AC 2007-804: A PEER-LED TEAM LEARNING PROGRAM FOR FRESHMEN ENGINEERING STUDENTS: IMPACT ON RETENTION

Pilar Pazos, Northwestern University

PILAR PAZOS is Research Associate at the Searle Center for Teaching Excellence at Northwestern University. She holds a Ph.D. in Industrial Engineering from Texas Tech University. She is involved in evaluation of undergraduate programs, specifically the GSW Program.

Denise Drane, Northwestern University

DENISE DRANE is Assistant director at the Searle Center for Teaching Excellence at Northwestern University. She holds a Ph.D. in Speech and Language Pathology from Northwestern University. In addition to overseeing various research projects at the Searle Center, her involvement specifically includes designing the evaluation strategy for GSW.

Gregory Light, Northwestern University

GREGORY LIGHT is the Director of the Searle Center for Teaching Excellence and an associate professor in the School of Education and Social Policy at Northwestern University. He holds a Ph.D. in Education from the University of London, UK, and focuses his research on the theory and practice of learning and teaching in higher education.

Annette Munkeby, Northwestern University

ANNETTE MUNKEBY was a Graduate Research Assistant and program coordinator of the Engineering Workshops at the Searle Center for Teaching Excellence at Northwestern University. She is currently working towards her Doctorate in Music (DMA) at Northwestern University.

A Peer-Led Team Learning Program for Freshmen Engineering Students: Impact on Retention

Abstract

This paper evaluates an innovative instructional approach based on peer-led team learning available to freshman students in the Engineering School at an R1 university in the Midwest. The paper builds on results of a previous study which found a positive impact of the program on grades, an effect that was particularly significant for women. In an attempt to go one step further in evaluating the program's impact on academic success, we assessed the impact on student retention in a four course engineering sequence. The Workshop Program itself consists of small, diverse groups of students meeting weekly to tackle conceptually-based, challenging problems related to their classes. The program aims to promote conceptual learning and high academic achievement using a collaborative environment and is optional and complementary to the lecture classes. Retention was evaluated based on completion of a 4-course required sequence that is a core component of the engineering curriculum. Logistic regression analysis was conducted using incoming math SAT to control for pre-existing differences in students academic ability. Results indicate that students in the workshop have a significantly higher probability of completing the four-course sequence. Findings indicate that a workshop program using undergraduate leaders is an appropriate model for increasing students' academic success in freshmen undergraduate engineering courses.

Introduction

Increasing student retention among under-represented groups of students has become an important goal for higher education in the US. Demographic changes in academic institutions have called for new approaches to reduce attrition. Many institutions are making efforts to retain students, using strategies that focus on students' first-year experience in college. While there has been substantial encouragement for the introduction of instructional innovation in undergraduate engineering[1], there has been less interest in the development of innovative study programs devoted to increase performance and retention in Engineering.

This paper reports on the impact of the Engineering Workshop Program (EWP), a problem based, peer-led and collaborative group study program offered to all first year engineering students taking the Engineering Analysis (EA) sequence in the School of Engineering at Northwestern University. A previous study on the EWP program from 2001 to 2003[2] found a positive impact of the program on the academic performance of women. In this initial study, female workshop participants were statistically significantly more likely to be awarded a grade of B+ or better in 6 of 9 quarters than their female counterparts who did not participate in the program. In contrast, male participants had statistically significantly higher odds of obtaining a grade of B+ or better than male non-participants in only 2 of 9 quarters. While grades are an important indicator to evaluate student success, the rate of students completing academic degrees within the disciplines might be considered the critical success measure. Therefore, in this new study we conducted an analysis to determine whether the workshop program also had a positive impact on retention, and if it did, to determine whether the impact was again restricted to women, or extended to all participating students.

Engineering Analysis Course Context

All first year engineering students at Northwestern's McCormick School of Engineering are required to complete the four quarter, introductory EA sequence. While trailing classes are offered to transferring students and students who fall behind, the majority of engineering students start the sequence during their first quarter in college and complete it early in their second year. As a completed EA sequence is a core requirement for the engineering curriculum, retention within the sequence is an early indicator of whether students will eventually major in engineering. The EA course sequence integrates math, science and computer programming with engineering applications, and as with typical "gateway" courses in other science based disciplines, EA courses are taught in large lectures of about 80 students in each section. Parallel to each EA course, all students are offered the option of taking part in the Engineering Workshop Program.

EWP Program History and Structure

The EWP program at Northwestern University's McCormick School of Engineering was introduced in the Engineering Analysis course sequence in 2001. It was created as an extension to the Gateway Science Workshop (GSW) program that had been established for sophomores in introductory Biology at Northwestern in 1997[3] and extended to freshman chemistry and introductory physics course sequences in 1998[4]. The GSW program itself was modeled on the Emerging Scholars Program developed by Uri Treisman in calculus at the University of California at Berkeley and the University of Texas at Austin[5,6,7].

In the engineering workshops, students meet once a week in groups of 5-7 to solve conceptually challenging problems related to the course material and designed by course faculty. Workshop problems are intended to be more challenging than regular homework and are designed to encourage group discussions and joint efforts in solving them. Each workshop is facilitated by a student who participated in the EWP program and excelled in the course the previous year. These student facilitators receive weekly training by faculty on the workshop problems and are enrolled in a special course designed to develop their facilitation skills and understanding of teaching and learning. Most facilitators typically participate in the workshop program one year after they finish their own EA course sequence and workshop experience. The facilitators receive an academic credit for facilitating the workshops and completing the training course. Since there are indications that the facilitators may also benefit from the program with regard to their own learning, motivation and retention,[8] a deliberate choice has been made to engage new students as facilitators every year.

The students who choose to participate in the workshop program sign up voluntarily. All students are invited to join the program during the first week of the quarter by in-class announcements and email invitations. The invitations characterize the workshops as advanced and express a strong trust in the ability of the students to benefit from, and contribute to, the intellectual work of the student learning community. To further recruitment goals, program coordinators also visit special engineering student interest groups, such as the Society of Black Engineers, the Society of Hispanic Professional Engineers and Society of Women Engineers. Due to the engagement of a limited number of facilitators during the initial years, approximately half of the students who expressed an interest in participating were offered a spot in the program. To ensure a diverse student population, all minority students who applied were allowed into the program. Majority students were selected into the program to ensure approximately equal numbers of male and female participants. Overall, about 20% of all students in the EA classes participated in the workshops during the first three years. Since the implementation of a fully developed credited training program for facilitators in the fall of 2004 a higher number of facilitators were engaged and most students who expressed an interest in the program were accommodated.

Pedagogical Characteristics of the Program

The EWP program has several pedagogical features that are likely to promote learning and high academic achievement. By involving problem-focused, collaborative work in small groups, the program aims at counteracting many of the difficulties associated with large, introductory lecture

courses such as the lack of opportunity for students to receive feedback, the lack of time for cognitive elaboration and reduced student engagement. The dynamic learning communities created by the workshops offer students the opportunity to exercise critical judgment, analyze statements and causes, question underlying assumptions and check for underlying assumptions. In addition to the academic gains that might be measured by student's performance in class, we believe that the workshop experience may also increase student interaction and peer support to such an extend that it positively influences participating student's motivation for further study and investment in their discipline.

Research Methodology

Subjects

Subjects in this study comprised 337 freshmen students from the College of Engineering at Northwestern University who registered for the first course in the EA sequence during Fall 2004. Students in the College of Engineering are typically required to complete the sequence by the end of the Fall of the following year i.e.2005. Students from Computer Science were not included in the analysis since they have a different set of requirements and represent only 2% of the overall student population taking the Engineering Analysis sequence. Seventy-six percent of the students in the sample were male and 24% female, 86% majority, 8%minority and 5% of undeclared ethnicity. At Northwestern University, the majority student population is composed of white and Asian American students whilst the minority population (approximately 10% of the total student population) is composed of African American, Hispanic and Native American students. Table 1 shows number of workshop participants by gender and ethnicity.

Table 1. Workshop participation by gender and minority status. [*]

		Count
Male	Workshop	62
	Non-workshop	187
Female	Workshop	32
	Non-workshop	47
Majority	Workshop	74
	Non-workshop	213
Minority	Workshop	11
	Non-workshop	10

Workshop Participation

Workshop participation was the main independent variable in the study. Participation in the workshop was voluntary. All EA students were invited to participate in the workshop by GSW staff during the first EA lecture of the Fall quarter. Announcements were also made to students during meetings of the Society of Black Engineers and Women in Engineering groups over the

[*] Note that the number of majority and minority students does not sum to 337 as 24 students chose not to disclose their ethnicity.

summer. The workshop is characterized as a collaborative advanced conceptual workshop, open to students of all levels of ability. A student was defined as a participant in the workshop program in a given quarter if they attended at least 8 of the 10 workshop meetings in the quarter.

Participation in the workshop by gender and ethnicity for the Fall 2004 quarter is shown in Figure 1. The percentage reported represents the percent of each group who participated in the workshop. For example, 25% of males registered in EA participated in the workshop in the Fall quarter. Females participated in the program at higher rates than males and minority students also participated in higher rates than majority students.

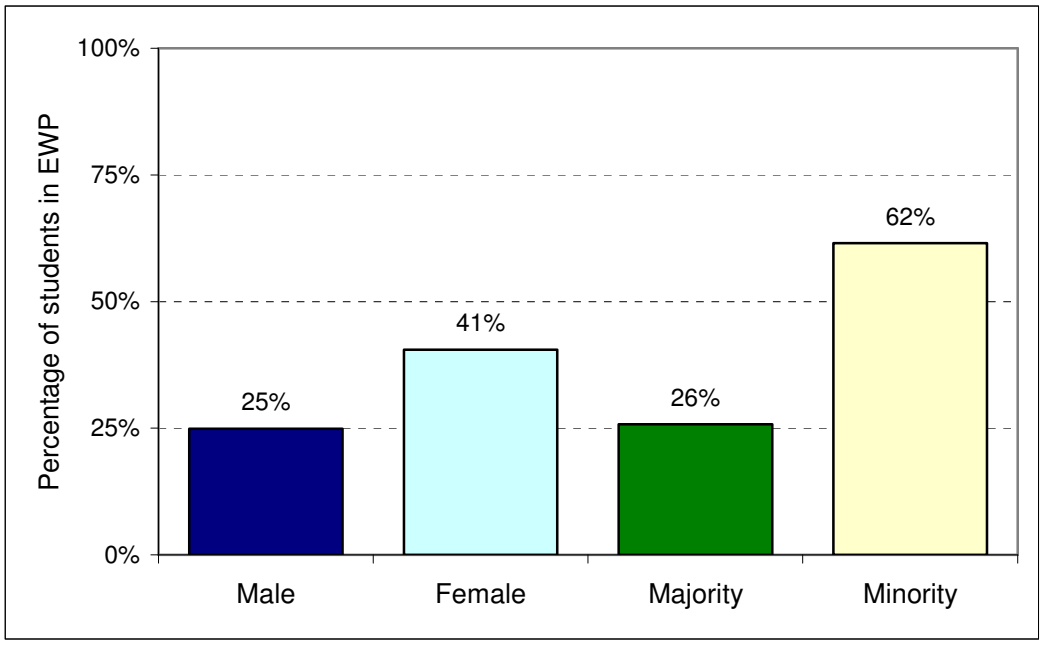

Figure 1. EWP Fall quarter participation rates by gender and ethnicity.

The aim of this study was to determine if students who participated in the EWP program were more likely to complete the course sequence than students who did not participate in the program. For the purposes of this analysis, workshop participation was measured using a bivariate variable indicating two possible events: participation in at least two workshops or participation in less than two workshops. Participation in two or more workshops was considered as an appropriate indicator of workshop participation since participation in one weekly meeting over a single quarter was not considered sufficient exposure to really benefit from the ESW program. As a result, participation in the program for at least 2 quarters was decided as a more appropriate measure of participation than participation in the program for one quarter.

By definition, program participants had to have completed at least the first 2 quarters of the course sequence. Therefore, to reduce the possibility of bias in analysis of the retention data, all analyses were restricted to students who registered for the first two quarters of the four quarter sequence. As the vast majority of students register for and complete the first 2 quarters of the sequence, this decision resulted in exclusion of only 32 students from the original cohort of 337.

Course Retention Measure

Retention was defined as completion of all 4 quarters of the EA course sequence consecutively. Retention was thus measured using a bivariate variable indicating whether the student completed the 4-course EA sequence within the first 4 quarters of their engineering coursework or not.

Statistical Analysis

We assessed the impact of the EWP program on retention by comparing the percentage of participants and non-participants who were retained in the course. As noted above, all analyses were restricted to students who registered for the first two quarters of the, four quarter sequence.

Chi-square tests and logistic regression analyses were used to analyze the data. In the logistic regression analyses, the dependent variable chosen for the analysis was completion of the EA sequence. The variable took a value of 1 if the student completed the EA sequence and 0 otherwise. Independent variables in the analyses were workshop participation, gender and ethnicity. The ethnicity variable had two categories, majority and minority

Co-variates

Since participation in the EWP program is voluntary, the issue of selection bias requires specific consideration. To address selection bias we first compared SAT-math score between participants and non-participants to determine if there were any pre-existing differences in prior academic performance between the groups. Table 2 shows the comparison of mean SAT-math scores for participants and non-participants. Independent t-tests revealed that participants in the workshop had statistically significantly higher average SAT-math scores than non-participants (T=2.28; df= 289; p=0.024). On average, SAT-math scores of participants were 78.8 points higher than those of non-participants. We incorporated SAT-math as a covariate in the logistic regression model to account for these pre-existing differences in prior academic performance between participants and non-participants.

Table 2. Mean SAT-math by workshop participation

	N	Mean SATm	Std. Error Mean	SIg.
Workshop	206	678.1	15.4	0.024
Non workshop	85	599.3	30.8	

Final Sample Size

Students who were registered for only the Fall quarter were excluded from the analysis, as were students who chose not to disclose their ethnicity and students who had missing data on SAT-math. As a result, 291 of the 337 (86.3%) students in the Fall cohort were included in the analysis.

Results

Overall Retention in the Course

As a preliminary analysis, we recorded the number of quarters of the EA sequence that students completed (Table 3). The check mark indicates successful completion of the quarter. The table indicates that overall, 82% of the students complete the four-course sequence.

Table 3. Number of students successfully completing the EA sequence

F 04	W 05	S 5	F 05	Number of passing students	Percentage
√	√	√	√	277	82.4%
√	√	√		11	3.3%
√	√			16	4.8%
√				20	6.0%
				12	3.6%
Total				336	

Impact of the Program on Retention

We used a chi-square analysis to compare retention of students who completed 2 or more workshops with retention of students who completed less than two workshops (i.e. 1 or 0 workshops). Results suggest a marginally significant relationship between workshop participation and completion of the sequence (X=2.37; df=1; p=0.080) (Table 4). Eighty percent of students who participated in 2 or more workshops were retained in the course compared to 71.7% of students who participated in less than 2 workshops.

Table 4. Results from the chi-square test

		completed AE sequence		Total
		not retained	retained	
Workshop Participation	Less than 2 workshops	64	162	226
		28.3%	71.7%	
		17	69	86
	2 or more workshops	19.8%	80.2%	
Total Count		81	231	312

	Value	df	Asymp. Sig. (2-sided)	p
Pearson Chi-Square	2.370(b)	1	.124	
Fisher's Exact Test				.080

a Computed only for a 2x2 table

Results from the logistic regression analysis suggest that students who completed 2 or more workshops were more likely to complete the EA sequence than students who participated in less than two workshop quarters (Table 5). Specifically, after adjusting for SAT-math score, gender and ethnicity, students who participated in the 2 or more workshops were 5 times more likely to complete the sequence than those who participated in less than 2 workshops (p=0.036; 95% CI 1.1- 25.9).

We did not find a significant interaction between workshop participation and ethnicity, suggesting that both majority and minority students benefit positively from participating in the program. For majority students, almost 95% of those who participated in 2 or more workshops were retained in the course compared with 82.5% of students who participated in less than 2 workshops. This difference was statistically significant (Table 6, p=0.002).

Table 5. Results from the logistic regression

		Wald	df	Sig.	Exp(B)	95.0% C.I.for EXP(B)	
						Lower	Upper
	Completed 2 or more workshops	4.385	1	.036	5.370	1.114	25.894
	satm	5.036	1	.025	1.001	1.000	1.002
	sex(1)	1.117	1	.291	.656	.300	1.434
	minority	7.307	2	.026			
	minority * Completed 2 or more workshops	4.496	2	.106			
	gender * Completed 2 or more workshops	.020	1	.886	.853	.096	7.583
	Constant	4.198	1	.040	2.322		

a Variable(s) entered on step 1: two_or_more_workshops_completed, satm, sex, minority, minority * two_or_more_workshops_completed , sex * two_or_more_workshops_completed .

Table 6. Logistic regression analysis for majority students

		B	S.E.	Wald	df	Sig.	Exp(B)	95.0% C.I.for EXP(B)	
								Lower	Upper
	Completed 2 or more workshops	1.411	.464	9.234	1	.002	4.102	1.650	10.193
	SATm	.000	.001	.031	1	.860	1.000	.999	1.001
	gender	-.518	.348	2.224	1	.136	.595	.301	1.177
	Constant	1.186	.483	6.043	1	.014	3.275		

a Variable(s) entered on step 1: two_or_more_workshops_completed, satm, sex.

Figure 2 represents the percentage of students who completed the EA sequence by ethnicity. The graph shows that minority students who participated in two or more workshops were more likely to complete the course sequence than minority students who participated in less than two workshops. About 91% of minority students who participated in 2 or more workshops were retained in the course, in contrast to only 50% of minority students retained from those who participated in less than two workshops. From the initial sample of 27 minority students, six students who did not participate in the workshop dropped from the program after the first quarter. Those were not included in the analysis since they did not register for their second quarter. On the other hand, none of the minority students in the Fall workshop dropped within the first two quarters. Due to the small number of minority students (n=21), we did not deem the use of regression analysis appropriate. A Fisher's Exact (chi-square) test revealed that this difference was not statistically significant (X^2=0.485; df=1; p=0.586). One possible reason for the failure of this difference to reach statistical significance is the low statistical power associated with the small sample size. The odds ratio computed was 10 indicating that minority students who participated in 2 or more workshops were 10 times more likely to be retained in the program than their counterparts who participated in less than 2 workshops. It is particularly noteworthy that retention of minority workshop participants (91%) exceeded retention of majority non-participants (83%) and was very close to that of majority participants (95%).

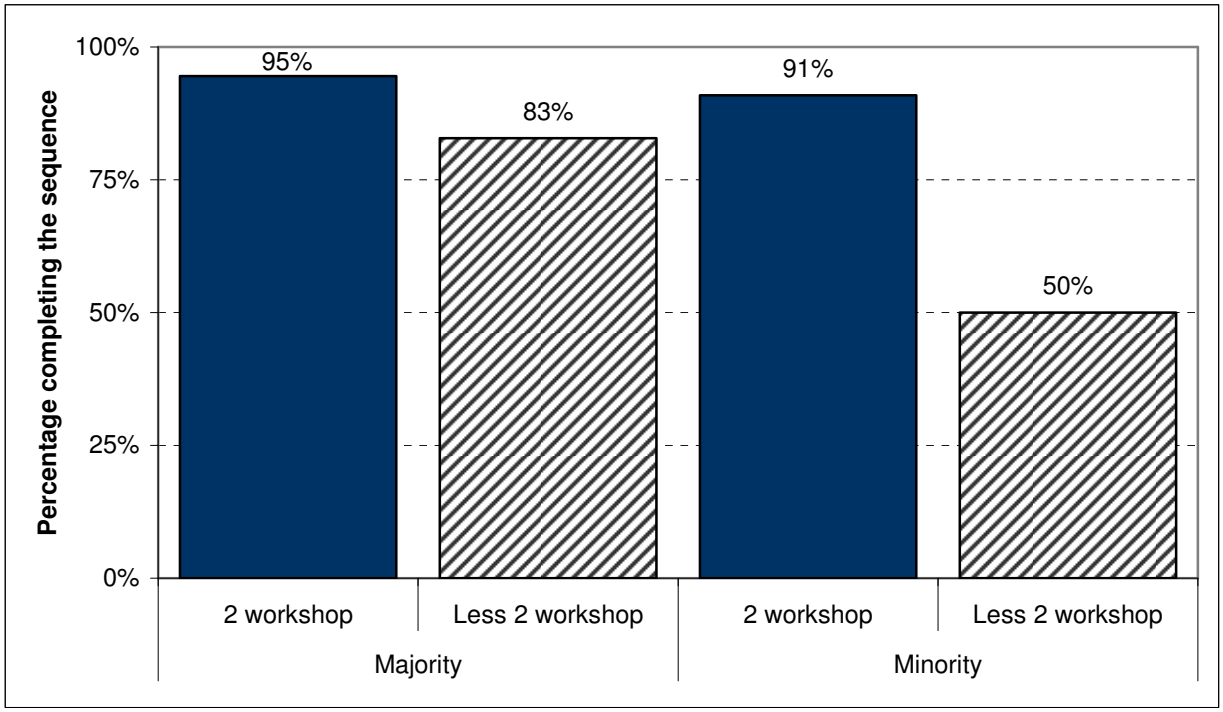

Figure 2. Retention in the EA sequence by program participation and ethnicity.

There was no interaction between workshop participation and gender (p=0.886). Figure 3 shows the percentage of students completing the EA sequence by gender. Both genders seem to benefit similarly from workshop participation. Such results are consistent with the lack of significance in the interaction between gender and workshop participation.

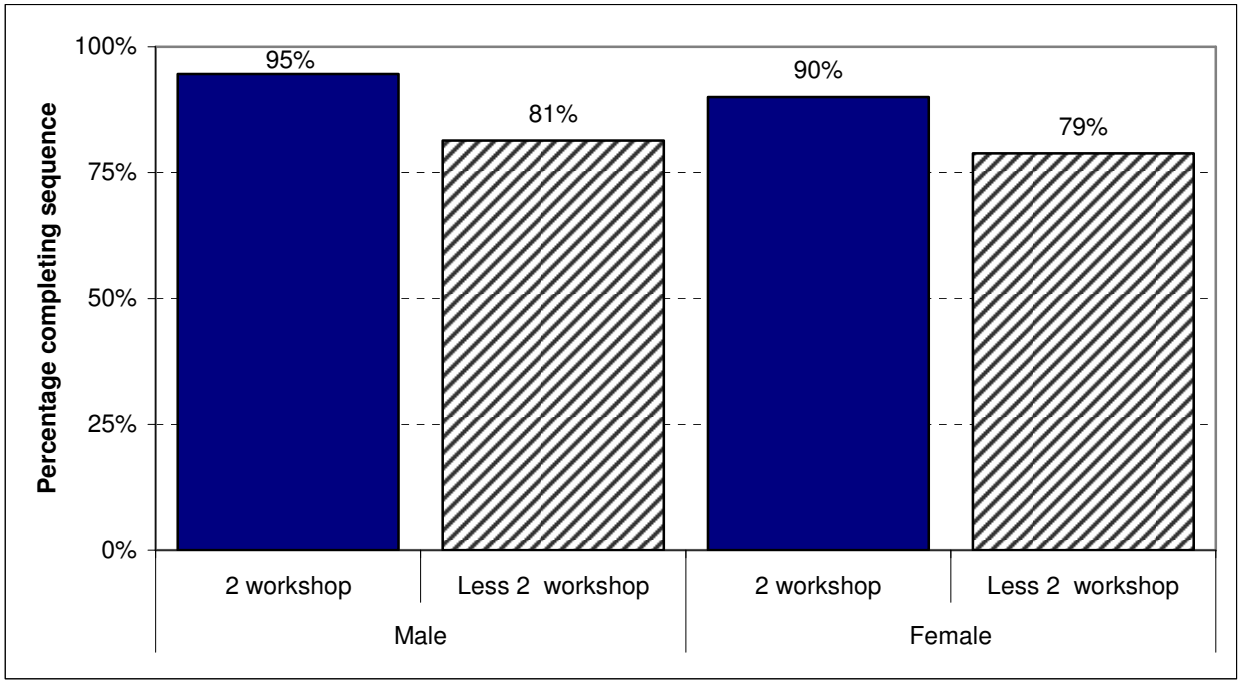

Figure 3. Retention in the EA sequence by program participation and gender.

Discussion

Results from the statistical analyses performed suggest a positive impact of the EWP program on completion of the EA sequence. After adjusting for SAT-math score, gender and ethnicity, students who participated in 2 or more workshops were 5 times more likely to complete the EA course sequence than students who participated in less than 2 workshops. Overall, results indicate that the program seems to be advantageous for all students, regardless of gender or ethnicity. Differences in retention between minority participants and non-participants probably failed to reach significance because of the small sample size and low statistical power. However, analysis of the raw data for minority students suggests that the program may have a very positive impact on retention of this group. We found that 91% of minority students who participated in 2 or more workshops completed the EA course sequence compared to 80% of minority students who participated in less than 2 workshops. It was particularly encouraging to see retention of minority program participants approaching that of their majority counterparts. These result must of course be interpreted cautiously due to the small number of minority students in the study (n=27) but are encouraging.

Our previous analysis of data from the program found an interaction between workshop participation and gender. The result indicated that ESW program had a stronger impact on females than males, with female participants generally receiving higher grades than female non-participants, but few statistically significant differences between male participants and non-participants. However, in the retention analysis reported here, we did not see an interaction with gender as we did for grades, indicating a similar impact of workshop on retention for males and females. Thus, males and females appear to benefit equally on the retention measure. Such results are very encouraging and indicate that the program has been a successful in its efforts to improve retention in engineering.

Results of this study are consistent with those of other studies of peer-led team learning in other disciplines that have also found positive impacts on student retention [9, 10, 11](Bonsangue and Drew, 1995; Tien et al 2002; Drane et al 2005)

One clear limitation of this study is the fact that students were not randomly assigned to participate in the workshop. As the GSW program is an entrenched program at Northwestern and is offered to all students that want to participate, random assignment was not possible. Although we adjusted for prior academic performance as measured by SAT-math score, it is possible that the differences that we observed in retention may be due to some other pre-existing difference(s) between participants and non-participants. For example, possible factors that could show pre-existing differences are motivation or interest in the discipline. We suggest that further studies on the impact of peer-led team learning programs on student retention are warranted. In particular, studies on the benefit of the program for minority students should be conducted.

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