Understanding the Factors Influencing Student Participation in Supplemental Instruction in Freshman Chemistry

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Understanding the Factors Influencing Student Participation in Supplemental Instruction in Freshman Chemistry

Abstract

This study examines the factors that are most important from the perspective of a first year engineering student in utilizing supplemental instruction in a required introductory course in general chemistry. Prior studies have indicated a strong correlation between success in a course and utilization of supplemental instruction, especially for students under-represented in engineering. Supplemental instruction includes peer tutoring, instructor office hours, review sessions, study groups, and other programs to assist students outside of the classroom. Based on the demonstrated success of supplemental instruction programs developed for women in engineering, the College of Engineering at Northeastern University expanded the programs to all engineering freshmen (male and female). Review sessions for a course in general chemistry for engineers led by upper-class women tutors studying chemical engineering were particularly successful. Tutors attended instructors' chemistry lectures and served as role models to support and encourage freshmen in this challenging first year course. Although the program has been run successfully for a number of years, with typically 60% of female engineering freshmen enrolled in chemistry attending, the team of tutors, course coordinator, and program advisors sought to increase student participation. Our current research is directed towards understanding what causes students to utilize supplemental instruction.

To understand the factors influencing student participation in supplemental instruction, first year engineering students in the Fall 2012 offering of General Chemistry for Engineers were asked to complete a survey at the beginning and again at the end of the semester. For most students enrolled in this course, this semester is their first in college. Both surveys were completed by 221 students (51 females and 170 males) for a response rate of 54% (i.e. 221 survey participants out of 407 total students who were enrolled and completed the first year required chemistry course). This response rate was reasonable considering students under the age of eighteen were not permitted to complete the survey. In addition, a 54% response rate was comparable to the response rate of similar surveys conducted in past years. Students who elected not to participate in the surveys had a similar male to female ratio as that of survey participants.

The pre-survey included questions about a student's previous experience with tutoring in high school and his/her likelihood to utilize extra resources at the college level. It also included questions to uncover the "trigger point" at which a student decides they will seek additional help. Not surprisingly, women had a higher trigger threshold than men (course grades of A or B for women versus B or C for men on average). Both male and female students saw convenience as a main factor determining whether or not they used supplemental instruction. They indicated that frequency, time, and location of tutoring sessions were the most important factors. The tutor's depth of understanding and ability to explain material well were also key factors that motivated students to continue to attend tutoring sessions. Students felt most comfortable receiving help from tutors who were closer to them in educational background. As a result, students were most likely to seek tutoring from friends and other undergraduate students and least likely to seek tutoring from their instructor or other faculty members.

This paper presents the results of pre- and post-surveys, as well as an analysis based on gender and prior experiences. The analysis identifies correlations among use of supplemental instruction, attitudes towards chemistry, success in freshman General Chemistry for Engineers, and overall success in the College of Engineering program.

Background

The transition from high school to college often involves a change to larger class sizes and classes that are relatively impersonal.[1] This can make the transition difficult for college freshmen. Many freshmen engineering students experienced few academic challenges in high school and are therefore unprepared for the level of work expected in college engineering courses.[2] Supplemental instruction is a common instructional technique at many universities to help freshman adjust to college courses. A study at a Rocky Mountain research university showed that students who used supplemental instruction earned higher average course grades, as well as higher overall semester grade point averages (GPAs) than their peers who did not attend.[3] All students, regardless of their entry credentials, benefit from the use of academic support services such as supplemental instruction.[2]

Many factors influence a student's decision whether or not to use supplemental instruction. A student's decision to seek out extra help is heavily influenced by that student's self-confidence.[4] For many students, seeking extra help lowers their self-esteem because they find it demoralizing that they cannot master the material on their own. The degree of a student's perceived threat to self-esteem is directly related to their tendency to avoid seeking help. Students are embarrassed to ask for help because they risk exposing their vulnerabilities to their peers.[1, 5] Therefore, students who are unsure of themselves socially are less likely to seek help.[4] This is especially true if the students are confident in their academic abilities and have not needed to seek extra help in the past.[6] Students who need the most help often fail to seek it because they feel that seeking help is a public statement to their peers of their academic failures.[4] Students who are not confident in their ability to perform well in a course are more likely to seek help than their more confident peers.[7] A 2004 study done at Texas A&M University demonstrated that students who were more engaged in supplemental instruction had significantly lower self-efficacy, but achieved higher final course grades.[7]

The personality of the tutor is also an important factor students consider when seeking extra help.[5] Students feel that traits associated with a good tutor are empathy, patience, sensitivity, diplomacy, friendliness, intuitiveness, supportiveness, responsiveness, and care.[8] If students feel that tutors are arrogant or not empathetic to their concerns, they are unlikely to continue getting help from that tutor.[5] Tutors must also be sensitive to the potential embarrassment felt by the student because they need extra help. Students who feel more affection towards their tutors and teachers are more likely to seek extra help.[4]

Males and females showed different attitudes towards supplemental instruction.[9] Young women reported more positive attitudes towards seeking help and were more likely to use supplemental instruction than young men.[7, 9] This is partially due to different attitudes towards schoolwork between genders. Females seem to have more positive attitudes toward school and learning.[9]

They are more intrinsically interested in learning the material they are taught. Males prefer to get the right answer without publicly revealing a need for help. They ask for help in order to avoid working hard and to obtain answers quickly without much effort. Males and females also have different psychological perspectives towards seeking extra help. Young women perceive extra help as beneficial because it promotes learning.[10] Young men view seeking help as threatening as it is evidence of low ability and will cause others to judge them negatively. A 2004 study of engineering students at a southeastern university showed that the reluctance to ask for help was most prevalent in white male students with low GPAs.[2] These students indicated concern that asking for help would make it appear as if they would not be successful in an engineering program.

At Northeastern University, engineering students typically take General Chemistry for Engineers in the fall of their freshman year. This course meets three times a week, for 65 minutes each, in a lecture format that consists of approximately 100 students in a large lecture hall. There are four different lecture sections taught by one instructor. The lecture part of the course mostly consists of the professor introducing material and concepts, and usually includes one or two practice problems for students to consider during class. In addition, the lecture requires students to use a clicker at least once during each class to answer questions posed by the instructor. These clicker questions serve to provide students and instructor feedback regarding how the students are retaining and understanding material, while simultaneously tracking students' attendance. In addition to the lecture, students meet once a week in a recitation section of typically about 30 students. In this setting, students are able to explore concepts introduced in lecture at a deeper level and work on their weekly on-line homework assignments that are due on the day of their recitation. A teaching assistant leads each recitation by reviewing key concepts or helping students solve difficult problems. Students have three 65-minute midterm examinations throughout the semester and one two-hour final examination at the end of the semester. Students in all sections take common exams.

In addition to instruction that is received during lecture and recitation, there are multiple additional resources available for students seeking help throughout the semester. The Connections Chemistry Review Program is run by three upper class, female, chemical engineering students who attend all instructors' lectures. The tutors then lead attending students in a weekly review of the key concepts and skills introduced in lecture and assist students with their homework problems. An additional resource is instructor office hours; the instructor sets aside an average of four hours per week during which students, individually or in small groups, can receive help. Students also have the option of going to "Chem Central," where at least one chemistry professor or graduate student is present weekdays from 10 am-4 pm to assist students on a walk-in basis. The College of Engineering provides a free-of-charge tutoring center, staffed with graduate engineering students, to all freshmen for their first year classes, including chemistry. A graduate student who staffs this center also attends one of the instructor's lectures daily. The university also offers a one-on-one peer tutoring service, where an upper class undergraduate student is paired with a freshman student in chemistry for hourly tutoring instruction once per week. Finally, engineering students are encouraged to form study groups with peers also taking general chemistry.

The primary focus of this paper is to examine the factors that affect whether a student uses the resources for supplemental instruction described above and the relative effectiveness of each type of resource. Particular attention is directed to research questions such as how does a student's previous experiences with seeking extra help in high school affect whether and how they seek extra help in a required introductory general chemistry course, what "trigger points" determine when and how a student uses supplemental instruction, and what factors are most important in how the supplemental instruction is offered (*e.g.*, tutor's personal attributes). Underlying these questions are the general topics of what differences exist between male *vs.* female perceptions of extra help and how should resources most effectively be allocated among alternative forms of supplemental instruction.

Results

A total of 221 engineering students completed both the pre- and post-surveys out of the chemistry class of 407 students (54% response rate). Of the 221 students participating, 78% were males and 22% were females. It should be noted that of the 46% of students who did not participate in the survey, 81% were males and 19% were females, which was a similar distribution as that of survey participants. The research questions analyzed focused on the trigger point at which students felt the need to seek out additional resources based on their grade, the main factors that determined whether students chose to use supplemental instruction, and the main factors that determined whether students continued to use supplemental instruction. Understanding the differences between male and female responses was the main goal of this research. Seventy-six percent of females and sixty percent of males reported that they used at least one of the extra help resources offered. Extra help resources are defined as any of the following: Connections Chemistry Review Program, "Chem Central," the College of Engineering (COE) Tutoring Center, one-on-one peer tutoring through the university, and instructor office hours.

Use of Supplemental Instruction in High School

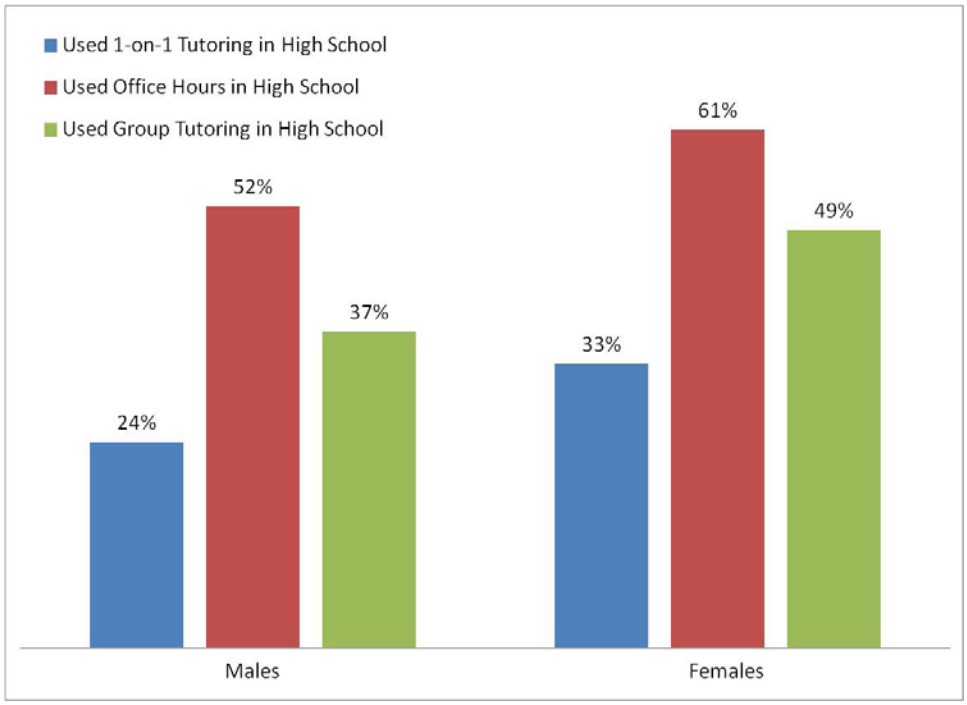

Figure 1a

Projected Use of Supplemental Instruction in College

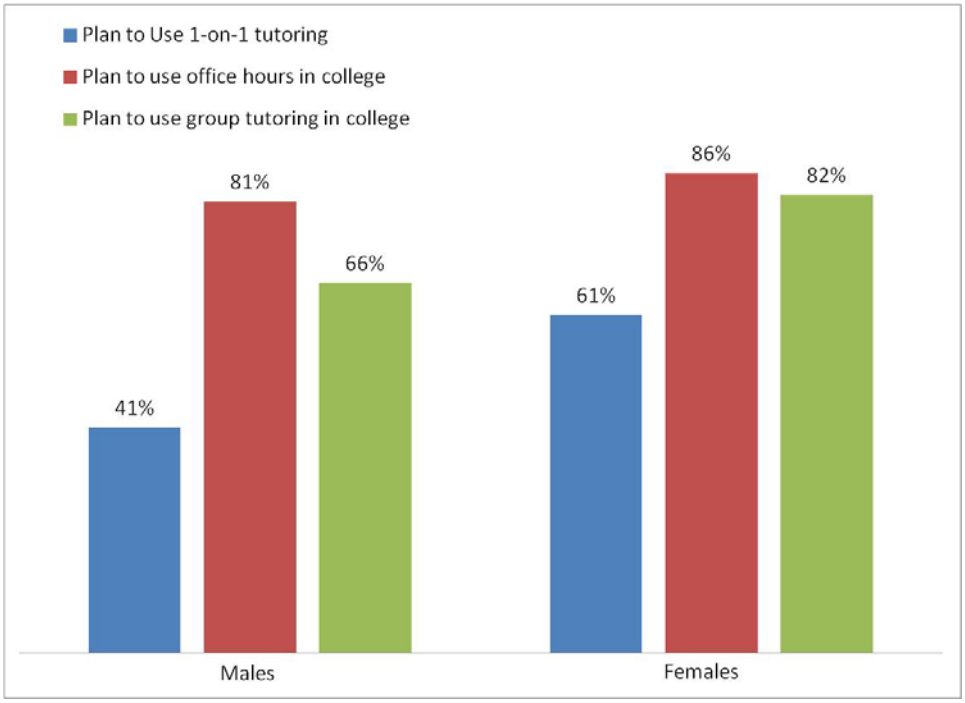

Figure 1b

Figure 1a is a graph of student feedback from the pre-survey regarding their usage of three different types of supplemental instruction in high school. These three types of supplemental instruction are one-on-one tutoring, instructor office hours, and group tutoring. Figure 1b is a graph of student feedback also from the pre-survey on their projected usage of these same three additional resources in college during the Fall 2012 semester. For all three types of supplemental instruction, a larger percentage of females used these resources in high school and planned to continue to use them in college. Instructor office hours were used more than one-on-one tutoring or group tutoring by both males and females in high school. As a result, students responded that they were more likely to use office hours in college versus the other two resources. Students were also asked whether they used any of these three types of instruction specifically for their chemistry course in high school and whether they planned to use any of these for their General Chemistry for Engineers course in college. Student responses revealed the same trends for past and projected use of supplemental instruction for chemistry as for all other courses.

When Students Feel the Need to Seek Out Extra Help

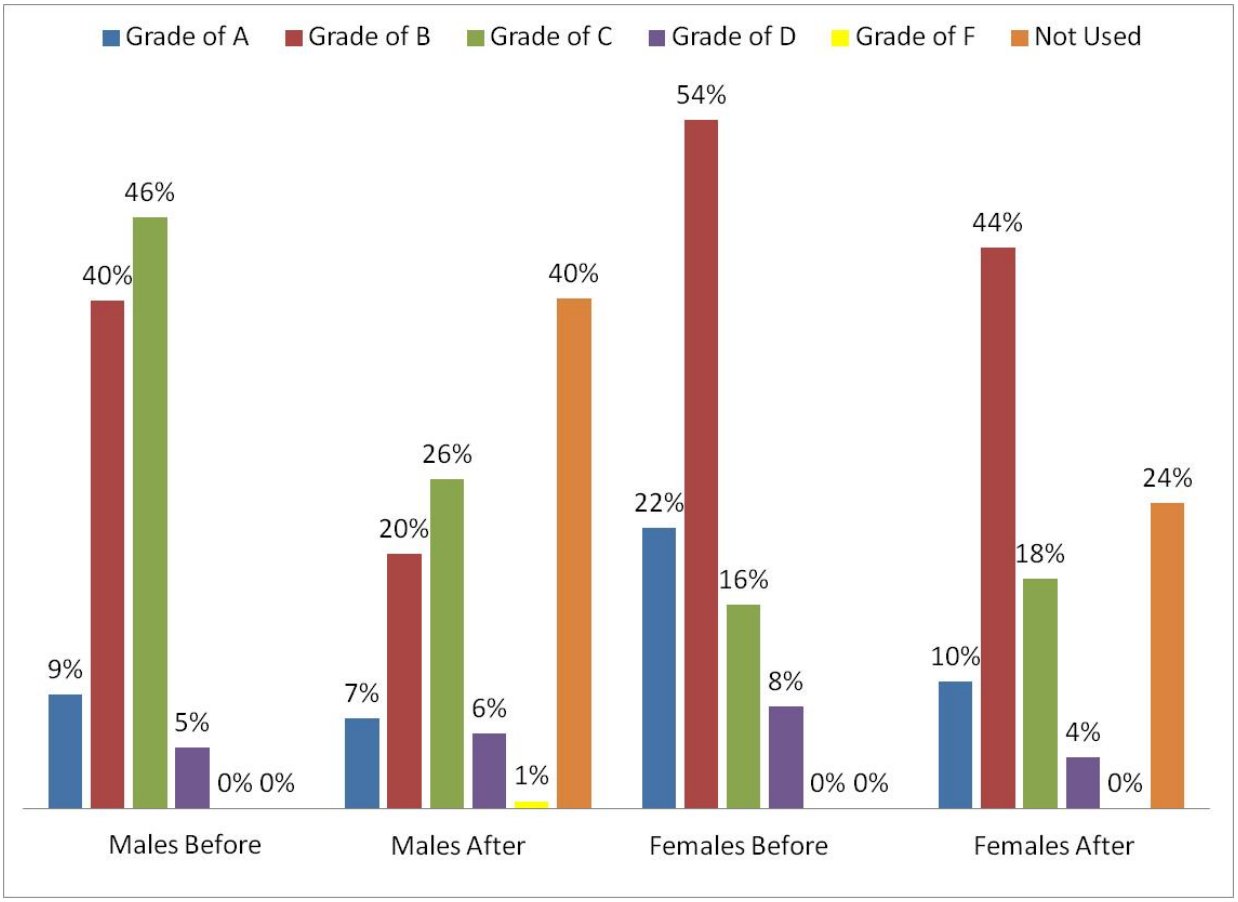

Figure 2

Figure 2 is a graph of survey responses indicating when both males and females felt the need to seek out extra help based on their grade in chemistry. This question was posed both before and after completion of General Chemistry for Engineers as follows:

> 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)

Females had a lower reported threshold for seeking extra help and were more likely to actually seek out the additional resources offered. The majority of females felt they would seek out extra help when they had a B, and most sought out extra help with a grade of A or B. The majority of males felt they would seek out extra help with a grade of B or C in the pre-survey, which was the case as reported in the post-survey. A larger percentage of females, 76% versus 60%, used some form of extra help than males. Ninety-five percent of males responded on the pre-survey that they would seek help when receiving a grade of A, B, or C. The post-survey revealed that only 53% of males sought help throughout the semester when their standing in the class was an A, B, or C. In fact, 40% of males did not seek help during the semester at all. These differences can be attributed to students either not seeking help when they projected that they would, or students receiving better grades than their trigger point. The same can be said about female survey participants, although only 24% of female students did not seek out help during the semester.

Students' Rating Supplemental Resources as Useful or Very Useful

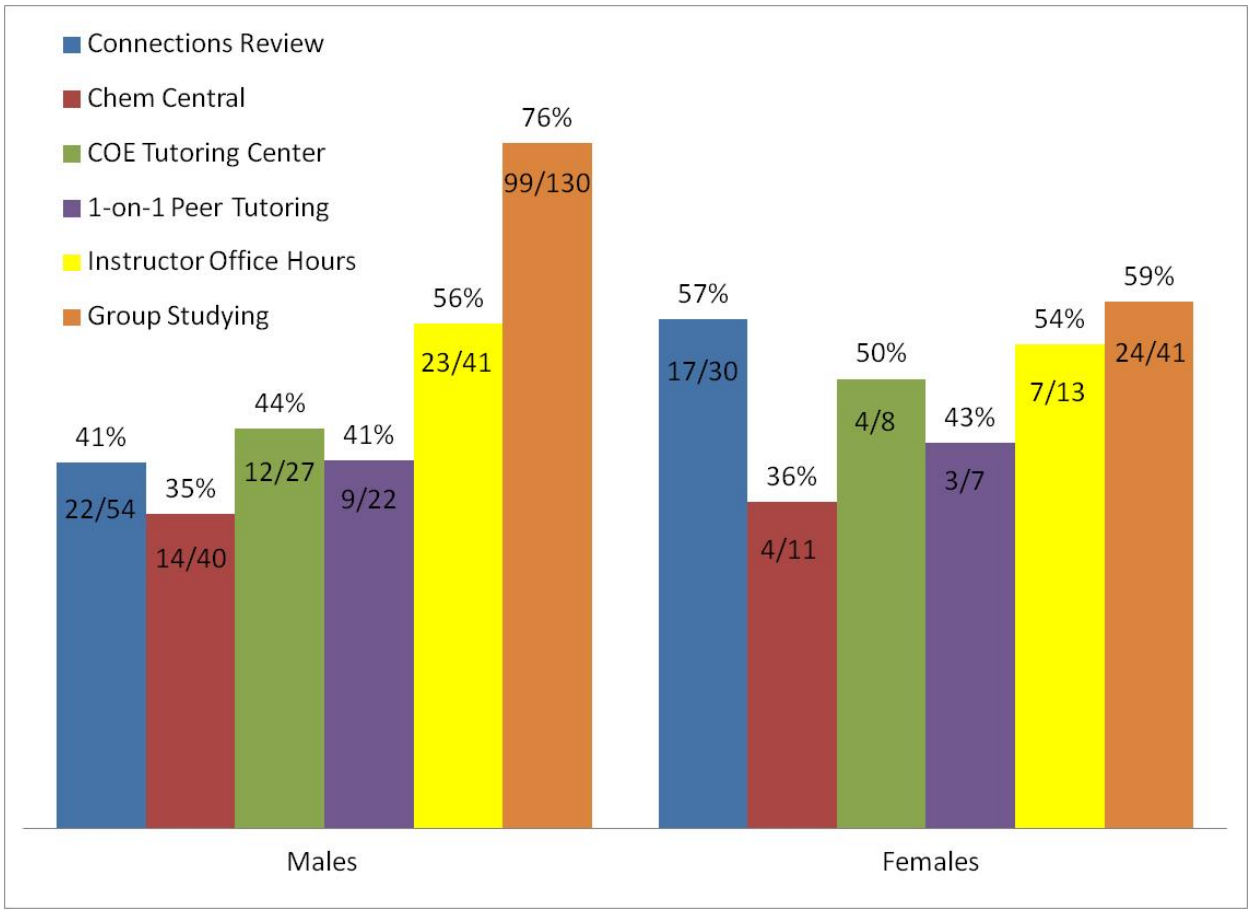

Figure 3

Figure 3 is a graph of males' and females' attitudes towards the effectiveness of the six extra help resources available to them throughout the Fall 2012 semester. These resources were the Connections Chemistry Review Program (weekly group reviews run by undergraduates), "Chem Central" (drop in 1-on-1 tutoring by faculty and graduate students from the Chemistry department), the College of Engineering (COE) Tutoring Center (drop in 1-on-1 tutoring by engineering graduate students), one-on-one peer tutoring through the university, instructor office hours, and group studying. Students were asked to rank the resources they used on a scale of one through five, with one being detrimental and five being very useful. Students who ranked the extra resources either a four or five define the useful or very useful category. The number of students that rated the resource as useful or very useful was plotted as a fraction of the total number of students which used that resource. For example, 54 males reported that they attended the Connections Review Program; of these 54 males, 22 of them rated the review program useful or very useful.

Females found group studying the most beneficial out of the supplemental resources with 59% of respondents rating group studying as useful or very useful. The next highest rated resource reported by females was the Connections Chemistry Review Program with a 57% positive rating.

This is not surprising, since the Connections Review is run by three upper-class, female, chemical engineering students. On average, females felt that these two resources were more useful than not, which explains why more females took advantage of these resources than the other four available. The largest percentage of males used both instructor office hours and group studying with peers. Males found these resources more effective than the other four offered, with 76% and 56% rating of instructor office hours and group studying as useful or very useful, respectively.

Males Comfort Level with Different Individuals as Extra Help Resources

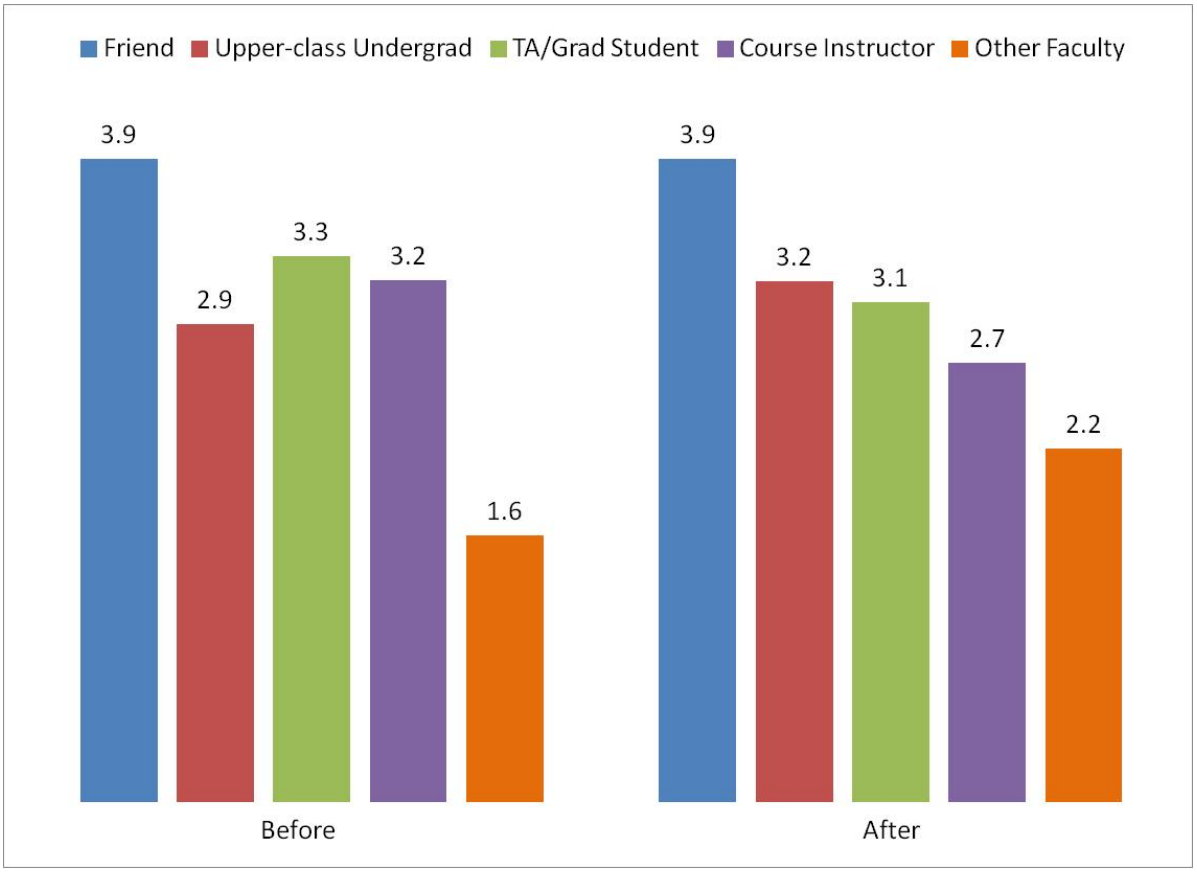

Figure 4a

Females Comfort Level with Different Individuals as Extra Help Resources

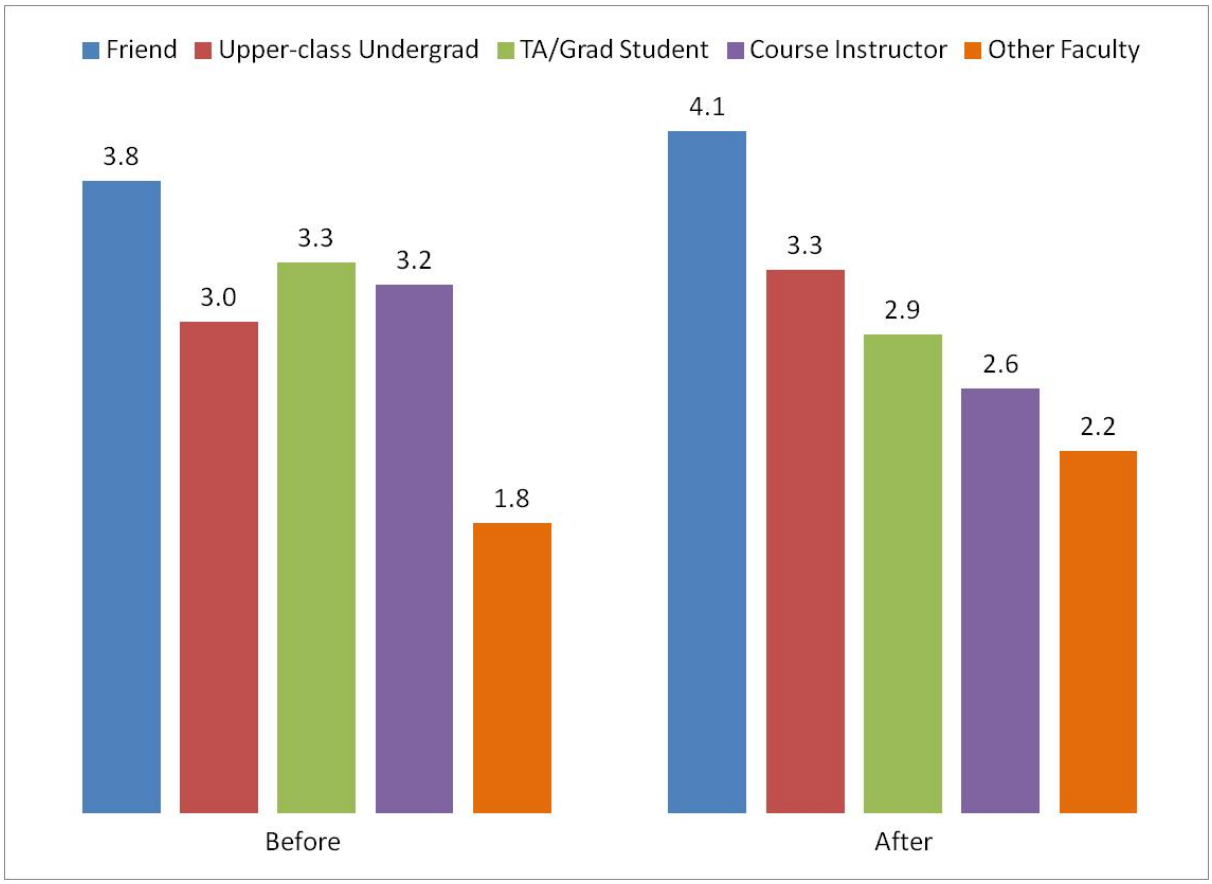

Figure 4b

Figures 4a and 4b graph both males' and females' comfort level with different individuals as additional resources both before and after taking chemistry. Male and female responses to the same question on the pre-survey were not measurably different than their responses on the post survey. Students were asked to rank their comfort level with each individual on a one through five scale with one being the least comfortable and five being the most comfortable, using each number only once. Male and female responses were averaged to determine the numbers shown on the graph. Both males and females were most comfortable with friends as extra help resources, which is most likely why almost all students used group studying throughout the semester. Both males and females were least comfortable with an unfamiliar faculty member. These results show that the closer in educational background the person is to the student's, the more comfortable the student is with using that person as an additional resource.

Importance of Certain Qualities to Male Students in a Tutor

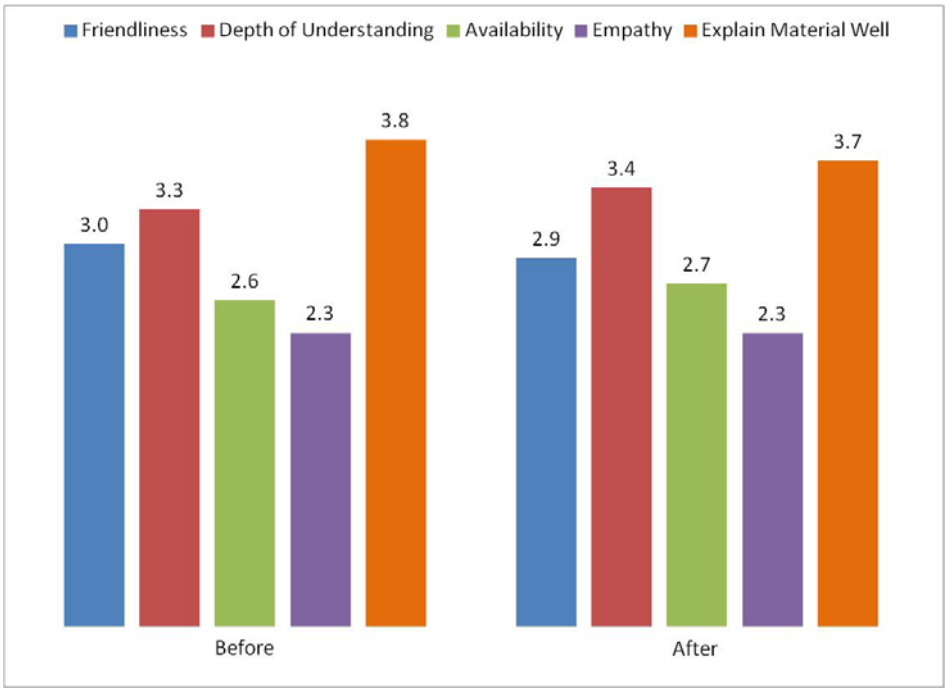

Figure 5a

Importance of Certain Qualities to Female Students in a Tutor

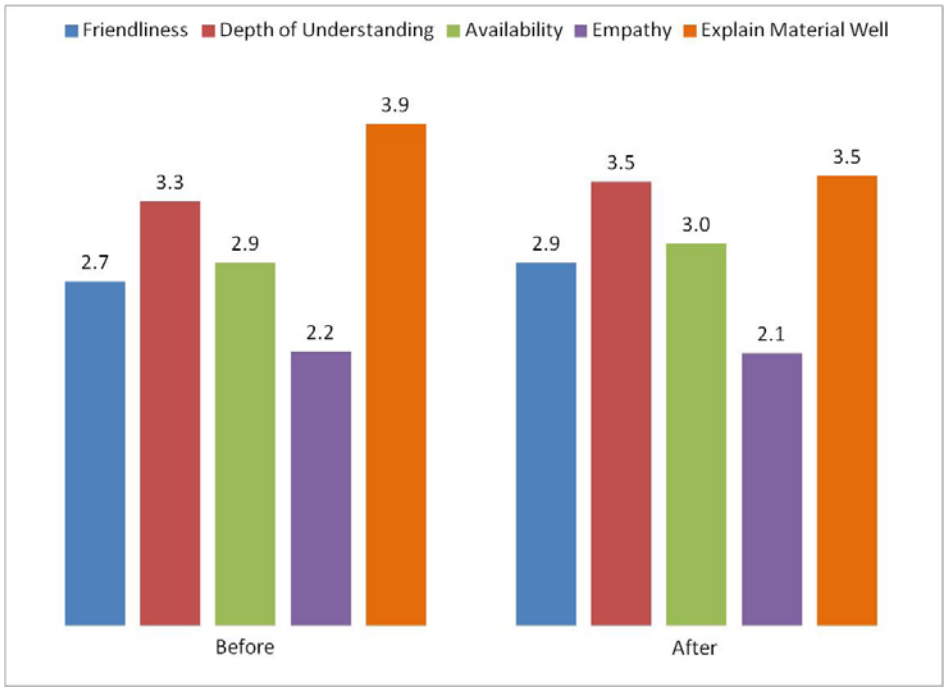

Figure 5b

Figures 5a and 5b graph the importance of certain qualities in a tutor as reported by male and female students both before and after taking chemistry. Students were asked to rank the importance of each quality on a one through five scale with one being the least important and five being the most important, using each number only once. Male and female responses were averaged to determine the numbers shown on the graph. The trends were found to be near identical before and after taking chemistry for both males and females. Being able to explain the material well was the most important quality for a tutor to have for student respondents. The second most important quality for both males and females was the tutor's depth of understanding. The least important quality reported by both male and female students before and after taking the course was empathy. Availability and friendliness, both before and after taking the course, had similar levels of importance. These results were somewhat surprising, because it was hypothesized that empathy and friendliness would be the most important qualities to females and that these qualities would be more important to females than males, which was not the case based on these surveys.

Importance of Certain Qualities to Male Students When Seeking Out Extra Help

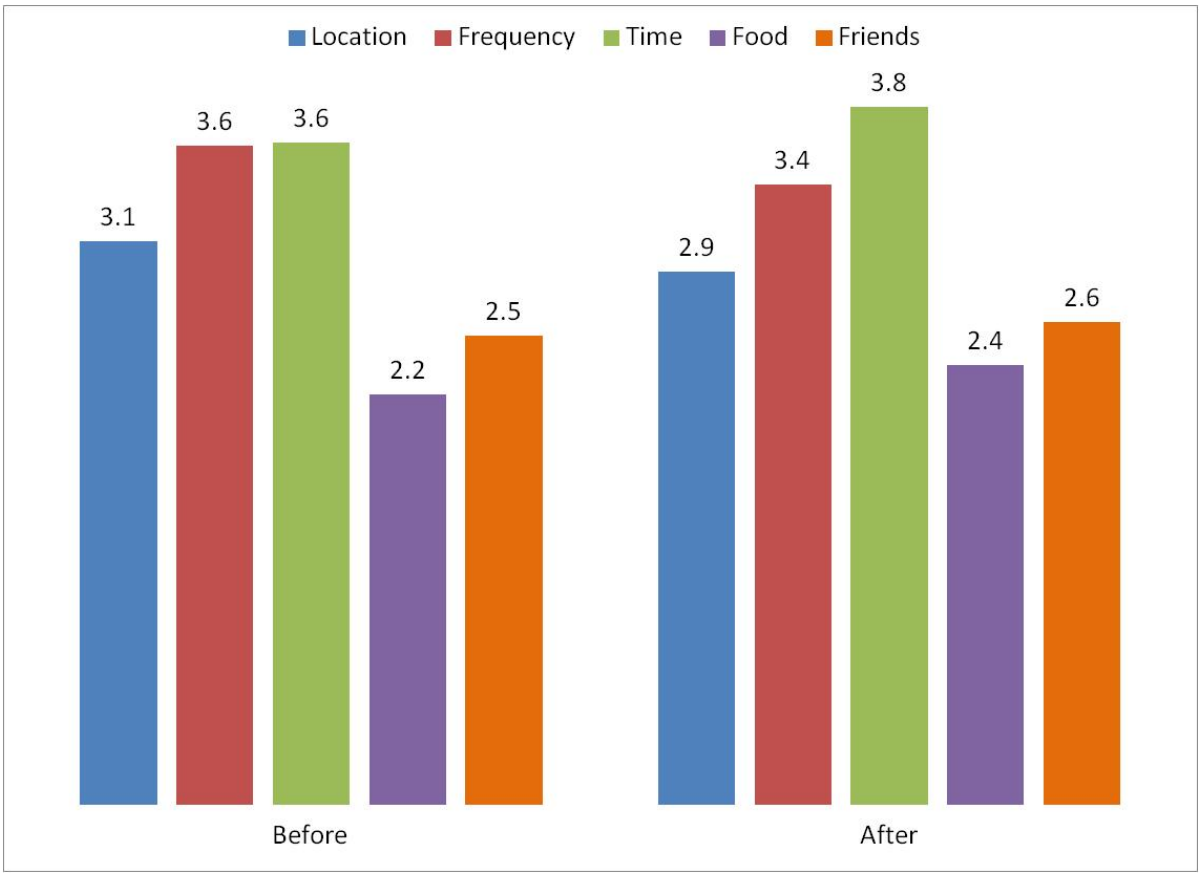

Figure 6a

Importance of Certain Qualities to Female Students When Seeking Out Extra Help

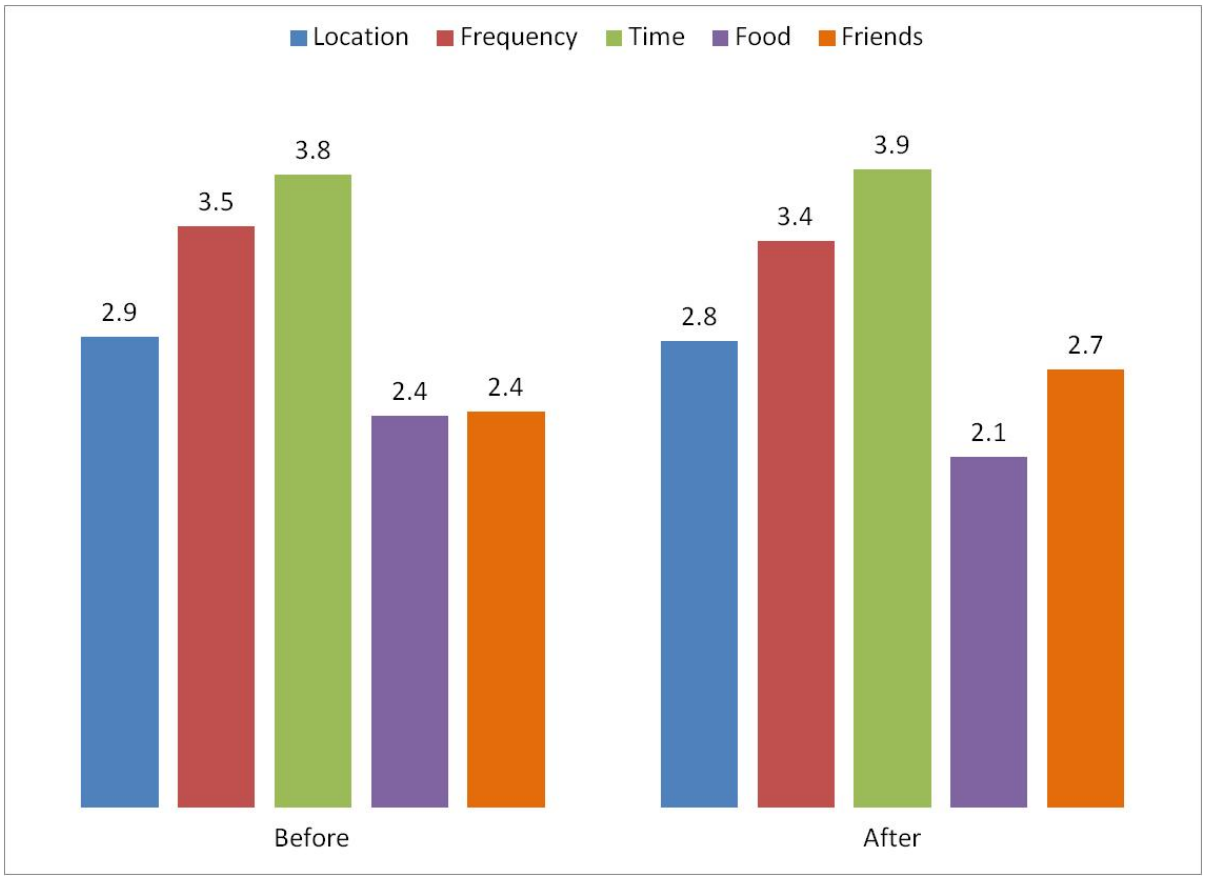

Figure 6b

Figures 6a and 6b graph the importance of certain factors for males and females when seeking out extra help resources both before and after taking chemistry. Students were asked to rank the importance of each quality on a one through five scale with one being the least important and five being the most important, using each number only once. Male and female responses were averaged to determine the numbers shown on the graph. The trends were found to be nearly identical before and after taking chemistry for both males and females. It was predicted that males would find food and friends more important than frequency, time, or location because they would serve as an incentive to attend extra help. This hypothesis was determined to be false, as males ranked time, frequency, and location the most important factors. These factors are related to convenience, which may explain why males ranked them higher than food or friends when seeking out extra help. The results also show that there is little to no difference between males' and females' opinions on the importance of these qualities when seeking out extra help.

Discussion and Conclusions

The importance of retention and academic success for engineering students today has resulted in the provision of multiple resources for supplemental instruction for freshmen. Significant amounts of time, money, and resources are consumed in the planning and execution of these

programs for supplemental instruction. Therefore, it is important to understand the trigger points leading students to seek extra help, the factors that affect which resource a student chooses, and what affects a student's decision to continue with a resource. Understanding these factors will allow universities to design programs that will be more effective, better used, and warrant continuation rather than invest in programs that may not provide students with meaningful assistance.

Two research questions examined in this paper are how do female and male students differ in the use of supplemental instruction in freshman chemistry and what is the trigger point when students decide to seek out an extra help resource. We found that female freshmen were more likely to seek extra help than their male counterparts, consistent with previous reports in the literature. A larger percentage of the female students, 76% in this study, actually used some form of extra help than male students, 60%. Shown in Figure 2, the trigger point at which females decide they need extra help (grade of B) has a lower threshold than males (grade of C). These trends were very similar both before and after taking the General Chemistry course at Northeastern University. This observation suggests that students who did seek extra help did so at the same trigger point as they had anticipated prior to the course.

Second, this paper studied the possible motivating factors for students to choose among alternative resource for extra help. Based on how students ranked their comfort level among various possible tutors, we found that as a student's educational background became more separated from that of a tutor, the student felt less comfortable with that resource. This trend was observed for both males and females and can explain why the majority of students primarily used group studying or the Connections Chemistry Review sessions, as the former involved peers and the latter was run by undergraduate upperclassmen. Both of these groups have either the same or very similar educational backgrounds to a first year student. The study data suggests that offering supplemental review programs involving high-achieving freshmen or underclassman may yield a higher turnout and participation.

This study also found that the convenience factor of extra help resources greatly contributes to whether a student uses that resource. Both before and after the course, males and females chose location, time and frequency of the resource as the most important qualities, rather than free food and whether their friends attend. This result contradicts what we had expected, as we had hypothesized that students need incentives to seek extra help, such as food and friends. The data suggest that logistical concerns should be considered strongly in the design and implementation of supplemental resources. For example, our data support expanding extra help resources to offer more frequent Connections Chemistry Reviews or increase the flexibility in office hours offered by the instructor. Also, the comfort level of students with peers and undergraduates correlates to convenience: many students lived near their peers or knew upperclassmen from orientations and mentoring classes, making it easy for the student to approach this group of potential help resources.

Our examination of what qualities students seek and find essential in a tutor revealed that both male and female students desire a tutor in freshman chemistry who can explain material well and has a great depth of understanding. These observations contradict the literature, which suggests that students seek tutors who are empathetic and friendly. Also, it is interesting that these results did not change after taking the chemistry course, indicating that qualities students' desire in a tutor did not change with their first semester of college. However, the question was posed to the

students as desired qualities when they seek a resource, not necessarily whether these qualities are strong determinants to their continued participation. For example, some students may seek a tutor with a great depth of understanding but may choose to not continue utilizing that tutor due to their lack of friendliness or empathy.

One of our goals in this study was to identify in general the factors that contribute to whether a student either continues or stops using a resource. Tutor qualities could factor into this decision, as discussed above. Also, students were given the opportunity to offer comments and criticisms of the Connections Chemistry Review program at the end of the semester. Many students indicated that they continued to use this resource because of its location, right in the center of the freshman side of campus. Students also indicated that they continued to use the resource if they felt that the tutor could explain the material well and perhaps in a novel way compared to the instructor. One student commented in a post-survey that "[Sessions were] very comprehensive in … information. [The tutors] knew their material well and could simplify difficult concepts". Another student commented, "[The review sessions] made a comfortable, open environment [for extra help]". This supports the theory that the students continued using the resource because they felt comfortable with the tutors.

Some students indicated they wish the sessions met more than once per week. This observation correlates with students choosing frequency as having high importance when utilizing a resource, as it may better fit with their scheduling as the semester progresses and new activities arise. Some students indicated that they stopped using the Connections Chemistry Review because they wanted help with more difficult material, not basic topics. For example, one student stated that he wished the review sessions would "spend more time on more difficult concepts instead of easier questions." This research study and feedback will be utilized at the Northeastern University College of Engineering to continue to improve upon the supplemental instruction offered to better serve the freshmen taking General Chemistry for Engineers and other required freshmen courses. The overall trend in retention has improved significantly over the past 5 years (from 85% freshmen to sophomore retention to 94%) in part we believe to supplemental instruction.

An underlying concern with any study of freshmen is making sure the students who elect to participate in the study truly represent the overall population that the study targets. This issue is complicated when students younger than 18 years old are excluded from participating, as was the case for a number of students taking general chemistry for engineers at Northeastern University. Freshmen in a common course required for all engineering majors, regardless of their choice of sub discipline for subsequent specialization, occasionally show up late for classes or neglect to participate, which further complicates the ability to administer surveys of freshmen. The number of responses we received (221), however, offer the opportunity to assess a significant number of students and their perceptions. Continued efforts are needed to identify the perceptions and needs of non-respondents and is a subject of current attention.

In conclusion, this paper revealed information that can be used to improve the implementation and design future resources for supplemental instruction for freshmen engineers. There is a confirmed gap in the trigger point for male and female participation in extra help resource programs. The analysis indicates that females will seek out extra help sooner than their male counterparts with the same grade standing in the course. Consequently, additional attention is warranted to encourage male students to seek extra help before their grades get to a C or lower.

Otherwise, no statistically significant differences were noted between male and female responses. Students seek out resources that involve people with whom they feel comfortable. Therefore, the provision of resources for extra help should consider involving undergraduates rather than graduate students or faculty, freeing up the time for these more experienced individuals to guide undergraduate tutors and help students who need a greater level of individualized attention. Students value convenience, not incentive, in an extra help resource. Resources should be provided frequently, close to freshmen residence halls, and at varied times. Students also desire tutors who have a high understanding of the material and have an ability to explain the material. Programs should strive to select tutors who can strike a balance between depth of knowledge and delivery of material. Paying attention to these attributes will increase the likelihood that students will participate in supplemental instruction.

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