in the nature of the positive association found, at least for this data set, but rather in interpreting the results, such as considering whether that association could be not only predictive but considered in any way attributable to the instructional interventions themselves, for instance for policy-making decisions on credit requirements.

Uncontrolled high school level and student level variables may have substantially influenced the results of this study, in non-construct relevant ways. For instance, students taking higher levels of coursework may be from high schools surrounded by relatively high socio-economic conditions. If this exists, then those students who take higher level coursework may also be exposed to additional widely recognized systems that lead to college readiness factors, such as smaller class sizes and more supportive home conditions. Student demographics, such as gender and ethnicity, whose impact on college success has been studied by other researchers (HERI 2010, Horn, Kojasku, & Carroll 2001, OUS 2003, Seastrom, et al 2007, Tie, Sadler, & Loehr 2005), may also confound the results. The participant's state of graduation may impact the results of this study, with varying graduation requirements, state curriculum standards, and the teacher experiences.

In this study, there was a large difference in the sample sizes of the different categories. This violation of equal sample sizes may result in a differential weight to the variable categories, which could have resulted in a type 1 error. In this case, that would result in this study indicating relations between the type of high school science coursework and final course grade, and between the number of semesters of high school science courses and final course grade when, in fact, there is no relation. If this study were to be repeated, balanced sample sizes would help to reduce this source of error.

There may be other methodological weaknesses in the sampling procedures, as described previously, or in coding the variables. It is also possible that there were validity issues in measurement, to do with the collection and interpretation of the information, such as the balance of point-awarding in the various examinations and assignments, and of course the self-report data on the independent variables for students as has been described. Future research may benefit from utilizing a mixed methods design, using qualitative procedures to provide a more thorough explanation of obtained effects. The qualitative research could study the student, the school, or even both.

The question can be raised examining if the results observed in this study generalize beyond the “elite” group of students such as those found at Berkeley. Would the same or possibly larger effect be obtained at another university with a more heterogeneous population? If this study were broadened to include a more heterogeneous sample with respect to high school course-taking patterns, an area of future implications to explore is whether this effect would still be observed, or even perhaps be substantially amplified. This, however, is outside of the scope of the current study to consider.

## **Implications**

The results in this study may help support policy decisions made regarding state graduation requirements. As each state examines current graduation requirements, or looks to create more rigorous requirements, the results of this study seem to indicate that, at least within the area of science coursework, two plausible options include; increase the number of science courses students are required to take to graduate, and specify the types of science courses that students must take in order to graduate. Both policy decisions carry significant financial implications. If states increase the number of science credits that students must take, as Oregon recently has done, then states need to consider the cost of increasing the number of science teachers within schools, as well as providing increased resources such as textbooks and laboratory materials.

Given the recent economic downturn across the nation, this may not be fiscally possible. However, if states mandate the type of science coursework students need to take in order to graduate- specifically higher level coursework- then schools must ensure that there are sufficient numbers of teachers qualified to teach those high level courses. Under NCLB mandates, schools must provide highly qualified teachers in content areas, or notify parents when a class is taught by a teacher who is not highly qualified in the subject area (U.S. Department of Education, 2002). Of course, well qualified teachers have been shown to be an important part of student learning outcomes.

Instead of specifying type of coursework students must have to graduate, states may opt to change the content standards in science curriculum. Increasing the rigor of the curriculum standards may reduce the numbers of lower level courses students take by

changing the content of those courses, although taking fewer lower level courses was *not* associated with a positive outcome in this study, based on considering the interaction effect. However, future studies might consider how aligning curriculum across states, such as through a mechanism like that of AP or IB courses, may also increase rigor at a more consistent level, providing a more consistent experience for students at a national level. If increased rigor of content standards is accompanied by the measures to ensure fidelity across the state, states may also be able to reduce variability among classrooms across between and within districts and schools.

In conclusion, this study observed a positive association between student course taking patterns in high school and performance in first-year college chemistry. Taking more semesters of science is positively associated with higher grades at the conclusion of the course. Taking higher level coursework is also positively associated with higher grades. Although further research is needed, the results of this study could have implications for the development of graduation requirements that will improve the likelihood that student will graduate from high school with the career and college readiness skills needed for success in their post-high school pursuits.

## APPENDIX

### CIRCUMSTANCES SURVEY FALL 2009

#### Circumstances Survey Fall '09

##### 1. Consent

###### 1. Consent/Assent Information for Students

Dear Student:

We would like to invite you to participate in our research study. As part of a research project being conducted with the Chemistry Education group at The University of California at Berkeley, some of the materials used in your chemistry class this year are being evaluated. The intent of the research project is to determine how best to help students understand, apply and retain chemistry concepts. Along with this, a variety of possible circumstances affecting students' performance are being evaluated. Researchers from the College of Chemistry, Michelle Sinapuelas, and Sandhya Rao, under Professor Angelica Stacy will conduct the study.

If you agree to participate in this study, you will be asked to complete a short survey including questions about your background and factors affecting your performance. In addition you are allowing the researchers access to materials you submit as part of the course (assessments, homework, etc.). The assessments will be administered in a variety of formats. Your work will be collected by your instructor and reviewed by members of the Chemistry Education group at UC Berkeley. This is not extra class work, but only material that all students will complete regardless of whether or not they allow their papers to be used in the evaluation. Only students who consent/assent to be included in the study will be included in the evaluation.

Along with materials collected as part of the course routine, we would like to interview some students individually and in pairs about their experiences in the course and thoughts about the content and assessment items. Some interviews may also be used in evaluating students understanding of the material. These interviews will be conducted on the UC Berkeley campus and may be video or audio taped. Interviews will take approximately one hour each. In addition if you give added consent/assent, researchers may video tape you while you participate in normal course activities(i.e. discussion section or lecture). Taping of course activities will not exceed

## Circumstances Survey Fall '09

four hours per student. Capturing your responses on video will allow researchers to perform a more complete analysis since it provides a real time record.

All materials reviewed for project research will be coded to student names and kept confidential. The key code to names will be stored in a separate locked location. They will be used by the University of California only for evaluation of the materials used to assess chemistry learning. No student names or identifying information will be used in any research reports. As with all research, there is a chance that confidentiality could be compromised; however, we are taking precautions to minimize this risk. The data collected will be retained for approximately four years after the completion of the research project. Your participation in this research is voluntary. You are free to refuse to take part, and you may stop taking part at anytime. Participation will have no bearing on standing in the class or school. While there is no direct benefit to the student from this research, we hope the research will benefit society by improving how students learn about science.

If you have any questions about this project, please call Sandhya Rao or Michelle Shaver Sinapuelas at (510) 642-3990. If you choose to take part in this research, please click yes below. Please feel free to request a second copy of this letter for your own use. Thank you for your participation.

If you have any questions about your rights or treatment as a participant in this research project, please contact the University of California at Berkeley's Committee for Protection of Human Subjects at (510) 642-7461, or e-mail: [subjects@berkeley.edu](mailto:subjects@berkeley.edu).

**I have read this consent/assent form and agree to take part in the following aspects of the research (please select all that apply):**

- I agree to have my course materials, communications through the bSpace website or emails, and survey responses collected
- I agree to participate in group observations during class time
- I agree to participate in interviews or focus groups

## Circumstances Survey Fall '09

**2. If you are willing to be contacted for participation in interviews please include the email address that is best to contact you through.**

\_\_\_\_\_

**3. Are you 18 years of age or older?**

Yes

No

## Circumstances Survey Fall '09

2.

### 1. Please rate the following statements based on your opinions:

	strongly disagree	somewhat disagree	somewhat agree	strongly agree
I like studying chemistry because it is fact based	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I do well in math and science courses	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I have friends in this class	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I am more interested in learning chemistry than in the grade I earn	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
There are times, in high school or college, when I have asked my parents for help with my schoolwork	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Chemistry material does not come naturally to me	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I have to work much harder than my peers to do well	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Knowing math is the secret to success in a chemistry course	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ultimately the only thing that really counts is your final grade	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
My friends believe in me	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
To be successful at chemistry, hard work is much more important than inborn natural ability	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I am only taking chemistry because it is required	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
There is more than one correct way to think about concepts in chemistry	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
My parents do not care how well I do in school	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Science is about searching for the right answers	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I will let my family down if I do not do well in this course	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Chemistry concepts are not that relevant to the real world	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I will do more than the minimum amount of work I need to do, to get by	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Chemistry does not always have one right answer to every problem	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I expect to get an A in this class	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I do not have a great network of support	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Someone in my family is always there for me	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I will work as hard as I need to get an A in this class	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I do not have anyone to call when I am frustrated or overwhelmed with school	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I just need to do enough work to pass this class	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I already have a good understanding of chemistry from previous courses I have taken	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
My parents encourage and push me to do well in school	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I am not very good at Chemistry	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I have people I can call for help when I have questions about chemistry	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

## Circumstances Survey Fall '09

When learning chemistry, I focus more on understanding the underlying theory than memorizing facts	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
My family understands the struggles of studying science in college	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I can get an A in this class	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Science is not just facts to memorize independently, they relate to each other	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
My friends understand the struggles of studying science in college	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
My parents are proud that I am at UC Berkeley	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Science is just a lot of facts that you need to memorize	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

## Circumstances Survey Fall '09

3.

**1. Students have a variety of circumstances that either help or hinder their performance in class. These can be related to how the course is structured or other life factors (for example family, friends, other commitments).**

**Below, please indicate what are the top 3 circumstances that are hindering your performance in Chem 1A. If none of these apply to you, please indicate "none of these" and then fill in your own response in the text box below.**

	Most influential factor	Second factor	Third factor
Factors:	<input type="text"/>	<input type="text"/>	<input type="text"/>
Other (please specify)	<input type="text"/>		

**2. What grade do you need to get in this course to feel successful?**

- A
- B
- C
- D
- F
- Pass

**3. Which would best describe where you live?**

- the dorms
- at home with family
- in apartment with roommates
- in apartment or studio, single occupancy
- co-op
- Fraternity/Sorority

## Circumstances Survey Fall '09

### 4. If you have a job, how many hours per week do you work?

- less than 10
- 10-20
- 20-30
- 30-40
- more than 40
- I do not have a job

### 5. Did you transfer to UC Berkeley from another college or university?

- Yes
- No

### 6. What is your intended major?

- Life Science/Biology
- Engineering
- Physical Science
- Mathematics
- Humanities
- Undeclared
- Other

### 7. How many semesters of science courses, total, did you take in high school?

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- More than 8

## Circumstances Survey Fall '09

### 8. Which science courses have you taken in the past? (check all that apply)

- Integrated Science
- Environmental Science
- Earth Science
- Biology
- Honors Biology
- AP Biology
- Chemistry
- Honors Chemistry
- AP Chemistry
- Physics
- Honors Physics
- AP Physics
- IB Science

Other (please specify)

### 9. How many semesters of chemistry have you completed previously, in high school and college together?

- 1
- 2
- 3
- 4
- more than 4
- I have never taken Chemistry

## Circumstances Survey Fall '09

**10. Prior to taking Chem 1A, what was your final grade in the last chemistry class you took?**

- A
- B
- C
- D
- F
- Pass
- No Pass
- I had never taken chemistry

**11. What was the last mathematics course you took?**

- Algebra
- Geometry
- Algebra II
- Pre-Calc
- Trigonometry
- AP Calculus
- College Calculus
- Other AP or advanced math

**12. What was your final grade in the last mathematics course you took?**

- A
- B
- C
- D
- F
- Pass
- No Pass

## Circumstances Survey Fall '09

### 13. What was your SAT score? (leave blank if you did not take SAT)

Writing

Mathematics

Critical Reasoning

### 14. What High School did you graduate from?

Name

City

State

### 15. Which of the following best describes your socio-economic class when you were growing up?

- Wealthy
- Upper-middle or professional-middle
- Middle-class
- Working-class
- Low-income or poor
- Decline to state

### 16. What is the highest level of education you plan to eventually complete?

- Bachelor's degree
- Master's degree
- Medical degree
- Professional degree (other than medical)
- Doctorate (Ph.D.)

## Circumstances Survey Fall '09

### 17. What is the highest level of education your father completed?

- did not complete high school
- high school degree
- some college
- two-year degree
- four-year degree
- some graduate school
- graduate degree
- not sure

### 18. What is the highest level of education your mother completed?

- did not complete high school
- high school degree
- some college
- two-year degree
- four-year degree
- some graduate school
- graduate degree
- not sure

### 19. Are you the first in your family to major in science?

- Yes
- No

### 20. Are you the first in your family to go to college?

- Yes
- No

## Circumstances Survey Fall '09

### 21. What is your ethnic category? (mark all that apply)

- American Indian/Alaska Native
- Chinese/Chinese American
- East Indian/Pakistani
- Japanese/Japanese-American
- Korean/Korean-American
- Filipino/Filipino-American
- Pacific Islander
- South East Asian
- Other Asian
- African-American/Black
- Mexican/Mexican American/Chicano
- Spanish-American/Latino/Latina
- Middle Eastern
- White
- International Student
- Decline to state

Other (please specify)

---

## Circumstances Survey Fall '09

**22. Of the ethnic categories below, which do you self-identify with most?  
(pick one)**

- American Indian/Alaska Native
- Chinese/Chinese American
- East Indian/Pakistani
- Japanese/Japanese-American
- Korean/Korean-American
- Filipino/Filipino-American
- Pacific Islander
- South East Asian
- Other Asian
- African-American/Black
- Mexican/Mexican American/Chicano
- Spanish-American/Latino/Latina
- Middle Eastern
- White
- Mixed Race
- International Student
- Decline to state

**23. What is your first language?**

- English
- Spanish
- Cantonese
- Mandarin
- Vietnamese
- Korean
- Filipino

Other (please specify)

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## Circumstances Survey Fall '09

### 24. What is your gender?

- Male
- Female
- Transgender
- Decline to state

## Circumstances Survey Fall '09

### 4. SID

**1. We appreciate your feedback and ask for your student ID to verify your enrollment in the course. We will not use your student ID to track individual responses. Before this data is used, or any staff see it, your Student ID will be removed. Thank you for your participation.**

CAL SID

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