



The Impact of Supplemental Instruction on the Performance of Male and Female Engineers in a Freshmen Chemistry Course

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Abstract

This study investigates the connection between the use of supplemental instruction (SI) by engineering students and their performance in a required first year general chemistry course. SI includes group and one-on-one peer tutoring as well as instructor and teaching assistant office hours. Previous research has shown that participation in SI correlates with higher course grades, more confidence in course material, greater material retention, higher overall GPA, and greater student retention and graduation rates.^[1] Engaging students in SI, however, has been a persistent challenge. For example, a previous study found only 40% of students enrolled in historically difficult classes (including general chemistry) took advantage of the SI provided. This study found participants in SI were more likely to have a final course grade of B or better and less likely to withdraw from the class.^[2]

Last year we conducted a study comparing the performance of students who did and did not use available forms of SI and correlated performance outcomes with factors deterring students from using the offered forms of SI. Our focus this year is to identify statistically significant trends in our data from this year's and last year's classes and assess the impact of level of participation in SI on student self-efficacy and attitude towards SI for freshmen enrolled in a required general chemistry course.

To understand a student's choice to participate in SI and to determine correlations with course assessments and grades, students enrolled in a required general chemistry course were surveyed at the beginning and at the end of the semester. This year (fall 2014) 524 students participated in the pre-survey, a response rate of 89%. Last year (fall 2013) 417 students participated in the pre-survey, a response rate of 88%. The gender distribution was 28% females (fall 2014) and 32% females (fall 2013), which has a slightly higher percentage of females than the distribution of first year students in the College of Engineering (COE) at Northeastern University.

Our previous studies suggested female students had a higher "trigger point" (*i.e.*, grade at which they decided to seek out SI) than males upon entering college. These studies also examined the benefits of class attendance and the correlation between use of SI and increased course grade. Based on statistical analysis of this year's data, these hypotheses remain robust, with a generally increased confidence level in these hypotheses.

Our current study builds on our previous ones by collecting another year of data (which coincides with increased enrollment of over 100 students). This study also applies more rigorous statistical methods to distinguish trends in both the current year's data (fall 2014) and last year's data (fall 2013). Our ultimate goal is to use this study focused on a general chemistry class as a model for identifying how to improve the engagement and efficacy of SI for freshman engineering students and to address any issues related to gender differences.

Background

This paper is a continuation of last year's work, titled "Correlating Freshman Engineers' Performance in a General Chemistry Course to Their Use of Supplemental Instruction." The overall focus of this year's paper is identifying statistically significant trends within and between last year's data and this year's data. We specifically are focusing on the correlation between the performance of freshman engineering students and their use of supplemental instruction (SI) in a required general chemistry course. General chemistry is a common course taken by first year engineering students during their first semester at Northeastern University. Previous studies conducted have shown that the majority of such students have had at least one, if not more than one, year of chemistry in high school. In addition, it has been found that students who choose not to go on to major in chemical engineering form strong opinions regarding the difficulty and utility of further study in chemistry. Retaining these students in engineering during the freshman year is a major priority. Successful programs designed to support these students should have potential impact beyond just courses in general chemistry for engineers. These impacts include developing freshman skills in time management, studying at the college level, and developing problem solving skills necessary for subsequent success in their college studies towards a bachelor's in an engineering discipline.

Supplemental Instruction and Course Success

SI is a common instructional technique used at many universities to help freshmen and upper-classmen succeed in challenging college courses. SI can consist of peer tutoring, instructor office hours, review sessions, study groups, or any combination of these. Students who use SI have been shown to earn higher term and cumulative grade point averages (GPA's) as well as more timely graduation rates than their peers who do not utilize SI.^{[3] [4] [5]} It also has been shown that there is a statistically significant correlation between higher term GPA's and more time spent in SI.^{[2] [6]}

"The U.S. Department of Education has designated SI as an Exemplary Educational Practice and has validated the following three research findings:

- Students participating in SI within the targeted historically difficult courses earn higher mean final course grades than students who do not participate in SI. This is still true when differences are analyzed, despite ethnicity and prior academic achievement.
- Despite prior academic achievement, students participating in SI within targeted historically difficult courses succeed at a higher rate (withdraw at a lower rate and receive a lower percentage of D or F final course grades) than those who do not participate in SI.
- Students participating in SI persist at the institution (reenrolling and graduating) at higher rates than students who do not participate in SI."^[7]

In addition, studies have shown that highly motivated students have considerably higher final course grades and fewer D grades, F grades and withdrawals on average than unmotivated students.^[2] Moreover, it has been found that less-easily measured factors, such as long-term retention of course information, teamwork, communication skills, and information processing skills, are improved when students engage in SI.^[3] A study conducted at Lund University in

Sweden on an introductory calculus course found that SI participants were more motivated to study and were better at working in groups. Students who took advantage of SI were also found to have a better attention span, could study for longer periods of time, were less dependent on “last minute” studying, and were more accustomed to being helped or helping other classmates understand difficult course work.^[1] These findings support a similar study that we conducted in the fall of 2013, which determined that students who not only found extra resources (recitation, on-line availability of materials, course textbook, and class handouts) provided by the instructor useful but also took advantage of these resources received a higher final grade in general chemistry.

Much research has been conducted worldwide to determine if SI participants in college earn higher course averages than non-participants in a variety of historically challenging courses, including chemistry, mathematics, physics, and biology. Almost all of these studies have statistically determined that SI participants earn a significantly higher percentage of A and B grades and overall higher final course grades than non SI participants. It also has been determined that SI participants earned a significantly lower percentage of D grades, F grades, and withdrawals.^{[2][8]} With so many positive outcomes resulting from the utilization of SI, it may be surprising that most of these studies found that only 40% of students enrolled in a course where SI was offered take advantage of it.^[2] *How does the use of SI vary between genders? Are there correlations between class attendance and grade earned? How do males and females differ in their patterns of attendance in class and SI? What specific factors or qualities lead students to engage in SI?* To address these research questions in the context of supporting freshmen enrolled in a required course in general chemistry, we have been evaluating the impact of utilization of different forms of SI on students’ performance in this course. Using statistical methods, our ultimate goal is to use this study, focused on a general chemistry class as a model, for designing strategies to improve the engagement and efficacy of SI for freshman engineering students.

In pursuit of identifying the specific variables that lead students to engage in SI, social research has isolated three major reasons why people do not ask for help when it might be needed: embarrassment, threat to self-esteem and reputation, and feelings of indebtedness. Students with low self-efficacy are more likely to believe that their help-seeking will indicate a lack of ability, which therefore reduces their likelihood of asking for help. A student with high self-efficacy does not worry that others will associate his/her failure with a lack of capability and, thus, is more likely to seek help. Thus, the students who most need the help do not ask for it due to an association with a negative response from the helper.^{[9][10][11]} It also has been shown that the time it takes a student to ask for help is significantly correlated with how many helpers are available (the more helpers available, the longer it takes a student to ask for help). This observation is supported by social impact theory, in that as social forces become stronger, the inhibiting impact of help seeking does too.^{[9][12]} Although most SI is targeted for weaker students, SI overwhelmingly is used by stronger students rather than weaker ones because of feelings of low self-efficacy.^[1]

Another focus for our study is which of the SI resources offered have the strongest correlation with student success and how programs in SI can be structured like these successful programs to promote best student retention and course success. While some studies suggest that there is no correlation between SI and increased retention and college graduation, other studies have found a

positive relationship between SI and these factors.^{[2][6][1]} W. David Tilley III, in his book titled Best Practices in School Psychology V, defined four key attributes that SI should have in order for it to be successful. He believes SI must be explicit, more intensive than core instruction, more supportive of the students, both emotionally and cognitively, and must include methods for student progress monitoring.^[19] Our study also examines which of the SI resources offered for this general chemistry course had the strongest correlation with student success, which will help us to better understand how to restructure other SI resources to better promote course success and retention.

Gender Differences in Use of SI

A longstanding goal of our research has been identifying how gender differences impact the use and effects of SI. The gender distribution in engineering is very skewed towards males at most universities and nationally. Enrollment in COE at Northeastern University has increased over the past few years, with a 19% increase in overall freshman class size from fall 2013 to fall 2014. The freshman class comprised of 28% women in the fall of 2013 and 26% in the fall of 2014. Fewer women enroll in engineering initially, and it has been shown that more women leave engineering in their freshman year of college to pursue other fields than men. Women who continue to study engineering beyond the first year, however, perform comparably to the men in their classes.^[13] Thus, it is a priority for schools to retain women in their first year engineering programs. At Northeastern University efforts have been ongoing to increase the numbers of women entering COE and to increase the effectiveness of programs to retain them through graduation.

Previous studies have found that males had more negative attitudes towards SI and were less likely to ask for help when needed than females, which can be attributed to females being viewed as dependent when asking for help.^[14] It also has been shown that women tend to ask more questions, thus they seek help more often than their male counterparts.^[10] These findings are supported by our previous research from the fall 2012 semester, when 76% of females and 60% of males used some form of SI, and from the fall 2013 semester, when 82% of females and 60% of males used some form of SI.^{[15][16]} Several studies indicate that females not only seem to have more positive attitudes, but are also more intrinsically interested in learning.^[17] In contrast, male freshmen feel a greater threat to their self-confidence if they require additional help to succeed and master course material. Although there are gender differences in attitudes towards SI, it has been reported that both male and female students benefit equally from SI.^[18] To explore such issues we previously have examined what “trigger points” led students to take advantage of resources available for SI and how these trigger points correlated with grades. In both the fall of 2012 and 2013 females on average sought out extra help when they had a grade of B. This threshold was lower than for males, who on average sought out extra help with a grade of C. In the fall of 2013, we were able to correlate course averages with “trigger” points. Overall, course averages were greater than many students’ trigger points. This outcome supports the hypothesis that students may not have sought SI when they expected to or when they had grades higher than their trigger points. Those students who did not use SI were succeeding in the course, receiving grades of B+ or better and, therefore, did not feel the need to seek extra help.^{[16][15]}

Study Context

Our studies have been conducted in the context of a General Chemistry for Engineers course that is required for all engineering students during the fall of their freshman year, unless a student enters the university with advanced standing (AP Chemistry credit, IB Chemistry credit, or transfer credit from another institution for an equivalent course). This course consisted of three required 65-minute lectures (of approximately 100 students) and one required 100-minute recitation (of approximately 20-40 students) per week. The lecture was given by a course instructor, and the recitations were led by graduate teaching assistants (TA's). The class was divided unequally into honors and non-honors sections, with students placed into the honors section if they were enrolled in the University Honors Program. Students gain admission to this program upon their admission to the university based on their high school credentials. Course grades were based on homework assignments, weekly quizzes, recitation attendance, three 65-minute in-semester exams, and a two-hour final exam.^[16]

A variety of resources for SI were offered, primarily for students in the non-honors section of the course. All respective SI sources were made known to enrolled students on the first day of class and emphasized by instructors and academic advisors throughout the semester. Instructors and TA's held weekly office hours outside of class during which attending students could ask specific questions and receive help one-on-one and in small groups. Students were offered a weekly "Connections Chemistry Review," a group review session run by three upper-class chemical engineering tutors. In 2013 these tutors were three females, but in 2014 these tutors were two females and one male. These reviews consisted of a reprise of key concepts and skills introduced in lecture each respective week as well as help with homework problems. Instructors held 60-90 minute review sessions before each exam as well. In addition, there were a variety of walk-in SI services available throughout the time of the course. Northeastern University's COE offered one-on-one help through the COE Tutoring Office staffed weekdays by graduate and upper-class undergraduate engineering students. Through the chemistry department, "Chem Central" was offered to students as a place to receive one-on-one and small group help on a walk-in basis from a chemistry professor and/or TA on weekdays. In addition, engineering students were encouraged to create study groups with peers taking the same course. All SI services were free of charge to freshman students taking this General Chemistry for Engineers course.^[16]

Methods

Data were gathered from two types of sources: (1) IRB approved surveys administered to students enrolled in General Chemistry for Engineers in the fall 2013 and 2014 semesters, and (2) information provided from the instructors regarding grades and attendance. The population for our study included all students enrolled in the course that provided feedback on the pair of surveys administered at the beginning and end of the semester. There are points that should be considered in regards to the population sampled. The students sampled were from a high level institution, with many students having taken an honors or AP level chemistry course in high school. Students who dropped the course or were not in attendance for administration of surveys were not included in the study. For subsequent statistical analysis letter grades assigned by instructors and letter grade thresholds for seeking SI self-reported by students were converted to

numerical values based on a scale of 0-4, with an “A” being a 4.0, a “B” a 3.0, a “C” a 2.0, a “D” a 1.0, and a “F” a 0, with + and - grades converted as fractional adjustments of 1/3 (e.g. B+ would be a 3.333, B- would be a 2.667). Attendance was recorded for Connections Reviews and the COE Tutoring Office but not for other forms of SI.

During the first meetings of recitation at the beginning of the semester, pre-surveys were administered to all sections. The purpose of the pre-survey (Appendix A) was to gather information from students about their expectations and experiences, their own performance, and use of SI in chemistry. During the final meetings of recitation at the end of the semester, post-surveys were administered to all sections. The purpose of the post survey (Appendix B) was to determine attitudes of the students toward outcomes of the course and their use or lack thereof of SI. Students’ ID numbers were used to organize data from pre- and post-surveys in order to connect expectations and outcomes with data supplied by instructors. This identification method allowed for confidentiality of information gathered from surveys and instructors.

A statistical analysis with the collected data from fall 2013 and fall 2014 was used to determine which variables (*i.e.*, final grades, gender, use of SI) were correlated statistically. Two types of tests were used to determine if relationships were statistically significant: a Pearson’s Product Correlation Analysis to determine if two variables (*e.g.*, final grade and trigger point for seeking SI) were linearly correlated, and a one-tailed Z-test to determine if there was a significant difference between means for a variable for two independent populations (*e.g.*, final grades for males and females).^[20] Unless otherwise stated statistical metrics for these two types of tests were compared with critical values for 95% significance.

Results and Discussion

Demographics of Students Studied

In 2013, a total of 417 students completed both the pre- and post-surveys out of an overall class of 474 students (an 88% response rate). In 2014, a total of 524 freshman engineering students completed both the pre- and post-surveys out of an overall class of 589 students (an 89% response rate). The demographics of the groups surveyed in both 2013 and 2014 are shown in Figure 1 and expanded upon in Table 1.

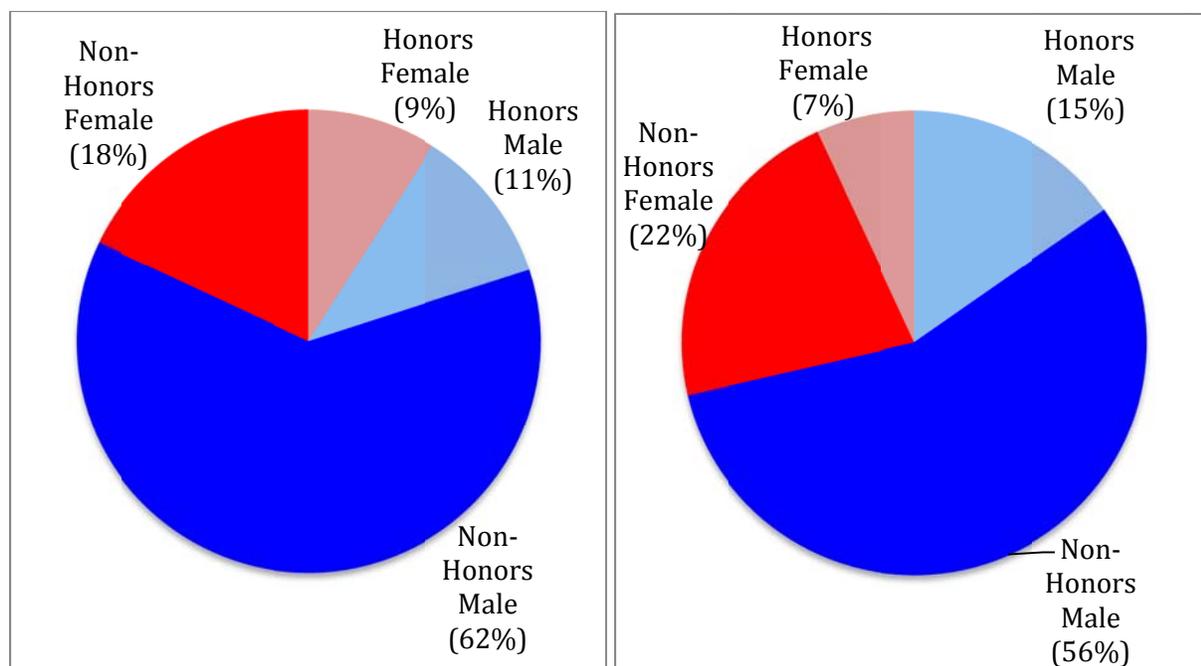


Figure 1: Demographics of students who participated in both the pre- and post-survey in fall 2013 (left) and fall 2014 (right).

Table 1: Expanded demographics of students in General Chemistry for Engineers in fall 2013 and fall 2014.

| Population | 2013 | | 2014 | |
|-------------------|-------------------|---------------------|-------------------|---------------------|
| | Students Enrolled | Survey Participants | Students Enrolled | Survey Participants |
| Non-honors | 375 | 334 | 456 | 408 |
| Honors | 99 | 83 | 132 | 116 |
| Non-honors male | 283 | 260 | 336 | 294 |
| Non-honors female | 92 | 74 | 120 | 114 |
| Honors male | 62 | 46 | 91 | 80 |
| Honors female | 37 | 37 | 41 | 36 |

The distribution of males and females in both the honors and non-honors sections was similar in fall 2013 and fall 2014. This distribution is representative of the distribution typically seen in the College of Engineering at Northeastern University. We examined whether the distribution of gender for students who did not take the survey was similar to the distribution of gender in the population that did take the survey. In 2013 of the 12% of students who did not participate in the survey, 68% were males and 32% females. In 2014 of the 11% of students who did not take the survey, 72% were males and 28% females. Therefore, the survey population was representative of the overall population of students enrolled in the general chemistry course. The subsequent

analysis in this paper focuses on the non-honors population of students surveyed in 2013 and 2014, as this population was the one for which SI primarily was targeted. Emphasis of the study is placed on variables from pre- and post-surveys that bare statistically significant relationships after analysis.

Correlations between Grades, Trigger Points for Using SI, Attendance Patterns, Gender

At the end of their course in general chemistry, students in both 2013 and 2014 were asked when they sought out extra help based on their grade. This question was posed on the post-survey as:

When, based on your grades, did you feel the need to seek out extra help? Please check **one**.

- Doing very well, but need clarification (A)
- Doing well, but seeking to do better (B)
- Doing okay (C)
- Doing poorly (D)
- Failing the class (F)
- Did not seek any extra help in this course

For students who chose to seek SI, a Pearson's Product Correlation Analysis was performed to test the correlation between grade threshold for seeking extra help and final grade. We found a statistically-significant positive correlation between trigger point for seeking SI and grade obtained, based on R values of for the Pearson's Product Correlation Analysis of 0.23 and 0.47 for fall 2013 and fall 2014, respectively, and a critical value of 0.076 for 95% confidence.

Based on this observation we then examined whether there were differences between grade triggers for the use of SI by males and females and their final grades and attendance in lecture. Table 2 provides a summary of means and standard deviations in variables we examined for different populations. We first examined whether females and males had different grade thresholds for seeking SI. We found that in 2013 females on average had a higher grade threshold for seeking SI than males. In 2014, however, there was no significant gender bias related to grade threshold for seeking extra help.

In fall 2013 females on average received higher grades in general chemistry than males, and this difference was greater comparing females who sought SI and males who sought SI. In fall 2014, however, there were no correlation between gender and grade received, regardless of whether SI was sought. We note that how grades were assigned differed in one key aspect between 2013 and 2014: in 2013 students received extra credit for attending lecture, but in 2014 extra credit was not offered for attending lecture. This difference offers an explanation regarding why the overall class average was higher in 2013 than in 2014.

Table 2: Comparison of grade thresholds, final grades, and lecture absences between male and female non-honors students. Data reported as means \pm standard deviations.

| Population | 2013 | | | 2014 | | |
|-----------------------|------------------------------|-----------------|------------------|------------------------------|-----------------|------------------|
| | Grade trigger for seeking SI | Final grade | Lecture absences | Grade trigger for seeking SI | Final grade | Lecture absences |
| All females | - | 3.31 \pm 0.93 | 2.41 \pm 3.26 | - | 2.99 \pm 0.85 | 5.51 \pm 6.50 |
| Females who sought SI | 2.79 \pm 0.92 | 3.41 \pm 0.73 | 2.08 \pm 2.63 | 2.67 \pm 0.94 | 2.98 \pm 0.88 | 5.05 \pm 5.93 |
| All males | - | 3.16 \pm 0.93 | 3.41 \pm 4.39 | - | 3.00 \pm 0.81 | 7.27 \pm 7.80 |
| Males who sought SI | 2.67 \pm 1.00 | 3.10 \pm 0.91 | 2.96 \pm 3.39 | 2.64 \pm 0.83 | 2.97 \pm 0.74 | 5.87 \pm 7.02 |

Because females did significantly better than males in 2013 but not in 2014, we hypothesized that females may have attended lectures more regularly in 2013 than males and, consequently, received more extra credit to obtain higher final grades. We found that in 2013 males skipped more lectures than females but in 2014 there was not a statistically significant difference in attendance based on the lecture that tracked attendance. (In 2014 only one instructor, who taught three of the five lectures, tracked attendance; this same instructor also taught three lectures in 2013.) The fact that males skipped more lectures than females in 2013 when the extra credit was offered suggests that females responded more positively to extra credit incentives. This difference may be because females are less confident and feel they need extra credit to boost their grade. Our results suggest that SI resources were effective at improving grades for females but not for males enrolled in General Chemistry.

We also investigated potential interaction effects between seeking SI, attendance in lecture, and final grade. For example, we found that females but not males who used SI received statistically higher final grades than their same-sex counterparts who did not in 2013; in 2014 there were no differences in final grades, regardless of gender, between students who did and did not seek SI. However, for both years both males and females who sought SI had statistically lower rates of absences from lecture than their same-sex counterparts. A Pearson's Product Correlation Analysis did reveal that there was a negative correlation between skipping lectures and grade obtained in both years: the more lectures a student missed, the more likely the student was to receive a poorer grade.

Pre-Semester Expectations vs. Actual Received Final Grades

In order to understand why students chose to use or not use SI, an analysis of the final grades students received compared to the grades they expected to receive before taking the class was performed. Student confidence is examined in order to better understand students' grade thresholds for seeking SI. Analysis will serve to verify or discount the hypothesis that greater confidence going into a course is related to the grade threshold for seeking SI. At the beginning of the semester students were asked to indicate what grade they expected to receive in the class. Figure 2 compares these responses with the final grades these students received.

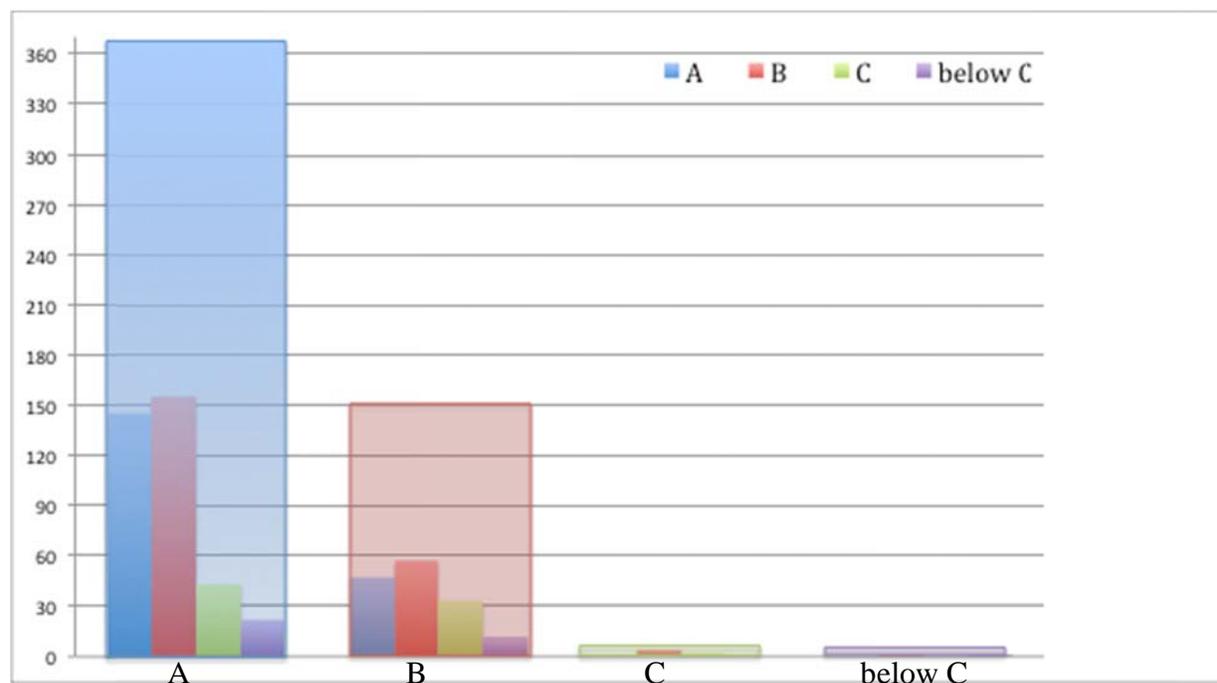
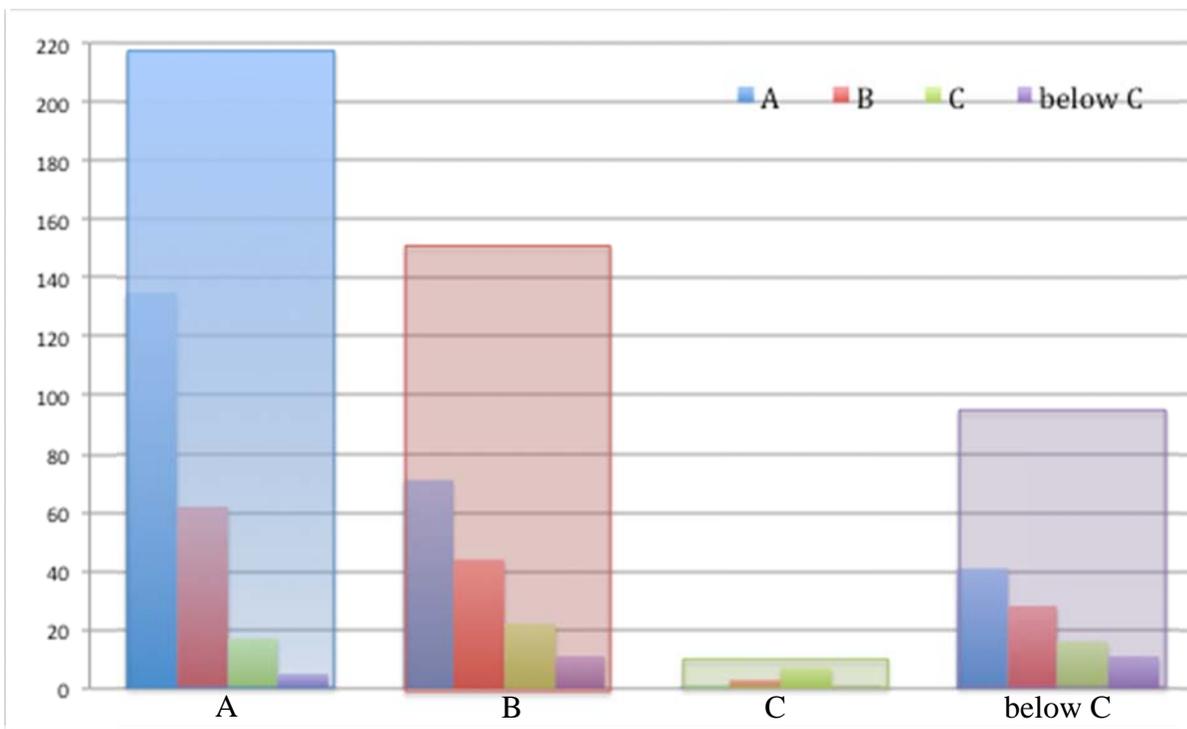


Figure 2: Students' expected grade in General Chemistry versus the grade students actually received in 2013 (top) and 2014 (bottom). Large bars represent students' predicted grades and small bars within the large bars represent students' actual grades.

Figure 2 shows that students were much more confident going into General Chemistry in 2014 than they were in 2013. In 2014 only nine students predicted that they would receive a grade of C or lower in the class, whereas in 2013 96 students predicted that they would get a grade below C in the class. This increased confidence may be attributed to a stronger incoming freshman class in terms of high school SAT scores in 2014 than in 2013 (average increase of 20 points Math + Verbal). As Table 2 shows, both males and females had higher grade thresholds for seeking SI in 2013 versus 2014 (numerical grade threshold of 3.01 in 2013 versus 2.68 in 2014 for females, 2.78 in 2013 versus 2.62 in 2014 for males). This higher grade threshold for seeking extra help in 2014 may stem from the students' confidence in their ability to learn the material and succeed on their own.

Correlations between Trigger Point for Seeking SI, Form of SI, and Final Grades

We also investigated which forms of SI students found more useful in 2013 and 2014. In both years two basic structures for SI were offered: weekly group tutoring scheduled on Monday evenings through the Connections Review led by upperclass peer tutors, and walk-in one-on-one tutoring held on weekdays and led by student peer tutors through the COE Tutoring Office or by instructors and TA's through Chem Central. Table 3 provides a summary of means and standard deviations in grade threshold for seeking SI and final grade for different populations.

Data currently are available for attendance only lumped for Connections Reviews and the COE Tutoring Office. For both years students who sought these forms of SI had higher trigger points for seeking SI than did students who did not use these forms of SI. In 2013 these forms of SI had no impact on final grades, but in 2014 students who used Connections Reviews and/or the COE Tutoring Office for SI did receive on average higher final grades. We believe this difference in impact on grades between 2013 and 2014 is in part the result of two changes in how the Connections Reviews and COE Tutoring Office were structured: in 2014 a male tutor was part of the peer leaders for Connections Reviews, whereas in 2013 these reviews were led by a team solely of female peer leaders, and in 2014 the COE Tutoring Office was staffed with an additional peer tutor who was highly-visible and recognized in one lecture. For both years students who attended the Connections Reviews also reported in a separate survey that they found these weekly reviews helpful. For example, one student wrote, "good general review of material and the review sheets [given during the sessions] were fantastically helpful tools for working through the homework and later review."

As data for attendance in Chem Central was not recorded either year, we chose to assess the impact of the resource for SI based on feedback from students in post-surveys. In 2013, students who found Chem Central useful had both higher trigger points for seeking SI as well as higher final grades; this correlation was found to be stronger for females than males (data not shown). In 2014 however, there were no correlations between Chem Central and these metrics. We believe the differences between the two years was associated with the inability of the instructor three lectures to hold his office hours in Chem Central in 2014 due to conflicts in his teaching schedule. Our results warrant follow up, including improving tracking of attendance for students participating in SI.

Table 3: Correlations between grade thresholds for seeking SI, use of group and one-on-one peer tutoring, and final grades for non-honors students. Connections Reviews offered group tutoring; COE Tutoring Office and Chem Central offered one-on-one tutoring. Data reported as means \pm standard deviations.

| Population | 2013 | | 2014 | |
|---|------------------------------|-----------------|------------------------------|-----------------|
| | Grade trigger for seeking SI | Final grade | Grade trigger for seeking SI | Final grade |
| Used Connections Reviews/ COE Tutoring Office | 2.80 \pm 1.00 | 3.29 \pm 0.90 | 2.70 \pm 0.98 | 3.13 \pm 0.76 |
| Did not use Connections Reviews/ COE Tutoring Office | 2.64 \pm 0.95 | 3.30 \pm 0.78 | 2.62 \pm 0.79 | 3.04 \pm 0.72 |
| Rated Chem Central useful | 2.68 \pm 0.91 | 2.99 \pm 0.84 | 2.63 \pm 0.79 | 2.80 \pm 0.81 |
| Rated Chem Central not useful | 2.55 \pm 1.26 | 2.89 \pm 1.22 | 2.67 \pm 0.98 | 2.78 \pm 0.73 |

Summary and Conclusions

This study used statistical analysis to examine correlations between first year engineering students' use of SI and their performance in a required general chemistry course at Northeastern University. Overall we found that students who used SI were more motivated in General Chemistry than their counterparts. We also draw the following specific conclusions from our data:

- Students who were more confident that they would receive a high grade in General Chemistry at the beginning of the course had a higher average grade threshold for seeking SI.
- Students who sought SI exhibited a positive correlation between grade threshold for seeking help outside the classroom and final grade received.
- Females who used SI had significantly higher grades than females who did not.
- SI in the form of Chem Central, the Connections Chemistry Review, and the COE Tutoring Office were all found to have the potential to have a significant positive impact on students' grades.
- Students who did not use SI were significantly more likely to skip lecture than students who do attend SI.
- Increased absenteeism in lecture was associated with lower final grades in both fall 2013 and fall 2014.
- Females were more likely to attend lecture regularly than males. When extra credit incentives were offered to attend lecture, both genders skipped significantly fewer lectures and received significantly higher grades.

We believe the results we have found regarding relationships between students' use of SI and their success in General Chemistry for Engineers can be applied to improve SI across the

freshman engineering curriculum. For example, as Chem Central, the Connections Chemistry Review, and the COE tutoring office were all found to have a positive impact on students' grades, resources like these could be created to help freshman students in their other courses. Further study of possible interaction effects among these and other variables for which we have data are ongoing. Our results also show that the students who often skip lecture are the students who do not take advantage of resources for SI and receive lower course grades. These may be students who need additional advising and mentoring during their freshman year in order to succeed. The issues raised are important topics of focus for future work in order to gain a further understanding of the impact of SI on freshman engineering students.

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General Conceptions of and Attitudes towards Chemistry

Please answer the following three questions by **circling** Yes or No.

13. My high-school chemistry teacher(s) was/were a good instructor(s) Yes No
14. I enjoyed my previous class(es) in chemistry Yes No
15. Understanding chemistry is important for being a successful engineer Yes No

Please **check** how often you expect to do the following: Never Sometimes Often

16. Browse the internet, check email, or similar activities during class _____ _____ _____
17. Do work for other classes during this class _____ _____ _____

General Conceptions of and Attitudes towards Resources for Succeeding in Chemistry

18. When, based on your grades, would you feel the need to seek out extra help? Please check **one**.
_____ Doing very well, but need clarification (A) _____ Doing well, but seeking to do better (B)
_____ Doing okay (C) _____ Doing poorly (D) _____ Failing the class (F)

For Questions 19 & 20 please **rank** each of the following factors on a 1-5 scale (with 5=most important and 1=least important). Please use each number only **once** per question.

19. How important is each of the following factors when seeking out extra help from any available resource?

- _____ Location of help _____ Frequency that help is offered
_____ Time of help _____ Food is offered _____ Friends go with you

20. How important is each quality in a tutor?

- _____ Friendliness _____ Availability _____ Empathy
_____ Depth of understanding of material _____ Ability to explain the material

21. Please **rank** your comfort level with using the following people as an extra help resource on a 1-5 scale (with 5=most comfortable and 1=least comfortable). Please use each number only **once**.

- _____ Friend _____ Upperclass undergraduate student
_____ TA/graduate student _____ Course instructor _____ Other faculty

Please check **all** that apply for the following four questions.

- | | 1-on-1
Tutoring | Instructor's
Office Hours | Study
Group |
|---|--------------------|------------------------------|----------------|
| 22. Have you used these resources for any class in high school? | _____ | _____ | _____ |
| 23. Are you planning to use these resources for any class this semester? | _____ | _____ | _____ |
| 24. Have you used these resources for chemistry in high school? | _____ | _____ | _____ |
| 25. Are you planning to use these resources for chemistry this semester? | _____ | _____ | _____ |

General Conceptions of and Attitudes Towards this Semester in Chemistry

26. Please circle the grade you think you'll receive in this class: A B C lower than C

Please **check one** selection for each of the following three questions: Yes No Not Sure

27. Do you plan to read the textbook material before it is presented in class? _____ _____ _____
28. Do you plan to use the COE Freshman Tutoring Office? _____ _____ _____
29. Do you plan to attend Monday Night Chemistry Review sessions? _____ _____ _____

Thank you very much for your participation!

Appendix B: Post-Survey

Directions: Please enter your NU student ID in the box below as your Student Code.

Under no conditions will your responses be matched to your name.

Student Code _____

DO NOT WRITE YOUR NAME ON THIS FORM!

CHEM 1151 General Chemistry for Engineers - Fall 2014

Post-Survey on Perceptions of Chemistry by Freshmen in Engineering

Thanks for your willingness to complete our survey of support programs for students taking CHEM 1151. This survey should take no more than 15 minutes. Your responses will be held in complete confidence. Note that “this class” means CHEM 1151 & CHEM 1153.

General Conceptions of and Attitudes towards Chemistry

Please answer the following five questions by **circling** Yes or No.

- | | | | | |
|---|-------|-----------|--------|----|
| 1. Chemistry is a hard subject to understand | | | Yes | No |
| 2. Understanding chemistry is important for being a successful engineer | | | Yes | No |
| 3. I worked hard in this class | | | Yes | No |
| Please check how often you did the following during class : | Never | Sometimes | Always | |
| 4. Browsed the internet, checked email, or similar activities | _____ | _____ | _____ | |
| 5. Did work for other classes | _____ | _____ | _____ | |

Resources for Succeeding in Chemistry

Please rate how effective the following were in helping you in this class this semester by **circling** the appropriate number using the scale defined below. Circle “Not Used” if you did not use the service.

| | 1 = Detrimental | 2 = Not useful | 3 = Somewhat useful | 4 = Useful | 5 = Very useful | |
|--|-----------------|----------------|---------------------|------------|-----------------|----------|
| 6. Clicker/Responseware/Top Hat questions during lectures | 1 | 2 | 3 | 4 | 5 | Not Used |
| 7. Handouts (“practice problems”) in lectures | 1 | 2 | 3 | 4 | 5 | Not Used |
| 8. Recitations | 1 | 2 | 3 | 4 | 5 | Not Used |
| 9. Required on-line homework assignments | 1 | 2 | 3 | 4 | 5 | Not Used |
| 10. Ungraded on-line practice questions for homework assignments | 1 | 2 | 3 | 4 | 5 | Not Used |
| 11. Posting of notes & other materials on Blackboard | 1 | 2 | 3 | 4 | 5 | Not Used |
| 12. Textbook | 1 | 2 | 3 | 4 | 5 | Not Used |
| 13. Monday Connections reviews | 1 | 2 | 3 | 4 | 5 | Not Used |
| 14. Chem Central | 1 | 2 | 3 | 4 | 5 | Not Used |
| 15. COE Freshman Tutoring Office (306 SN) | 1 | 2 | 3 | 4 | 5 | Not Used |
| 16. One-on-one peer tutoring | 1 | 2 | 3 | 4 | 5 | Not Used |
| 17. Instructor-led exam reviews | 1 | 2 | 3 | 4 | 5 | Not Used |
| 18. Instructor office hours | 1 | 2 | 3 | 4 | 5 | Not Used |
| 19. TA office hours | 1 | 2 | 3 | 4 | 5 | Not Used |
| 20. Studying in groups | 1 | 2 | 3 | 4 | 5 | Not Used |

21. When, based on your grades, did you seek out extra help? Please check **ONE**.

- _____ Doing very well, but needed clarification (A) _____ Doing well, but sought to do better (B)
 _____ Doing okay (C) _____ Doing poorly (D) _____ Failing the class (F)
 _____ Did not seek any extra help in this course

| Please check any of the factors that led you to NOT use the following resources: | Gender of supplemental instructor/tutor | Intimidating supplemental instructor/tutor | Inconvenient time | Inconvenient location | Did not think it would be useful | Did not know it existed | Other (Please specify below) |
|--|---|--|-------------------|-----------------------|----------------------------------|-------------------------|------------------------------|
| 22. Monday Connections reviews | | | | | | | |
| 23. Chem Central | | | | | | | |
| 24. COE Freshman Tutoring Office | | | | | | | |
| 25. One-on-one peer tutoring | | | | | | | |
| 26. Instructor-led exam reviews | | | | | | | |
| 27. Instructor office hours | | | | | | | |
| 28. TA office hours | | | | | | | |

For Questions 29 & 30 please **RANK** each of the following factors on a 1-5 scale (5=most important and 1=least important). Please use each number only **ONCE**.

29. How important was each factor when seeking out extra help from an available resource?
 _____ Location of help _____ Frequency that help was offered
 _____ Time of help _____ Food was offered _____ Friends went with you
30. How important was each quality in a supplemental instructor/tutor?
 _____ Friendliness _____ Availability _____ Empathy
 _____ Depth of understanding of material _____ Ability to explain the material
31. Please **RANK** your **comfort level** with using the following people as an supplemental instructor/tutor on a 1-5 scale (5=most comfortable and 1=least comfortable). Please use each number only **ONCE**.
 _____ Friend _____ Upperclass undergraduate student
 _____ TA/graduate student _____ Course instructor _____ Other faculty
32. Please **RANK** the **competence** of the following people as an supplemental instructor/tutor on a 1-5 scale (5=most competent and 1=least competent). Please use each number only **ONCE**.
 _____ Friend _____ Upperclass undergraduate student
 _____ TA/graduate student _____ Course instructor _____ Other faculty

Final Questions

33. Please **circle** the final grade you expect in this class: A/A- B+/B/B- C+/C/C- D+/D/D- F
34. Please **circle** how committed you are, after this semester, to pursue a degree in engineering:
 Very committed Somewhat committed Not committed Uncertain
35. Please **circle** your (intended) major:
 BioEngineering Chemical Eng. Civil Eng. Computer Eng.
 Electrical Eng. Industrial Eng. Mechanical Eng. Undecided Engineering
 Other: _____
36. Please **CHECK ANY** of the following that describe your current feelings towards **this class**:
 ___ Excited ___ Optimistic ___ Prepared ___ Inspired
 ___ Overwhelmed ___ Discouraged ___ Bored ___ Lost
37. Please **CHECK ANY** of the following that describe your current feelings towards **your overall studies**:
 ___ Excited ___ Optimistic ___ Prepared ___ Inspired
 ___ Overwhelmed ___ Discouraged ___ Bored ___ Lost

Thank you very much for your participation!