
AC 2011-2404: A DROP-IN TUTORING PROGRAM TO SUPPORT FIRST-YEAR ENGINEERING

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A Drop-In Tutoring Program to Support the Retention, Self-Efficacy and Identity of Undergraduate Engineering Students

Abstract

In spring 2008 the College of Engineering and Applied Science at the University of Colorado Boulder established *an inclusive excellence* program with a focus on increasing the academic performance and retention through graduation of students who are underrepresented in engineering — including women, minorities, low-income and first-generation college students. The Broadening Opportunity through Leadership and Diversity Center (BOLD) Center hosts the Student Success Center (SSC), a drop-in tutoring initiative that is available for all engineering students, with an eye towards building inclusion.

Launched in fall 2008, the SSC's primary goals are to foster student learning, maximize academic performance in math and science foundation courses and ultimately curtail the loss of students during the first, second and third years of engineering study. This paper presents the motivations behind hosting a college-wide tutoring center through the diversity-serving program in the college, the role of the SSC in improving the retention and success of first- and second-year engineering students and a comparison of SSC users with the first- and second-year engineering non-user student population.

Our primary research focus is to assess the factors associated with the use of facilitated informal learning environments, such as the SSC, that can impact student self-efficacy, identity and retention. Research includes probing the reasons behind the increased success we observe in SSC users, the impact of tutoring practices on student retention (especially those underrepresented in engineering), and examining the interest and academic performance of first- and second-year men and women who both persisted in or left engineering.

This paper focuses on the results for 220 unique students who used the SSC more than 1050 times during the 2009-2010 academic year, with most seeking support for Calculus I-III, Chemistry and Physics. Staffed by two tutors at all times, the SSC provided approximately 2000 hours of SSC support during the year—approximately 35-40 hours per week.

Highlights of the results include very low numbers of SSC users who go on probation and suspension, and an average GPA that is on par, to slightly higher than, the college average. Numerous repeating students who come as a group to work with the same tutors each week lead us to conclude that the SSC plays a strong role in guiding student study groups that are facilitated in a positive and safe learning environment.

Background

Plenty of stories circulate about enthusiastic, high-caliber students who enroll in an engineering program, only to encounter the immediate stumbling block of the challenging, and oftentimes crushing, first-year course load. At the same time, these new students are faced with their first extended experiences away from home, with the accompanying freedom (and choice) to study or *not*. Too often, poor first-year academic results become the most important factor in students choosing to leave engineering studies. Problems arise as early as the first set of exams, and,

unfortunately, grades continue to decline through the remainder of the semester. Students often believe that they know how to salvage their surprisingly poor grades, as most were successful managing a heavy load of honors, AP and/or IB courses during high school. Earning good grades and demonstrating proficiency in high school was relatively “easy” for most engineering students. Yet, once in university-level engineering courses, many students are unable to improve poor grades because they make the realization too late in the semester that they need help, have ineffective study habits, and/or do not know how to seek and find help.

The performance profiles of the first- and second-year engineering students in our institution are shown in Figure 1. Despite higher grade point averages while in high school and an incoming predicted GPA of 3.15 upon admission to our college, our students’ mean first-year GPA during the past three years was ~2.84. After their first semester, on average, more than 8% of our ~700 first-year students have GPAs below 2.0, immediately placing them on academic probation.

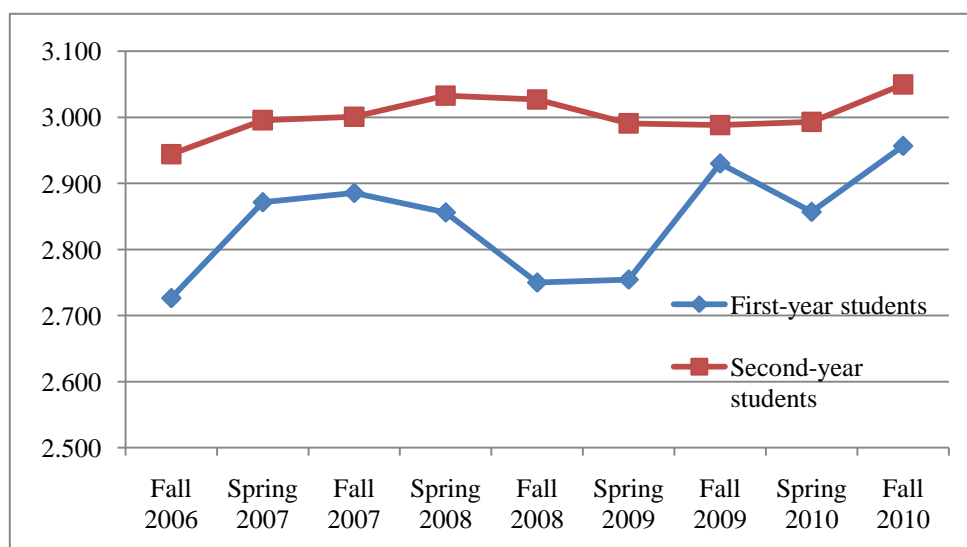


Figure 1. The average GPAs for each semester for first- and second-year engineering students from fall 2006 – fall 2010.

Over the past twenty years, our average retention rate of first-year students is ~80% (i.e., each year, by the start of the second fall semester, we have already lost 20% of our students from each entering cohort). And, after the passage of five years, we ultimately lose about 45% of each new undergraduate class — an unacceptably high loss of talented women and men. Our challenge was to take on this college-wide problem, and find ways for the BOLD Center to make a difference in the academic performance of first- and second-year college students to promote their retention in engineering.

Other engineering colleges offer various forms of drop-in tutoring or other types of academic support. The University of Wisconsin-Madison, for example, offers drop-in tutoring in their engineering library and tutoring help for several dozen courses, using more than 20 tutors.¹ Northeastern University offers drop-in tutoring for first-year engineering students in physics, chemistry, calculus and general engineering courses via two tutors.² University of Washington offers academic workshops in math, chemistry and physics courses,³ while UT Austin operates the Achieving College Excellence (ACE) program aimed at first-generation college attendees

and low-income students through their Division of Diversity and Community Engagement, as well as academic support for courses in all engineering departments.⁴ The academic performance results by students who use support programs such as tutoring are mixed; in a drop-in tutoring program focusing on math courses at Texas Women's University, there was no demonstrated link between the number of visits and the grade performance.⁵ In contrast, at Oklahoma State University, the academic workshops taught in residence halls were shown to benefit the students who attended.⁶ Budney and colleagues show that supplemental instruction using group learning for first semester courses directly correlated to retention through to graduation.⁷

We examined several student support programs already in existence in our college or on our campus:

- The college's student services program organizes individual or group tutoring sessions that have small, steady attendances.
- Similar to other campuses,⁸ individual tutoring in our campus' Engineering Quad residence halls is also offered.
- The Applied Math Department hosts calculus orals the week before exams, during which small groups of students at whiteboards simultaneously work with instructors and graduate students to solve problems to clarify concepts. Results indicate a 7-8% increase in the average test scores compared to students who do not attend.
- Also, the Applied Math Department offers weekly Calculus 1 and 2 (one-credit) workgroup classes, using a collaborative problem-solving approach.
- Perhaps our longest running example of a student support center occurs in physics, where as many as 100 students at one time can work with numerous graduate students on a drop-in basis.

Treisman showed that facilitated, collaborative study groups can be a model for academic excellence through a collaborative learning process.⁹ Through years of running "academic excellence workshops" in chemistry and calculus within our former Multicultural Engineering Program, we have had experience with and knowledge of the benefits of group learning environments, based on the work of Treisman.¹⁰ Finally, various campus departments, including physics and chemistry, use a "learning assistant" model in which undergraduates help faculty to facilitate classroom collaborative, problem-solving sessions.¹¹

By design, these support programs as a whole are limited — in their target student group, focus, hours of availability, or location — in their ability to help our engineering student population at large. To make academic support more broadly available, we started a program that is open to the entire engineering college student population by using the BOLD Center's inclusive and achievement-focused setting. We provide drop-in tutoring for chemistry, physics and math courses — the foundation courses required by all engineering disciplines — throughout the day, six days a week. Staffed by high-achieving, upper-division undergraduate and graduate student tutors, the Student Success Center's mission is to increase the overall retention and performance rates in engineering.

Establishing the Student Success Center

A primary obstacle to overcome was creating the financial means within our limited budget to support a staff of 10-12 undergraduate and graduate tutors. We proposed to pilot the program for the 2008-09 academic year to the student-guided (and funded) Engineering Excellence Fund (EEF).¹² This unique student organization, established 19 years ago, determines the distribution of over \$400,000 each year, raised from self-assessed, engineering student fees and tuition differential. Proposals submitted by college faculty, staff and students are evaluated based on the expectation that enhancements to student learning will be implemented. The BOLD Center's drop-in tutoring idea resonated with the nine-member EEF committee that is comprised of undergraduate and graduate students from all majors, and it was fully funded for its pilot and second-year. We subsequently garnered a combination of campus funds and corporate support from Chevron for the next two years.

Locating space conducive to individual *and* group learning was another obstacle to overcome. The BOLD Center initially agreed to provide dedicated space in one of its original study spaces — a small, ~100 ft² room equipped with white boards and tables, with seating for about 10 students.

We started with a schedule of 11 AM-7 PM, Mondays-Thursday and 4-8 PM on Sundays. Using marketing throughout the college and via faculty announcing its availability to students in their courses, the SSC soon outgrew its space and moved to a larger BOLD Center space of about 250 ft². The schedule was modified to a 9 AM start and an earlier finish of 6 pm, and we added hours on Friday while keeping the Sunday hours intact. This (current) modified schedule meets the needs of most students' schedules.

The SSC staff of tutors was recruited through recommendations provided by professors, as well as an application and interview process based on teaching experience, GPA and the ability to explain math or science concepts. Because the climate of the SSC is based on an *achieving excellence* (rather than a remedial) *model*, the average GPA over the past two years for the tutors — who represent most of the engineering majors — is 3.6.

Method and Participants

The SSC participants are primarily engineering students; more than 1,050 visits were made to the SSC. The method for the present study employs user surveys to investigate the SSC user experience. The surveys were administered in the 2008-2009 and 2009-2010 school years and generated 72 responses. See Appendix A for a list of survey questions. We also evaluated data from sign-in logs, official campus retention data and a brand new card swipe data system that enables direct access to student information, such as major and grade point average.

User Demographics

The primary users of the SSC are first- and second-year students. Figure 2 shows the demographics of the user population during the 2009-2010 academic year, in which 85% were first and second-year engineering students. Fifteen percent of the users are from other colleges, and 9% started in engineering and transferred to other colleges or no longer attend our university. Women and underrepresented minority students (URM) comprised 42% and 14%, respectively, of the total SSC users.

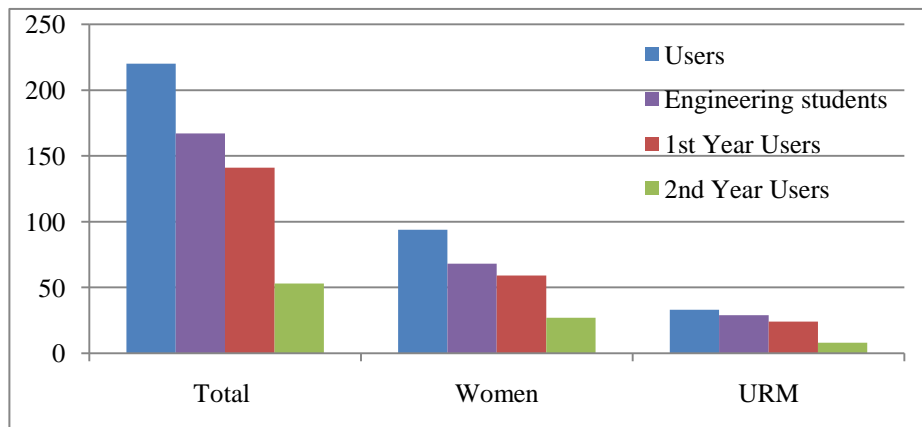


Figure 2. Distribution of all SSC users by demographic, including all engineering students, women, men and underrepresented minorities (URM).

SSC Students Benefits

Having dedicated tutors who know the course material enables productive learning sessions that enhance and clarify lecture and reading information, eliminate prolonged floundering while doing homework, and provide exam preparation guidance. Perhaps most importantly, a drop-in tutoring approach effectively meets individual needs as well as a range of levels of subject matter understanding.

SSC survey responses show that 96% of users ranked their tutoring sessions as effective to highly effective, and 71% reported academic improvements that they attribute to the SSC help.

The majority of SSC users, ranging from 60%-75% depending on the week, seek tutoring for math courses. Many of these same students also seek help for chemistry or physics. Tutors report that the most common area of struggle for students is developing conceptual understanding, especially in Physics and Calculus II and III.

The average GPA for SSC users is 2.99 overall, shown by demographic group in Figure 3. Most students using the SSC maintain good academic standing, with few put on academic probation (GPA < 2.0) or suspension (multiple semesters of GPA < 2.0 or cumulative GPA < 2.0). Since the SSC has been in operation, no more than four SSC users each year have been suspended.

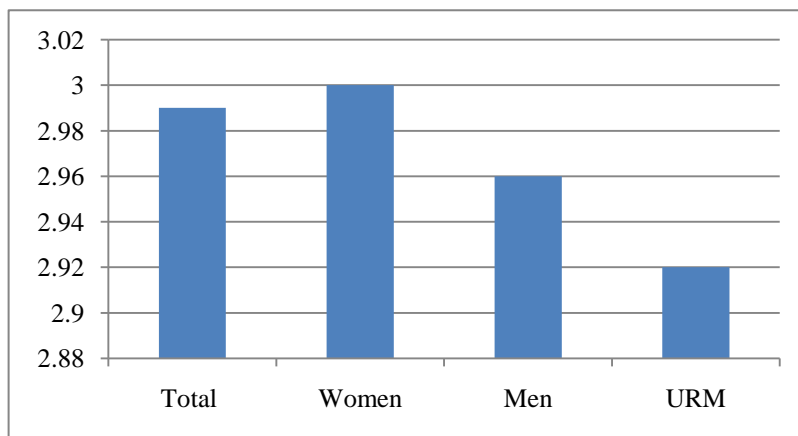


Figure 3. Average GPAs for SSC users, shown for all, women, men and URM students.

Tutors perform a variety of interventions to bolster understanding, by reviewing chapters and lecture notes, developing homework discussions, modeling the solution process, using examples and working on theory development. During fall 2010, many students sought SSC help for Calculus III after the professors made a significant change in the homework sets to emphasize conceptual understanding; students were frustrated by the comprehensive approach required for the solutions. To overcome these challenges, a regular group of students gathered in the SSC to work with the two applied math graduate students, who could help them reach solutions.

The SSC as an Inclusion and Retention Model

As the BOLD Center seeks to broaden participation in engineering for underrepresented student populations, the SSC can serve as a retention mechanism in support of this objective. Figure 4 examines the numbers of first- and second-year engineering students who used the SSC by student demographic. A summary of the findings includes:

- First-year women represented 27% of SSC users and 25% of the college’s first-year engineering women. Second-year women represented only 12% of SSC users and 17% of all second-year engineering women.
- First-year men represented 37% of SSC users and only 12% of all first-year engineering men. Second-year men represented only 12% of SSC users and 5% of all second-year engineering men.
- First-year URM students represented 11% of SSC users, and 32% of all first-year URM students sought tutoring from the SSC. Second-year URM students represented only 4% of SSC users, and 22% of second-year URM engineering students used the SSC.
- It should be noted that about 7% of users were juniors and seniors from a variety of majors including engineering.

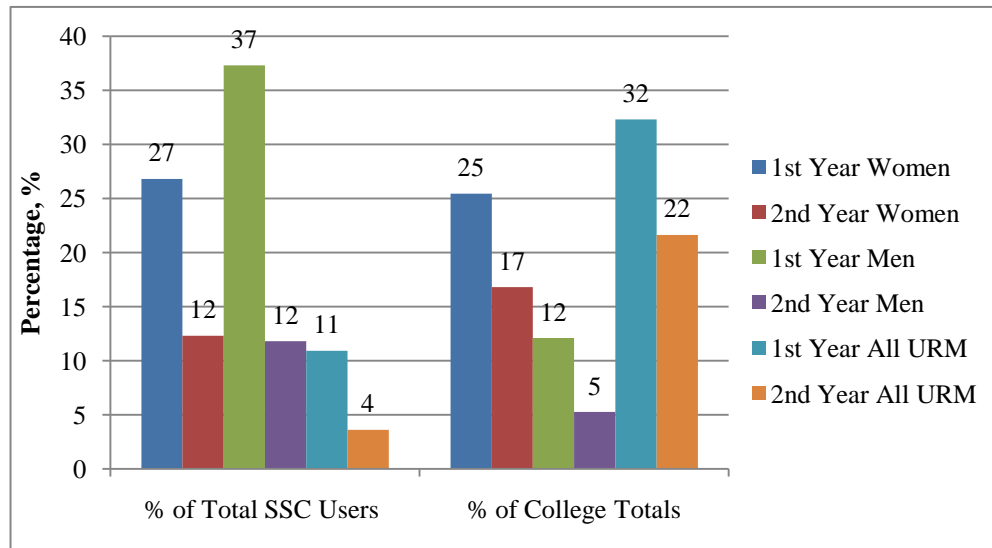


Figure 4. Percentage of first- or second-year engineering student SSC users who are women, men or URM.

The percentage of first-year women SSC users, 27%, is greater than its representation among our first-year engineering cohort, which is 24.6%. While the number of URM engineering students who use the SSC is small — 32 total students, of which 8 are first-year students — they represent nearly one-third of the first-year URM cohort and over one-fifth of the second-year cohort. Though first-year men (which includes both majority and URM men) are highly represented among the SSC users, they comprise a low fraction of the first-year engineering cohort. We note that the total number of second-year engineering students who use the SSC, 54, is small compared to the number of first-year SSC users, 129. Within this group, the percentages of second-year women and men who use the SSC are comparable but far less than the respective, first-year percentages.

Because the representation of women and URM students who use the SSC, especially in the first year, is greater than in the college, we contend that SSC offers an encouraging, inclusive-oriented, community environment. However, the drop-off in numbers of second-year users is concerning. Not only do we wish to boost usage, but we want to counteract the loss of students who leave during this important year. Bolstering usage must be a top priority so that more students can benefit and stay motivated to continue in engineering.

SSC users pervasively demonstrated higher rates of retention. Figures 5 (a) and (b) show the comparison of the retention of first and second-year students from 2009-2010 to Fall 2010 between SSC users and the college non-user populations. For instance, 80% of first-year women SSC users were retained to their second year, compared to 72% for all college first-year women, an 11% improvement. Here, the comparison is being made to the larger group that includes SSC users and non-users together.

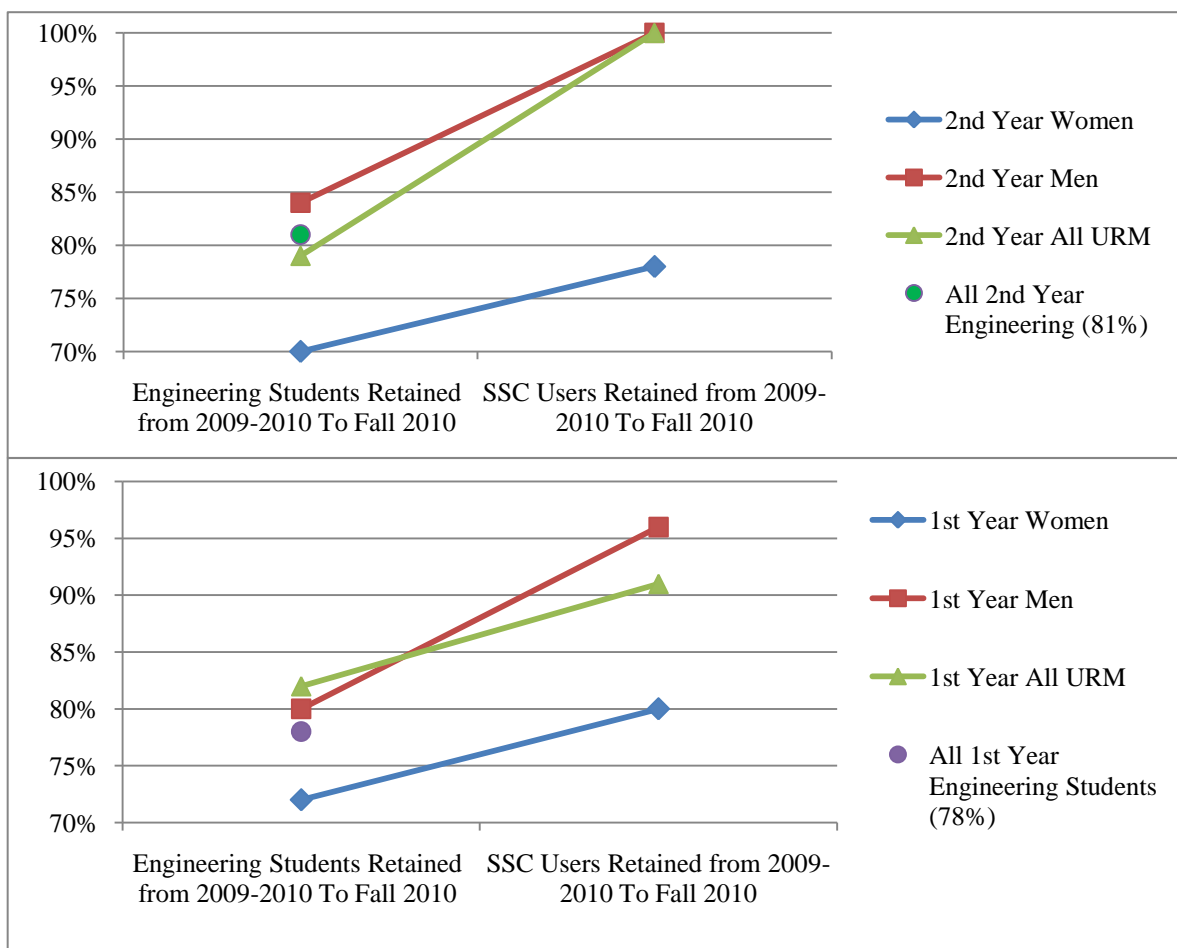


Figure 5 (a - top) and (b - bottom). Comparison of the retention of engineering students who used the SSC by gender and ethnicity for (a) second-year students and (b) first-year students.

The results for first-year men — 96% retention to the second year for SSC users compared to 80% for the college group, a 20% improvement — and URM students (91% for users compared to 82% for the college group, an 11% improvement) also show this result.

Higher rates of retention for second-year students are also shown for SSC users compared to the college populations: women — 78% vs. 70% (+11.4%); men — 100% vs. 84% (+19%); and URM students — 100% vs. 79% (+26.6%). The results suggest that tutoring programs like the SSC can play a strong role in improving the retention of students. The much higher rates of retention shown by the SSC users who were men (both majority and URM) and URM students (both women and men), compared to women, suggest that more evaluation is needed to identify the factors that may contribute to the higher likelihood of staying in engineering, and whether those factors can specifically apply to or affect women’s experiences in the SSC.

Leavers — Some evidence can also be gleaned from the 20 SSC users who left engineering. All were first- or second-year students, and 17 of the 20 were women, including two minority students. While the number of SSC users who left engineering is not large – only 9% of the total SSC user cohort – it is concerning that 85% of those who left were women. This finding corresponds to the lower retention rate of women, compared to men, who used the SSC; it is related to an overall pattern of declining retention rates for women in our college that highlights

the need for support structures like the SSC.¹⁴ To demonstrate the devastating effect on retention rates by the decision to leave, consider the following: if only four first-year and four second-year women leavers had chosen instead to remain in engineering, the retention rates for SSC women users would have increased to over 80%.

How different is academic performance among the leavers compared to those who were retained in engineering? The distributions of cumulative GPAs in Figure 6 for all SSC users, shown for “engineering students” and “students who started in engineering and left,” have similarities. Like those retained in engineering, the leavers generally were in good academic standing: ninety-five percent had GPAs ≥ 2.00 . Seymour and Hewitt also noted that women who leave engineering have GPAs that are on par with those who remain.¹³ As shown in Figure 6, 70% of students who left engineering have cumulative GPAs in the range of 2.50-4.00 and averaged 2.82 overall. Eighty-three percent of the women retained in engineering have GPAs in the range of 2.50-4.00, with an average GPA of 3.07. Might a quarter-point difference in GPA — from a grade of a B- to a B — be the tipping point for women?

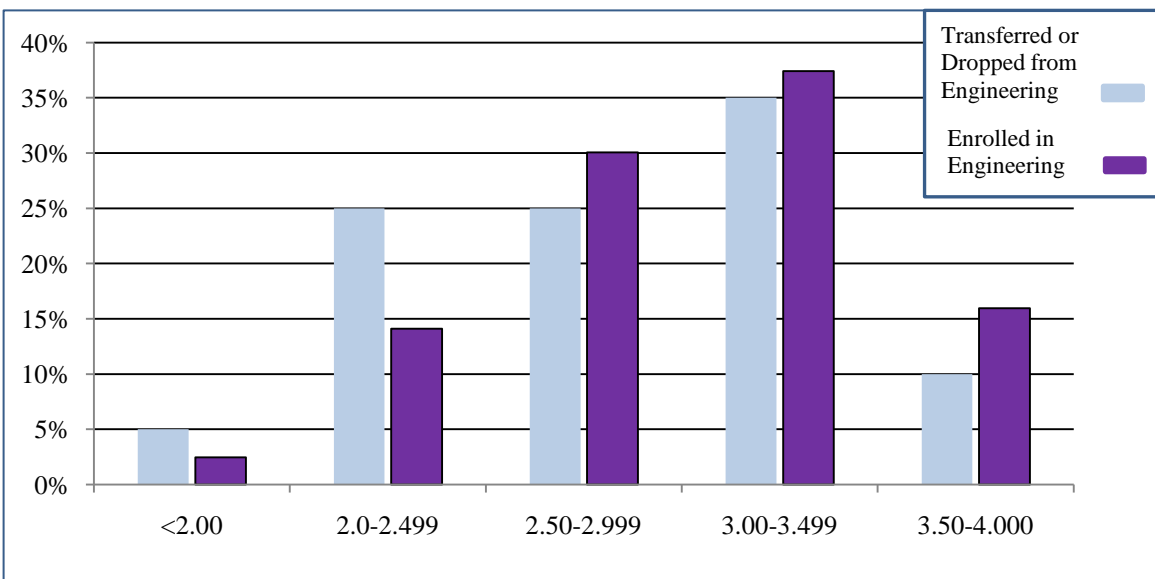


Figure 6. Distribution of GPA for SSC users who were retained in engineering or who left engineering

Figure 6 also suggests that achieving better than average grades is no guarantee that students will be retained in engineering. Forty-five percent of SSC students who left engineering earned grades of B or greater, a hallmark that is considered to be successful performance. However, we must remember that even with passing grades, some of these students might never be convinced that engineering is the right major choice for them. Factors such as interest and comfort level may have contributed to their decisions to leave.

More evaluative work needs to be conducted to determine additional interventions within and beyond the SSC that can be motivating factors for students for persisting in engineering. According to our previous work studying CU Boulder women’s retention in engineering, only 52% are satisfied with their academic performance, 44% have thought about dropping out

because of a grade they have received, and 41% found their academic performance different from what they expected in their first year.¹⁴

Others who have examined gender differences in academic performance and retention find that grades are only part of the story. Many students new to engineering have high school histories in which grades of A were relatively easy to obtain, and through weighted high school courses, a large percentage of engineering students had high school GPAs well above 4.0. Thus, they view themselves as “A level” students upon arrival in engineering. It may be difficult for these high-achieving students to accept lower than “A” performance in engineering where the work effort is prolonged and challenging. Felder and colleagues found poor grades lead to more women than men choosing to leave engineering earlier in the curriculum and that men persisted at a higher rate, despite having encountered academic difficulties.¹⁵ More women have been shown to admit to nervousness or anxiety about tests, attribute failures to their own lack of ability, and to demonstrate less confidence in getting the grades that satisfy their expectations.^{14,16, 17}

We can also examine the self-motivations of students whose lackluster performances may lead them to leave engineering instead of deciding to take on the challenge of mastering the courses in which they may struggle. In a comprehensive set of studies that examined student behaviors in approaching difficult problems to be solved,¹⁶ students demonstrated markedly different strategies: some relished the challenges, even the approaches leading to incorrect answers from which they learned, while others stopped trying to solve the problem altogether and lost confidence in their abilities.

SSC Gender-focused Interventions— Because we can demonstrate that using the SSC increases student retention in engineering, one suggested course of action might be to scale-up our efforts to engage more women in the program. Another might be to provide an over-representation of female tutors, whose presence can provide the gender role-modeling that is desired within the SSC’s academic environment. By increasing their academic abilities and self-efficacy, more women can reach the decision that they do belong in engineering and, thusly, stay in engineering.

We might also bolster the supportiveness perceived by SSC users. For instance, a tutor’s testimonial about her/his engineering identity may be a way to increase the understanding for a new student’s own developing identity, model that success can occur after experiencing low grades, and provide motivation to prepare for a professional career.

Looking Forward — On average, our first-year women arrive with higher high school GPAs and higher class ranks. Similar to other engineering schools, many of our students, notably women, enroll with numerous college-level credits for high school courses. By their second year, these students are likely to be enrolled in more advanced, core engineering courses, and finding academic support for these courses can be problematic. The SSC’s initial structure and funding model inhibited our ability to offer tutoring beyond the foundational math and science courses, despite frequent student requests. However, starting in fall 2011, we will add tutoring for a range of second- and third-year engineering courses, such as Circuits, Thermodynamics, Fluid Dynamics, and Probability and Statistics. Our past effectiveness in helping students in the Circuits and Material and Energy Balances courses in spring 2009 (which had numerous repeating students who worked in groups with the same tutors each week) leads us to the conclusion that we can play a strong role in guiding student study groups that are facilitated in a

positive and safe learning environment to support student performance and retention in engineering.

We suspect that women and URM students who use our drop-in tutoring program possess greater intentions and build self-efficacy to succeed in engineering. Because a low-barrier, open-tutoring forum helps cultivate community among students, the SSC can help to combat the feelings of isolation that academically successful, yet departing, engineering students often express. In the SSC we frequently see the same groups of students come repeatedly to work together, and tutors observe that many students use the SSC as their *homework location*, especially groups of men. And, we know that many students from our GoldShirt engineering program — a performance-enhancing first year for highly motivated but under-prepared students — are encouraged or, in some cases, required to use the SSC.¹⁸

In the 2010-2011 academic year we are encouraging the formation of more collaborative study groups in the SSC, by designating times for calculus sessions that are facilitated by specific tutors. In this manner, we can support, with the presence of a known tutor, the numerous students who want to meet others who are working on the same problems as they are.

We also plan to offer facilitated, collaborative, workgroups for Calculus 3 and Differential Equations, while also adding to the number of facilitated workgroups for Calculus 1 and 2 that do exist. These types of workgroups can also play a significant role in helping students new to engineering — especially women and URM students — to develop an academic community that knits them into the engineering structure and helps develop their identities as engineers. These additions to the SSC's offerings will mean that we can meet the academic needs for a far larger group of students.

Conclusions

The Student Success Center was established in the BOLD Center to provide academic support for foundation math and science courses using a drop-in tutoring format. Demand for the program has been demonstrated through numerous student visits that forced its relocation to a larger space. And, student user demographics confirm that the SSC is being used by a diverse group of students; women and URM students are represented in greater numbers in the SSC compared to college-wide numbers.

Students who use the SSC are retained at a higher rate than the general college population, leading us to believe that the drop-in tutoring program can play a greater role in increasing student retention, especially among women and minority students. While the number of students using the SSC who have left engineering is small, it is concerning that 85% were women. This result has implications for the future work of the SSC in expanding its offerings to attract more women and URM students to participate in this academic-enhancing program.

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Appendix A: Student Success Center Survey Questions

Survey Questions	Example Responses
1. Please indicate the course(s) for which you sought help.	Calc 1
2. How would you rank the effectiveness of your session? 1 (Low)–5 (High)	4
3. How competent were your SSC tutors in the subject matter? 1 (Low)–5 (High)	4

4. Did you receive information for test-taking strategies or study skills?	No
5. How functional is the room for this specific session? 1 (Low)–5 (High)	3
6. How many students were being tutored in the room with you?	4
7. Any comments or concerns?	<ul style="list-style-type: none"> • It really helped! • The tutor found any way he could think of to explain so that I would understand. • Will definitely come back.