

Engineering Enrichment Center Peer Tutoring Program: An Outcomes Evaluation

Abstract

The Engineering Enrichment Center Peer Tutoring program (EECPT) has been built on a fragment of the once comprehensive Maximizing Engineering Potential (MEP) program. EECPT seeks to replace the tutoring segment of the once robust MEP academic excellence workshop model. EECPT offers tutoring in the science and math courses foundational to all engineering majors, in a program designed to assist students identified as first generation, low income, or educationally disadvantaged (EOP) adjust to the rigors of an engineering curriculum, at a major research university. The goals of the tutoring program are to retain students in their respective engineering majors and to increase those students cumulative GPA. Slightly more than 50% of the students participating in the tutoring program were retained in their engineering major, however, ninety-five percent of the students in the program were retained at the university, a rate higher than the campus as a whole. The entire sample group-mean GPA increased during every quarter during the study period, as did the GPA for various cohorts grouped by student participation in EOP and/or by EECPT. Students not participating in EOP were more likely to be retained in their majors, but EOP students participating in EECPT were retained in their majors twice as often as EOP students not utilizing the tutoring program. Students participating in the program achieved increased GPAs each quarter during the study, allowing them to stay in their engineering major or providing them an opportunity to petition into the liberal arts college on campus. The literature repeatedly showed that tutoring programs aided retention, in part due to the individualized and interactive instruction provided via the tutoring environment. Although tutoring is only one of many opportunities that increase

retention, EECPT fulfills its mission by aiding in the retention of EOP students and assists in boosting all participating students' grade point averages.

Introduction

The Engineering Enrichment Center Peer Tutoring program (EECPT) is evolving from a program that was created to assist students identified as first generation, low income, or educationally disadvantaged (collectively referred to as EOP students) adjust to the rigors of an engineering curriculum at a major research university. The desired outcomes of the new program are to help students raise their cumulative GPA and to retain them in their engineering majors. The mechanism for achieving these goals is peer tutoring for the courses foundational to their majors, including: calculus, physics, chemistry and computer programming. Retention in this context refers to students remaining in their engineering major and maintaining or exceeding the required GPA threshold for moving from pre-major to full major status. This investigation assessed major retention and academic progress of EOP and non-EOP engineering student cohorts who had the opportunity to participate in EECPT during the 2004-05 academic year.

EECPT has replaced the Academic Excellence Workshop component of the state-wide maximizing Engineering Potential (MEP) program. The once robust MEP program also included a three-week summer bridge program to accelerate new students' academic and social acclimation to campus, academic advising, personal counseling, orientation and social activities, professional development, career advising and industrial interactions. The Academic Excellence Workshops were based on clustering students in the same sections of core engineering courses to create small-group learning cohorts outside of the classroom. Program administrators designed the workshops and created instruction modules and practice problem sets paralleling the course

outlines for calculus, chemistry, physics and computer programming classes. The cohorts met four times per week for course specific study sessions linked to their weekly homework. Trained student facilitators ran the study sessions and provided individual and group tutoring. MEP fulfilled its mission by providing activities and services that promoted the academic and social integration found to be critical to retention. Although under-prepared students still need programs that boost social interaction, and the demand for supplemental instruction in math, science and engineering courses continues to grow, budget cuts during the last five years forced the elimination of most of the components of this program.

ECCPT is being developed to meet an obvious student need. The program has been kept afloat by an influx of volunteer tutors and the largess of a few instructors and administrators. High achieving students in the College Honors Program and in the National Engineering Student Honor Society earn community service hours by serving as peer tutors for EECPT. The tutors are not trained and the program has not been systemically evaluated. An administrator matches students requesting tutoring with volunteers who select the subjects they wish to tutor. The program coordinator posts schedules advertising tutoring for individual courses at specific times, but the students are no longer clustered in cohorts by shared courses, and study modules are no longer prepared. Although the programs associated with MEP were originally designed to assist a wide range of educationally disadvantaged students succeed in science and engineering majors; data collected for this study showed that EECPT provides both EOP and non-EOP students with a structured tutoring program. This evaluation assesses if the Engineering Enrichment Center Peer Tutoring program is fulfilling its mission to retain EOP students in their Engineering major and if EOP students' cumulative grade point average (GPA) increased after participating in the program.

Literature Review

President James Garfield recognized the ideal teaching relationship when he proclaimed that the model university was Mark Hopkins at one end of a log and a student on the other. More than a century later, current educators are revalidating the importance of interactive (Craig, Driscoll & Gholson, 2004; Saunders, 1992) and individualized (Bergen & Mi, 2002; Higgins, 2004) instruction. The evolution of higher education during the last 100 years has greatly reduced the amount of one-on-one teaching. Peer tutoring is among the current campus resources providing individualized and interactive learning experiences. Recent literature revealed that various peer tutoring applications had a positive effect on academic achievement and subsequent retention (Henderson, Fadali & Johnson, 2002). In 2002, Bergen and Mi identified peer tutoring as successful in achieving academic gains outside the classroom and as well as being cost effective. In 2004, Craig et al., found that tutoring instigated interactive and individualized learning, with either a human or a computer tutor. Higgins' 2004 study on the retention of at-risk nursing students also supported Saunders (1992) findings that, particularly in the poly-technical fields, peer tutoring fosters individualized learning adding to students' academic success. Peer tutoring was also identified as beneficial because it allows students to question and explore academic material in a supportive environment, without fearing faculty judgment (Bigood, 2004). University structure and current faculty to student ratios prevent the majority of collegiate teaching from occurring through individual instruction. Peer tutoring supplements traditional lecture style instruction and compliments academic integration by providing an environment that immerses the student in interactive and individualized learning (Cambiano, Denny & DeVore, 2004; Codjoe & Helms, 2005; House & Wohlt, 1990;

Longerbeam, Sedlacek & Alatorre, 2004). Peer tutoring provides learning opportunities that require social interaction and compliment academic progress.

Multiple studies have concluded that academic and social integration are critical to college student retention (Cambiano et al., 2004; Coddie & Helms, 2005; Longerbeam et al., 2004; Saunders, 1992) and that interactive and individualized instruction were found to be effective in decreasing the departure of at-risk students from the university (Bergen & Mi, 2002; Higgins, 2004; Landis, 2005; Maggio, White, Molstad & Kher, 2005). First generation, female, and under-represented college students have been identified as under-prepared for college, more often than their white-male peers. However, all students clearly benefit from small group, interactive, and student-centered instruction, despite their economic, cultural or educational background (Bigood, 2004; Burdman, 2001; Hodges & White, 2001; House & Wohlt, 1990; Rheinheimer & Mann, 2000). Tutoring is one of the interactive experiences repeatedly shown to aid in retention (Burdman, 2001; Butler, 1999; Craig et al., 2004; Hodges & White, 2001). Additionally, multiple analyses have shown that tutoring is most successful when combined with a variety of support, including: orientation programs, faculty interaction, academic advising, financial aid assistance, mentoring and career counseling (Fields, 2002; Foreman, Wilkie & Keilen, 1990; Henderson et al., 2002; Hodges & White, 2001; Miller 2004). House and Wohlt (1990) reported that students that had participated in freshman tutoring programs earned more credit hours and earned higher GPAs at the end of term than the students not participating. The literature reviewed for this study repeatedly validated that peer tutoring is a mechanism that fosters academic and social integration and is a valuable component of retention.

The scholastic effects of peer tutoring are buoyed by multiple factors. Students are more comfortable disclosing their lack of knowledge or under-preparedness to a peer rather than to a

professor. Students gain a deeper understanding of new material when discussed in familiar terms, can use the tutor to help identify the most important information to remember (House & Wohlt, 1990) and frequently adopt more effective study habits due to their experiences with peer tutoring (Foreman et al., 1990). The tutee is less likely to be defensive or to fear reticence with a peer tutor than with a professor and gains a positive attitude about learning and experiences increased self-esteem in the neutral tutoring environment (Bergen & Mi, 2002). Students also reported academic gains and increased confidence due to the self-paced instruction provided by tutoring (Higgins, 2004; House & Wohlt, 1990; O'Connell & Schrader, 2003). Saunders (1992) also documented that peer tutors enrolled in, or attending, the courses for which they tutor enrich their tutees' understanding of the professors' lessons by reiterating and restating the very material the tutee heard presented in lecture. Additionally, tutees make valuable connections with other students during tutoring and in the related small-group study sessions, adding to their feelings of belonging on campus (House & Wohlt, 1990; Longerbeam et al., 2004; Hernandez, 2000). The collective gains of peer tutoring enhance both academic comprehension and provide under-confident students a experience in learning how to learn.

Multiple factors affect tutoring outcomes. Rheinheimer and Mann (2000) examined gender matching and tutor/tutee pairing based on cultural background and found that tutor training and attitude was more important to increased GPA than either gender or cultural matching. In 2002, Henderson et al. concluded that tutor training, and a tutoring environment based on mutual respect and trust, led to positive outcomes. Craig et al. (2004) found that any tutoring increased student outcomes, but that learning gains increased in programs with trained tutors. Hodges and White (2001) referred to the 1999 work of Boylan, Bonham, & Bliss that showed students achieved the greatest gains in tutoring programs that were regularly evaluated.

Bidgood (2004) reported that tutoring was very valuable, and that tutors with strong training and a mentoring system for the tutor were most successful. One study reported secondary benefits of peer tutoring extend to the tutor, including enriched communication and teaching skills (Bigood, 2004) and positive feelings that expanded self-esteem (Bergen & Mi, 2002). Tutor training and the attitudes of the participants emerged as vital factors in the learning gains achieved by participants in peer tutoring programs.

Students utilizing peer tutoring services frequently benefited from a broad range of campus services, including: orientation programs, mentoring, career counseling, financial aid workshops and frequent academic advising (Butler, 1999; Fields, 2002; Maggio et al., 2005; Reason, 2003). As an example, when the tutoring program for at-risk students at the University of Kansas added orientation and mentoring components for their students, retention rates surpassed the general student body rates (Dunn & Stevenson, 1997). Landis (2005) also reported that minority students needed more than the traditional student services of counseling, advising, and tutoring, and included that assistance with obtaining scholarships, internship placement and participation in campus organizations, as components that were critical to collegiate success. A study on students struggling with academic probation showed that structured study time, weekly meetings with faculty or staff mentors and study-skills seminars, all contributed to significant improvement in GPAs, with one third of the sample population returned to good academic standing (Foreman et al., 1990). Miller's 2004 study on instructional challenges, added that note-taking and study skills training were necessary in successful enrollment management programs. Hernandez (2000) reported that students involved in campus activities, both academic and non-academic, were more likely to feel that they belonged on campus, increasing their desire to succeed in college. Student support systems that combine tutoring, mentoring, faculty

interaction, small study groups and study-skills seminars, with the traditional services of counseling, academic advising and orientation programs boost academic integration. Students need a combination of personal fortitude and determination, coupled with a broad range of scholastic and community experiences and students services, to achieve the academic and social integration that is fundamental to collegiate success (Cambiano et al., 2004; Codjoe & Helms, 2005; Longerbeam et al., 2004; Saunders, 1992).

Higgins (2004) touts peer tutoring as a mechanism to slow the departure of at-risk students from higher education. Hendersen et al. (2002) concluded that students found tutoring to be a very successful strategy for improving their understanding of math and other subjects. Bergen and Mi (2002) found that peer tutoring was superior to a self-instruction module or the traditional lecture style of instruction, in building a positive attitude toward learning, increasing self-esteem and in becoming a more efficient learner. Students reported psychological benefits from tutoring, including a reduction in anxiety and improved self-confidence in the 1990 House and Wohlt study on the effect of tutoring on under-prepared freshmen. Burdman (2001) discussed tutoring as an enrichment tool for non at-risk students, a forum for excellence, not just survival. Cambiano et.al. (2000) concluded that student development is a major mission of higher education and retention is key to students attaining that maturity. Rheinheimer and Mann (p.1, year) state “tutoring has consistently been found to have a positive impact on retention, final grades in tutored courses, course completion and graduation rates.” The literature repeatedly showed that a variety of peer tutoring programs enhanced academic outcomes and increased retention rates for a diverse range of student populations.

The Method

This evaluation assessed if the Engineering Enrichment Center Peer Tutoring program fulfilled its mission, during the 2004-05 academic year, to retain students in their Engineering major and if students' cumulative GPA increased after participating in the program. The College population was 1,603 in Fall 2004 and 90 of those students participated in EECPT. A random sample of 35 students who enrolled in the tutoring program was selected for this study. A second random sample of 35 students was selected from the remaining college population; increasing the sample size and composition allowed for a broader analysis. The following data were extracted from an existing database for each student.

- Major in Fall 2004, Winter 2005 & Spring 2005
- GPA in Fall 2004, Winter 2005 & Spring 2005
- EOP status
- Sex

A chi-square test was used to compare expected and observed rates of retention for each sample population. The frequencies within, and between the groups, were compared. A new variable, 'GPA diff', was created representing the change in GPA from F'04 to S'05. Both one-sample *t*-tests using the variable 'GPA diff' and two-sample *t*-tests on GPA data from each quarter were run. These tests yielded identical results, verifying my belief that data manipulation and various statistical methods can be used to generate the same numeric outcomes. The results of the one-sample *t*-tests were used to compare changes in group mean GPA for the four cohorts: EECPT and EOP, EECPT and non-EOP, not-EECPT and EOP, and not-EECPT and non-EOP. The results of both the one-sample and the paired-sample tests are included in the appendix. Descriptive statistics were also performed to determine if the random samples reflected the populations from which they were drawn.

The Results

A Pearson Chi-Square test was used to compare the expected and observed rates of retention in the students' engineering majors at the end of the study period. Twenty of the 38, or just over 50%, of the students participating in the peer tutoring program were retained in their major after Spring quarter 2004. Thirty-four of 38, or almost 90%, of the students not participating in the program were retained in their major during the same time. This sample indicated that students not participating in the program are more likely to be retained in their engineering majors; this finding was significant at the .001 level. Whereas the students were more likely to be retained in their engineering majors if they were not participating in the program, it should be noted that 36 of the 38 program participants were retained at the university at the end of the study period – just two students withdrew completely from campus.

Grouped Chi-Square tests compared retention in the major at the end of the study period based on participation in EOP; the results were significant at the .001 level. Thirty-five of the 44 non-EOP students (almost 80% of them) were retained in their majors at the end of the study period. Conversely, just 19 of 32 of the EOP students (less than 60%) were retained in their majors at the end of the study period. This analysis showed that non-EOP students are more likely to be retained in their engineering majors, regardless of tutoring assistance.

A *t-test* was used to compare the year-end GPA differences between the tutored and non-tutored student groups. Both the tutored and the non-tutored groups experienced positive increases in mean GPA during the project timeframe, but the students participating in the program had a greater group mean increase in GPA, significant at the .001 level. A one-sample *t-test* was used to evaluate the mean GPA gains of the students grouped by EOP and program participation. All four groups had GPA increases between Fall 2004 and Spring 2005, with the

EOP students participating in the tutoring program having the greatest GPA gains. This group had an average gain of 0.185 grade points, significant at the .001 level.

Thirty of the 76, or almost 40%, of the students were female, 17 participated in EECPT. Thirty-two, or just over 40%, of the students participated in EOP, 15 of the EOP students were female. The EECPT students' group mean GPA was 2.38 in Fall 2004, and the non-EECPT students' group mean GPA was just over .5 higher, at 2.95. At the beginning of the study, the minimum GPA in the EECPT cohort was 1.58 and the maximum GPA in the cohort was 3.46. At the end of the study, the minimum GPA in the group improved to 1.81 and the maximum GPA increased to 3.66. The minimum GPA in the not-EECPT cohort was 1.67 and the maximum GPA in the cohort was 4.00. At the end of the study, the minimum GPA in the not-EECPT group improved to 1.90. The group mean GPA for each cohort increased during each quarter of the study.

Conclusion

The students, sampled for this study, benefited from their participation in the Engineering Enrichment Center Peer Tutoring program. Over half of the participants were retained in their major at the end of the year. This finding is not surprising given the results of numerous studies showing that tutoring repeatedly aided retention. Although the program may not be meeting its goal of retaining *all* students in their engineering majors, almost 95 percent of the students participating in the program were retained at the university at the end of the study. Since the campus wide retention rate for lower division students is about 85%, the program appears to positively affect retention at the university, if not the in college. Perhaps most importantly, half of the EOP students participating in the tutoring program were retained in their majors at the end of the study period, compared to only 25 percent of the EOP students not participating in the

program. These results clearly indicate that – for EOP students at least – participation in the program may have a positive effect on retention rates. This finding is reason alone to further develop the program and to get more of the college’s EOP students involved in activities specifically designed to bolster their collegiate success.

Although retaining students in an engineering major is one of the goals of the tutoring program, the second goal of the program, an increased GPA, is perhaps more important. The overall mean GPA for the students in EECPT increased at the end of each academic quarter during the study. For some students, the tutoring program assisted in increasing their GPA to 2.0 or greater, which was the key to being accepted into the College of Letters and Science; for those students the program seemed instrumental in their retention at the university. So despite leaving the College of Engineering, students who raise their GPA are more likely to be retained at the university, regardless of major. In that multiple factors affect fluctuations in GPA, the tutoring program certainly is not solely responsible for the group mean increases in GPA for students participating in EECPT, but apparently the program helps.

Multiple factors could have biased this evaluation. The undergraduate population in engineering is less than 16% female, but almost 40% of the sample was female. It is common knowledge that more females, than males, use student service resources, but the non-EECPT cohort had proportionally more women than men in it as well. Over 42% of the sample participated in EOP, but only 28% of the campus as a whole is similarly identified. To better understand the sample’s representation of the whole population, statistics that were unavailable during this study would be needed. Additionally, some students are better prepared for college than others, as evidenced by the difference in retention-in-major rates between the EOP and non-EOP cohorts. The non-EOP and non-EECPT students also had higher starting and ending GPAs

than the EECPT participants, and had the greatest number of students retained in their major. That cohort seemed to be adequately prepared for college and able to succeed in engineering without the tutoring program. The successes of the more prepared students should not be used as a benchmark for all the cohorts examined in this study. Further analysis, with cohorts grouped by other factors known to affect retention, should be performed to better isolate the effects of tutoring.

The literature reviewed for this evaluation showed that multiple factors affect retention. However, much has been gained by this analysis. Prior studies repeatedly showed that tutoring was most successful when packaged with faculty interaction, small study groups, mentoring, academic advising, personal and career counseling and study skills seminars. This research reaffirms that the original MEP model should be re-implemented at the earliest opportunity. The college should return to clustering small cohorts of under-prepared students in the science and math courses foundational to success in engineering. A tutor training program should be designed to insure that tutors provide, and grow from, these valuable, shared learning experiences. Mechanisms that increase faculty and student intellectual, and social, interaction outside the classroom need to be developed. The EOP students who did not participate in EECPT and had the highest exodus rate from the college need to be included in the program. The addition of these services and opportunities would compliment the existing program, but the current Engineering Enrichment Center Peer Tutoring already aids in retention and the academic success of the program participants.

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Results Appendix

Cross-tabulations and Chi-Square Tests

EECPT * Retained Crosstabulation

Count		Retained		Total
		Not retained	Retained	
EECPT	N	4	34	38
	Y	18	20	38
Total		22	54	76

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	12.539 ^a	1	.000		
Continuity Correction ^b	10.811	1	.001		
Likelihood Ratio	13.308	1	.000		
Fisher's Exact Test				.001	.000
N of Valid Cases	76				

a. Computed only for a 2x2 table

b. 0 cells (.0%) have expected count less than 5. The minimum expected count is 11.00.

EECPT * Retained Crosstabulation

Count			Retained		Total
			Not retained	Retained	
N	EECPT	N	1	25	26
		Y	8	10	18
	Total		9	35	44
Y	EECPT	N	3	9	12
		Y	10	10	20
	Total		13	19	32

Chi-Square Tests

EOP		Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
N	Pearson Chi-Square	10.775 ^a	1	.001		
	Continuity Correction ^b	8.424	1	.004		
	Likelihood Ratio	11.376	1	.001		
	Fisher's Exact Test				.002	.002
	N of Valid Cases	44				
Y	Pearson Chi-Square	1.943 ^c	1	.163		
	Continuity Correction ^b	1.045	1	.307		
	Likelihood Ratio	2.008	1	.156		
	Fisher's Exact Test				.267	.153
	N of Valid Cases	32				

a. Computed only for a 2x2 table

b. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 3.68.

c. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 4.88.

T-Tests

One-Sample Statistics

EECPT		N	Mean	Std. Deviation	Std. Error Mean
N	GPA diff	38	.0542	.15002	.02434
Y	GPA diff	38	.1250	.20984	.03404

One-Sample Test

EECPT		Test Value = 0					
		t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
Lower	Upper						
N	GPA diff	2.228	37	.032	.05421	.0049	.1035
Y	GPA diff	3.672	37	.001	.12500	.0560	.1940

One-Sample Statistics

EECPT	EOP		N	Mean	Std. Deviation	Std. Error Mean
N	N	GPA diff	26	.0742	.14763	.02895
	Y	GPA diff	12	.0108	.15222	.04394
Y	N	GPA diff	18	.0589	.18153	.04279
	Y	GPA diff	20	.1845	.21999	.04919

One-Sample Test

EECPT	EOP		Test Value = 0					
			t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
							Lower	Upper
N	N	GPA diff	2.564	25	.017	.07423	.0146	.1339
	Y	GPA diff	.247	11	.810	.01083	-.0859	.1076
Y	N	GPA diff	1.376	17	.187	.05889	-.0314	.1492
	Y	GPA diff	3.751	19	.001	.18450	.0815	.2875

T-Test

Paired Samples Statistics

EECPT	EOP			Mean	N	Std. Deviation	Std. Error Mean
N	N	Pair 1	F'04 GPA	3.0958	26	.55466	.10878
			S'05 GPA	3.1700	26	.53286	.10450
	Y	Pair 1	F'04 GPA	2.6433	12	.52234	.15079
			S'05 GPA	2.6542	12	.57019	.16460
Y	N	Pair 1	F'04 GPA	2.5078	18	.51332	.12099
			S'05 GPA	2.5667	18	.52042	.12266
	Y	Pair 1	F'04 GPA	2.2760	20	.28197	.06305
			S'05 GPA	2.4605	20	.31275	.06993

Paired Samples Correlations

EECPT	EOP		N	Correlation	Sig.
N	N	Pair 1	F'04 GPA & S'05 GPA	.964	.000
	Y	Pair 1	F'04 GPA & S'05 GPA	.965	.000
Y	N	Pair 1	F'04 GPA & S'05 GPA	.938	.000
	Y	Pair 1	F'04 GPA & S'05 GPA	.731	.000

Paired Samples Test

			Paired Differences								
			Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)	
EECPT	EOP					Lower	Upper				
N	N	Pair 1	F'04 GPA - S'05 GPA	-.07423	.14763	.02895	-.13386	-.01460	-2.564	25	.017
	Y	Pair 1	F'04 GPA - S'05 GPA	-.01083	.15222	.04394	-.10755	.08588	-.247	11	.810
Y	N	Pair 1	F'04 GPA - S'05 GPA	-.05889	.18153	.04279	-.14916	.03138	-1.376	17	.187
	Y	Pair 1	F'04 GPA - S'05 GPA	-.18450	.21999	.04919	-.28746	-.08154	-3.751	19	.001