AC 2009-2085: EVALUATION OF SUPPORT PROGRAMS FOR UNDERSERVED POPULATIONS IN ENGINEERING

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Evaluation of Support Programs for Underserved Populations in Engineering
ICE – Illinois Connections in Engineering
SAGE – Student Assisted Guidance in Engineering

I. Introduction

Engineers are key personnel to maintain or promote economic growth and create jobs through innovation in a society [1]. However, engineers experience difficulties in transition or socialization in multiple stages of their academic and professional career [2-5]. Especially, first-year engineering students are exposed to more critical environmental changes and discrepancies of identity [6, 7]. Unsuccessful transitioning into rigorous engineering education context induces low retention of first year engineering students. The National Science Foundation [8] reports that only 60% of students who enter engineering disciplines obtain an engineering degree. Some engineering colleges provide special support services to increase the retention of first-year engineering students [7, 9]. In addition, particular high attrition rate of underrepresented groups in engineering, e.g., female and minorities demand the exploration of alternative support options in transition [10, 11]. In the transition process of their first year at college of engineering, new engineering students are influenced by academic performance (GPA), social interactions with peers and faculties as well as family, support programs, pre-college characteristics, innate personalities, and perception toward engineering. [7, 10-15].

The purpose of this study is to identify and understand the effects of support programs to academic performance and retention in the first year. The study also seeks explanation as to how support programs affect perception of change toward engineering disciplines by conducting pre- and post assessments and focus group interviews.

A. Support Programs of University of Illinois

<u>Illinois Connections in Engineering (ICE) program</u>

The College of Engineering in University of Illinois hosted the Illinois Connections in Engineering (ICE) summer bridge program during summer of 2007. The purpose of ICE is to provide students who are entering the College of Engineering with the skills and knowledge necessary for academic success. The target group is underserved populations in engineering, i.e., women, minorities, first-generation students, and students from low-sending counties. We are cognizant of the fact that not all students are prepared equally for the rigors of an engineering education at the University. Through participation in this six-week intensive program with instruction in the core subject areas and academic success strategies, we hope to provide a “level playing field” for the fall semester.

The criteria for admission to ICE are:

1. All students with ACT-M < 27,
2. Females and minorities with ACT-M < 28, or

3. Females and minorities with ACT–M < 29 and ACT-C < 27.

The ICE program includes:

- Preparatory courses (Math, Chemistry, Physics)
- Workshops (CAD, Programming, Writing)
- Academic success strategies training
- Opportunities to interact with faculty/administration
- Tutoring
- Weekly journals
- Career explorations and plant trips
- Seminars for parents

ICE program participants receive university credit (elective hours) and a $1,000 stipend.

Student Assisted Guidance in Engineering (SAGE)

All first-year students who met the criteria for ICE were encouraged to enroll in SAGE, a semester long three-hour course. The goal of the course is to support students through mentoring and instruction of academic success skills. ICE students were strongly advised to enroll in SAGE. Twenty-three students enrolled in the Fall 2007 semester. Approximately one-third of the ICE 2007 students could not enroll due to scheduling conflicts.

The SAGE program includes:

- Mentors who meet with the enrollees weekly,
- Seminars on academic success skills and engineering careers,
- Required study sessions,
- Participation in Engineering Expo or Engineering Career Fair,
- Exploration of resources on campus,
- Weekly journals,
- In-depth group project,
- Required student sessions, and
- Meeting with professors.

B. Engineering Education Model for 1st Year Student Retention

The problem, decreasing number of engineers, has attracted great attention from many engineering professionals and engineering educators [1, 6, 8, 16]. The reduction in the engineering workforce is expected to reduce innovation capability of a country [17], and may even erode the capability of self-defense and security [18]. Anderson-Rowland [11] proposed that the reasons for high attrition of engineering are poor academic performance, high demand of engineering curricula and poor understanding of the topic since engineering is not taught in secondary schools. The attrition rate of women and underrepresented minorities is more severe [19-21]. The National Action Council for Minorities in Engineering (NACME) researchers [21] suggested six key actions to prevent and reduce high attrition of engineering students. The six key actions are

1) strong institutional commitment as measured by attitudes of faculty and staff, integral engineering programs, and allocation of resources, 2) focus on removing barriers to student success, 3) involvement of the corporate community, 4) precollege development of potential engineering students, 5) summer bridge programs, and 6) special attention to early success of freshmen. In addition, the high attrition problem of first year engineering students is not only prevalent in the U.S. but across the world [22].

Many engineering educators and scholars have proposed engineering education models to promote understanding of the high attrition phenomenon [10, 12, 14, 15, 23-27]. After reviewing many engineering education models, the authors synthesized and re-conceptualized them as following an integrative engineering education model for first-year students to address the research questions.

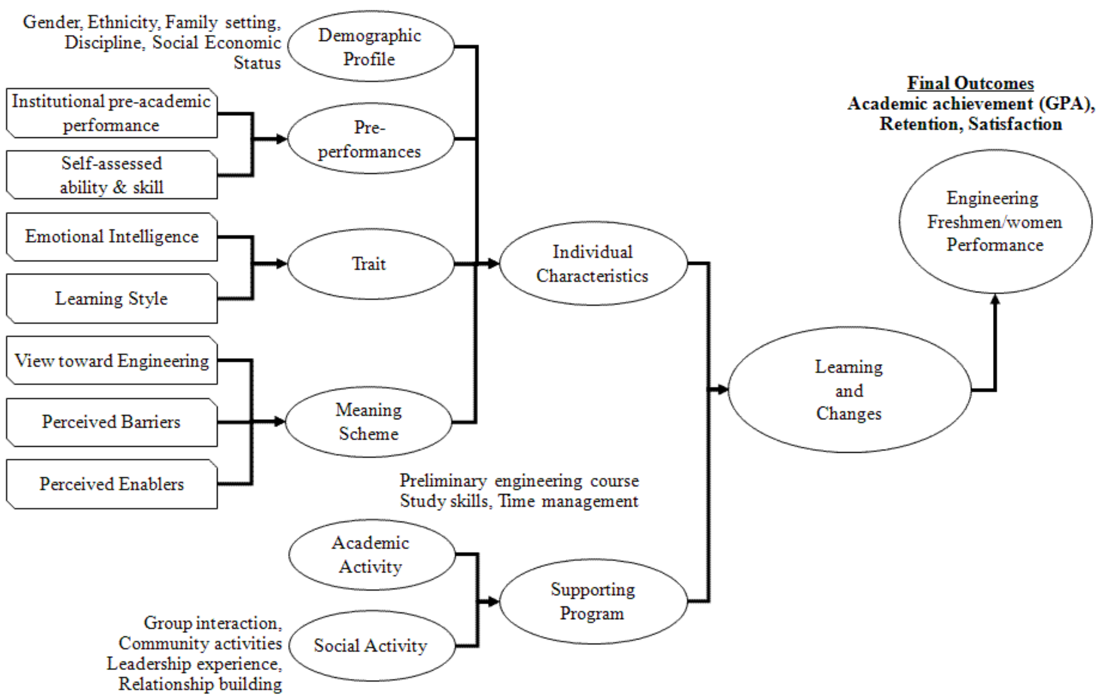
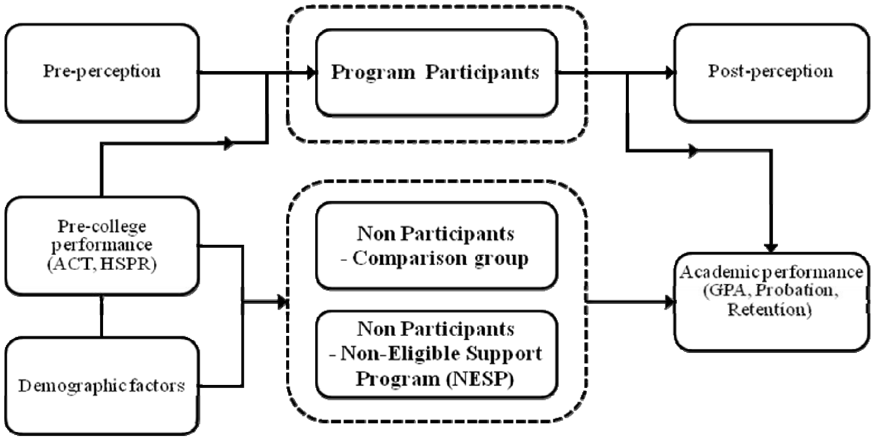


Figure 1. Integrative engineering education model for first-year students.

C. Conceptual Model and Research Questions

In this study, researchers investigated influences of support programs to academic performance, perception change, and retention of underserved first year engineering students. A conceptual model was proposed to investigate the influence of support programs in engineering. (See Figure 2.) The model is based on the integrative engineering education model for first-year students and revised with the characteristics of support program settings.



*HSPR: High School Percentile

Figure 2. Conceptual framework.

Four research questions were drawn from the conceptual model, they are

1. What are demographic profiles of support program participants?
2. What are differences of academic performance between program participants and non-participants?
3. Did support programs affect overall academic performance?
4. What changes of program participants are attributed to special programs (ICE and SAGE programs)?

II. Research Methods

A mixed method is applied to better understand influences of support programs to underserved populations in engineering. Mixed methods research is a research design or methodology for collecting, analyzing, and mixing both quantitative and qualitative data in a single study or series of studies. Even though there are some philosophical debates in mixed methods research, the research design is widely applied in educational or organization research for benefits of empirical orientation [28]. In order to address the proposed research questions, the research design as shown in Figure 3 was used.

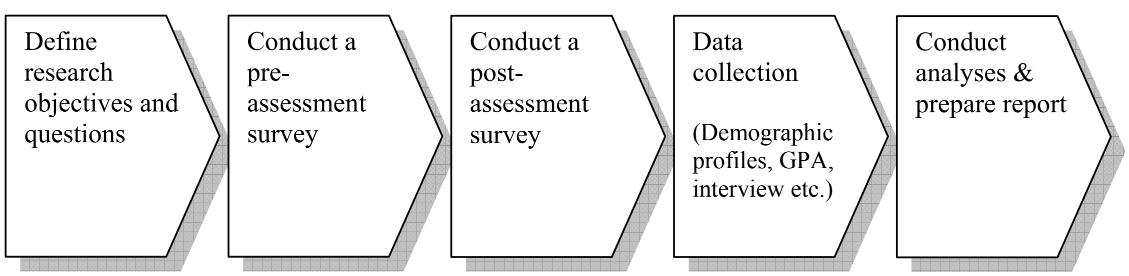


Figure 3. Research Process.

After defining the research questions, questionnaires for conducting pre- post assessments and interview and focus questions were prepared. Next, the pre-assessment was administrated. At the final stage of the support program, the post-assessment survey was completed by the students. During and after the conclusion of the support programs, data such as academic performance was collected. A letter inviting students to participate in focus groups was sent to participants and mentors. Instructors participated in interviews. The focus group interviews were conducted by trained facilitators.

III. Results

A. Demographic Profiles of Support Programs

Forty students participated in the ICE 2007 program. Twenty-seven males and thirteen females participated. The program participants were well diversified by engineering departments. The breakdown by ethnicity follows: Caucasian = 37 percent, African American = 27 percent, Latino/a = 25 percent, Asian = 8 percent, and 3 percent classified as Other. By generation, 45 percent of all participants were 1st generation and 50 percent of ethnic minorities came from first-generation families.

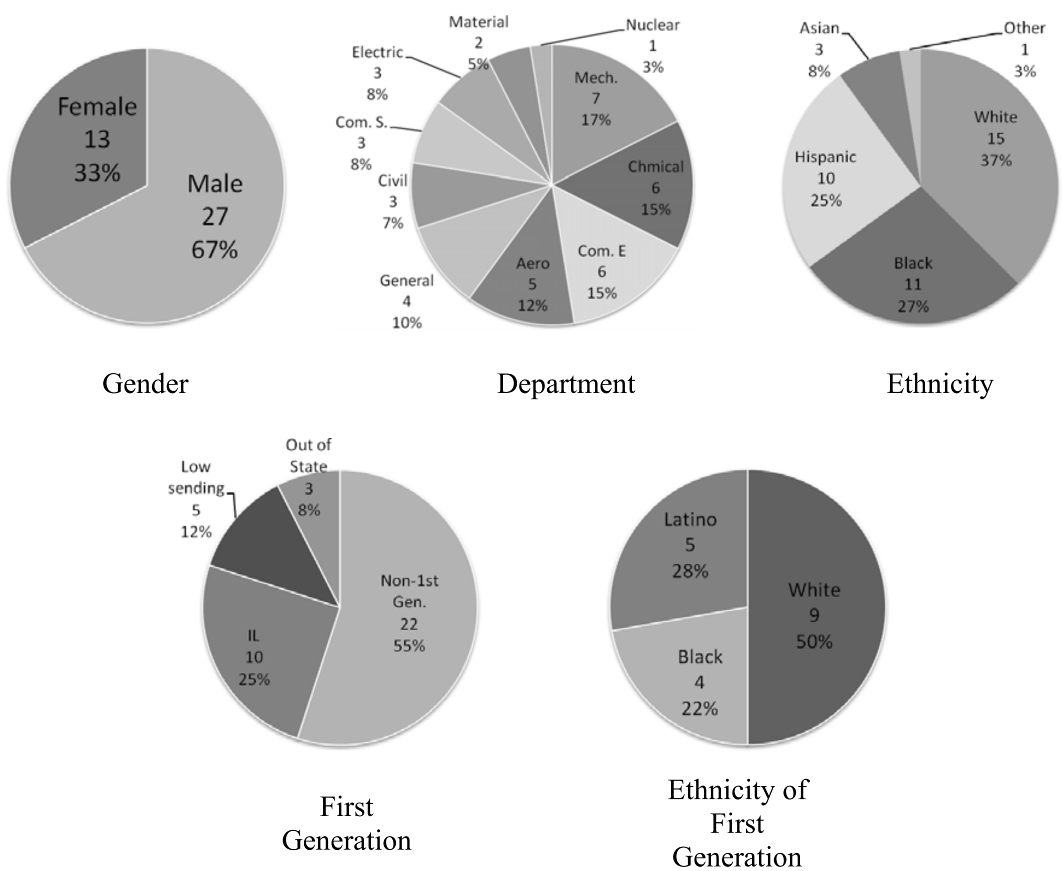


Figure 4. Demographic profile of ICE program.

Twenty-three students participated in the SAGE 2007 program. Contrary to the ICE program participants, gender composition was balanced (male: 13, female: 10). The SAGE program participants were also well diversified by engineering department, and the breakdown by ethnicity follows: Caucasian = 39 percent, African American = 26 percent, Asian = 22 percent, and Latino/a = 9 percent. Thirty percent of the participants were first generation.

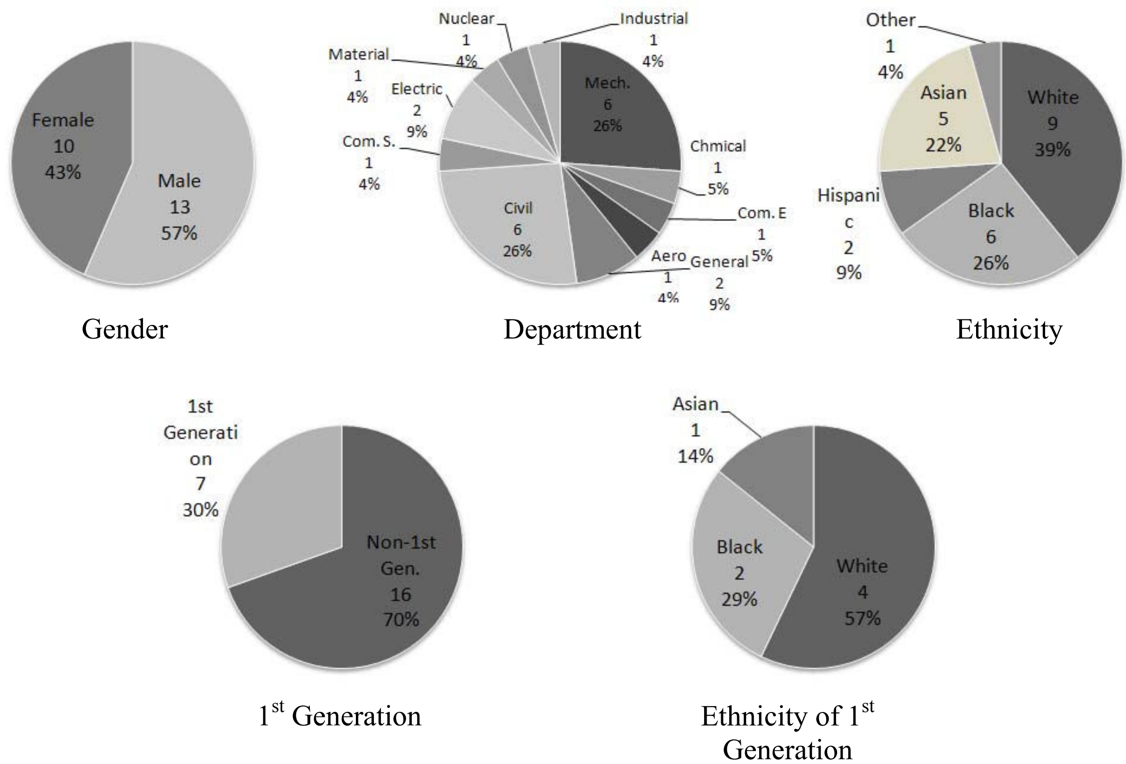


Figure 5. Demographic profiles of SAGE program

B. Quantitative Analysis of Academic Performance

Quantitative analyses were conducted to determine the performance of students in each of the following groups:

1. All students who participated in support programs (ICE, SAGE or both),
2. Students who met the criteria for support programs (same criteria are used for both programs) but who did not participate in either program, and
3. Students enrolled in an engineering discipline but who had ACT scores greater than those of ICE and SAGE students. This group will be called the “Non-Eligible for Support Programs” group, or NESP.

The composition of first year engineering students is depicted in Figure 6. In academic year 2007-08, there were 1,401 students in engineering disciplines and 63 students enrolled in support programs (ICE and SAGE program).

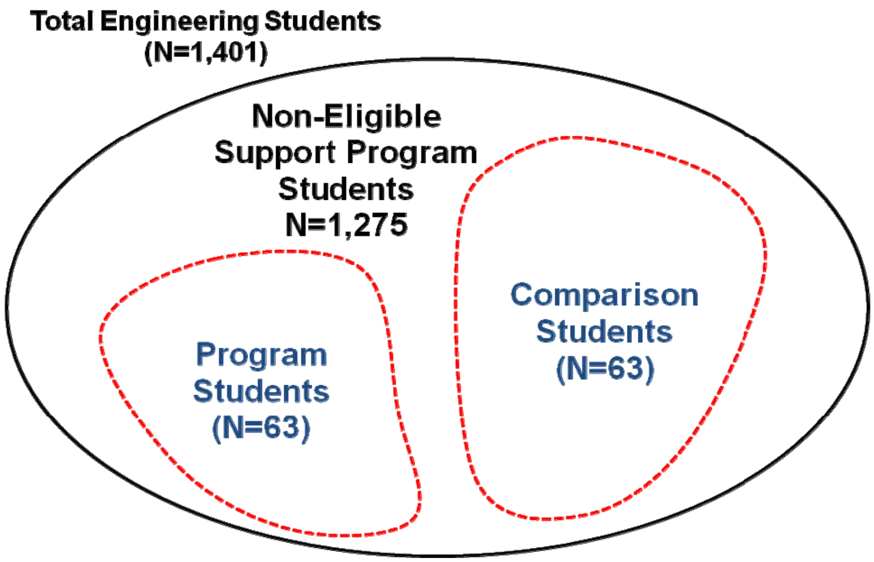


Figure 6. Compositions of first year engineering students by group.

Table 1 shows the pre-academic performances by group. The average ACT scores of program participants and comparison were lower than normal students since the selection criteria was 'lower pre-academic performance and underserved population.'

Average pre-college performance	ACT-Math	ACT-C	HSPR
Group 1: Program participants (N=63)	26.05	26.37	91.83
Group 2: Comparison students (N=63)	26.41	26.89	92.89
Group 3: NESP students (N=1,275)	32.94	30.95	90.58

Table 1. Pre-academic performances by group.

Academic performances of groups are presented in Table 2. GPAs of three consecutive semesters represent the achievement of program participants, comparison students, and students who did not meet the criteria for the support programs. At the conclusion of first semester (Fall 2007), the GPA of program participants was higher than comparison group. For all other semesters, academic achievement of program participants was lower than other groups.

Academic Year (2007-08)	Fall 2007 Average GPA	Spring 2008 Average GPA	Fall 2008 Average GPA	Cumulative GPA
Program participants (N=63)	3.06	2.57	2.37	2.66

Comparison students (N=63)	2.94	2.75	2.59	2.76
NESP students (N=1,275)	3.15	3.01	2.99	3.02

Table 2. Academic performances of first year engineering students by groups.

However, in order to conduct more rigorous analyses, three groups were formed with mechanical matching: students who participated in ICE, SAGE, or both (program students); students who were eligible for ICE or SAGE but chose not to participate (comparison students); and students who enrolled in an engineering major but were not eligible for either ICE or SAGE (Non-Eligible Support Program [NESP] students). Comparison students were chosen by matching each one with a program student based on the following variables in order of priority: ACT-M, ACT-C, HSPR, whether a first-generation college student, whether from a low-sending county, whether a U.S. citizen, race/ethnic group, gender, major program of study, and total GPA credit hours. NESP students were chosen that matched the program students on the same variables, except for ACT-M, ACT-C, HSPR, because those three variables were used to determine program eligibility. The three matched groups were compared on their weighted GPAs for Fall 2007 (the first semester after ICE), Spring 2008, and Fall 2008. For each semester, GPAs were weighted by the ratio of individual GPA credit hours to group mean GPA credit hours. The matching sample composition by group is presented in Figure 7.

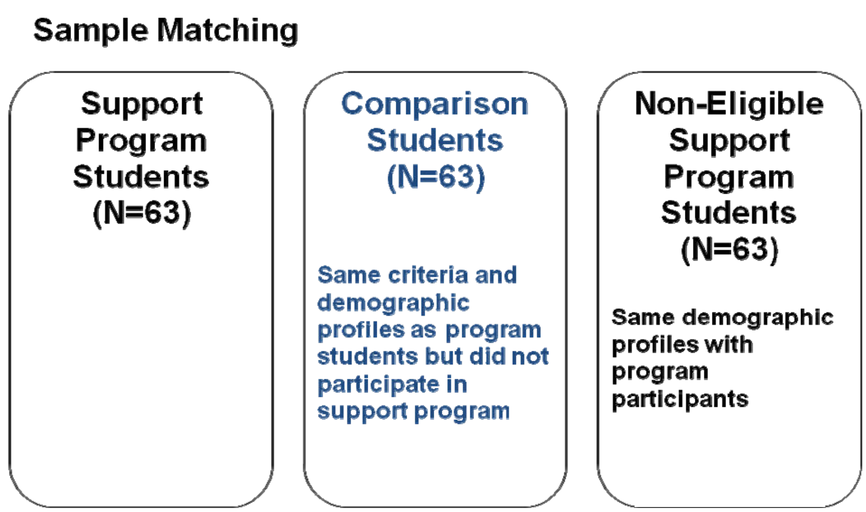


Figure 7. Matching sample composition by group.

Complete data and matches were found for 49 of the 63 program students, for an overall sample of 147 students split equally among the three groups. Missing data was an issue due to a large portion of missing GPAs in Fall 2008 with a discernible nonrandom pattern: comparison students missing Fall 2008 GPAs tended to have lower Spring 2008 GPAs than the other two groups. Implications of this pattern for our findings will be addressed in the discussion section.

A full-factorial repeated-measures general linear model was used in SPSS v16.0 to compare the three groups over the three semesters. Semester was used as a within-subjects independent variable, because GPA was measured repeatedly over three semesters. Group was also treated as a within-subjects independent variable, because group member selection was based on matching. All statistical assumptions such as multivariate normality and linearity held. No influential outliers were detected. A significant effect for group was found (Pillai's Trace = .204, F (2, 47) = 6.017, p = .005, observed power = .862), and also for semester (Pillai's Trace = .537, F (2, 47) = 27.253, p < .001, observed power > .999). The interaction between group and semester was also significant (Pillai's Trace = .270, F (4, 45) = 4.160, p = .006, observed power = .891), and explained a large portion of the variation in GPA (partial η^2 = .27) between semesters and groups.

Planned comparisons were carried out with the sequential Bonferroni procedure [29] on 18 pairs of groups formed by the group x semester combinations summarized in Table 4 (Table 3 provides *M*s, *SD*s, and.95*CI*s for each group). For the program group, the first semester (Fall 2007) mean GPA was significantly (α = .05) higher than the second and third semesters (Spring and Fall 2008, respectively). In contrast, no significant difference was found between the second and third semesters. Additionally, both the program and NESP group mean GPAs were significantly higher in the first semester than the comparison group mean GPA, but no significant difference between themselves. However, by the second semester, the program group mean GPA had dropped far enough to become significantly lower than the NESP group mean GPA, and to have no significant difference from the comparison group mean GPA. Although both the program and comparison groups continued to have significantly lower mean GPAs than the NESP group in the third semester, and the program group dropped even lower than the comparison group, there remained no significant difference between them. Figure 8 illustrates the trend lines of each group's GPA over the three semesters.

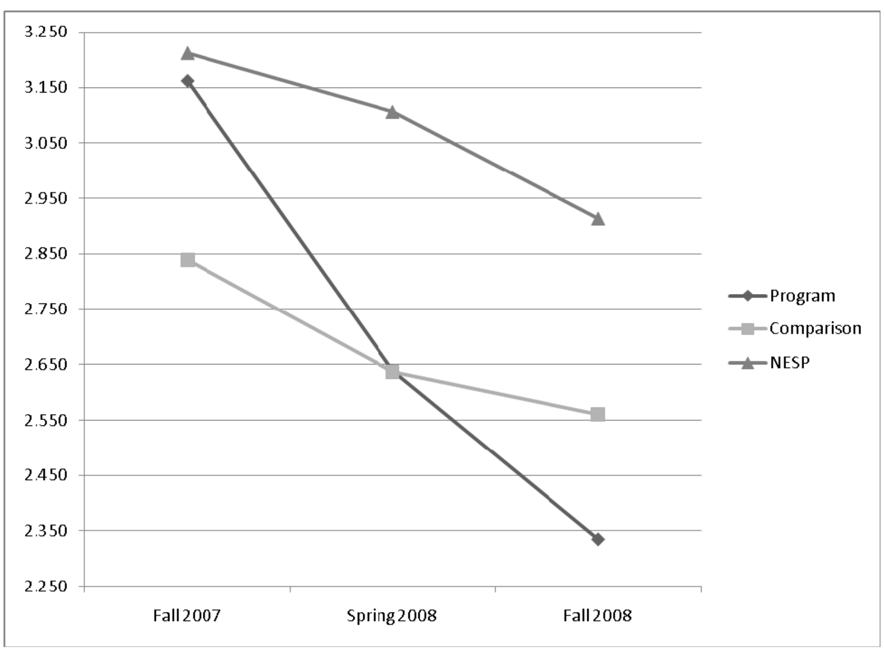


Figure 8. Estimated marginal means of weighted GPA of each group for each semester.

Group 1: program students; Group 2: comparison students; Group 3: NESP students. Semester 1: Fall 2007; Semester 2: Spring 2008; Semester 3: Fall 2008. (Total $N = 147$, 49 in each group).

				95% Confidence Interval	
Group	Semester	*M*	*SE*	Lower Bound	Upper Bound
Program	Fall 2007	3.161	0.086	2.987	3.335
	Spring 2008	2.638	0.108	2.420	2.856
	Fall 2008	2.335	0.140	2.054	2.616
Comparison	Fall 2007	2.839	0.114	2.610	3.069
	Spring 2008	2.637	0.141	2.353	2.920
	Fall 2008	2.561	0.162	2.236	2.886
NESP	Fall 2007	3.212	0.090	3.032	3.392
	Spring 2008	3.106	0.108	2.889	3.323
	Fall 2008	2.913	0.101	2.709	3.117

Table 3. Weighted GPA by group and semester (N = 147)

Paired comparison	Mean difference	*t*		|Critical *t*|
1. 1,1-1,3	0.826	6.555	*	3.057
2. 1,3-3,3	-0.578	-4.588	*	2.965
3. 1,1-1,2	0.523	4.150	*	2.965
4. 2,2-3,2	-0.469	-3.721	*	2.965
5. 1,2-3,2	-0.467	-3.710	*	2.965
6. 2,1-3,1	-0.372	-2.956	*	2.965
7. 2,3-3,3	-0.352	-2.794		2.833
8. 1,1-2,1	0.322	2.553		2.833
9. 1,2-1,3	0.303	2.406		2.833
10. 3,1-3,3	0.299	2.371		2.797
11. 2,1-2,3	0.278	2.209		2.758
12. 1,3-2,3	-0.226	-1.794		2.712
13. 2,1-2,2	0.203	1.608		2.659
14. 3,2-3,3	0.192	1.528		2.595
15. 3,1-3,2	0.106	0.843		2.515
16. 2,2-2,3	0.076	0.601		2.409
17. 1,1-3,1	-0.051	-0.403		2.255

Paired comparison	Mean difference	t		|Critical t|
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2. 1,3-3,3	-0.578	-4.588	*	2.965
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4. 2,2-3,2	-0.469	-3.721	*	2.965
5. 1,2-3,2	-0.467	-3.710	*	2.965
6. 2,1-3,1	-0.372	-2.956	*	2.965
7. 2,3-3,3	-0.352	-2.794		2.833
8. 1,1-2,1	0.322	2.553		2.833
18. 1,2-2,2	0.001	0.010		–

Table 4. Summary of sequential Bonferroni planned contrasts ($\alpha = .05$). The first number of each pair member indicates group membership (1 = program, 2 = comparison, 3 = NESP), and the second number indicates semester (1 = Fall 2007, 2 = Spring 2008, and 3 = Fall 2008). Contrasts are sorted in order of observed magnitude as part of the procedure. Significant contrasts are indicated by '*.' Critical *t*-values were given by [30]. Observed *t*-values were computed with $MS_{error} = 0.389$ and $df = 192$ [29].

Two trends are apparent when examining Figure 8: 1) all three groups declined in GPA in each semester, and 2) the program group declined most steeply. As supported by results in Table 4, the decline in GPA was insignificant for the comparison and NESP groups, but significant for the program students, particularly between Fall 2007 and Spring 2008. In addition, this decline had a large practical effect of 0.52 grade points, or almost 0.9 *SD.* This is strong evidence that the program students performed less well after program supports were removed.

Another pattern is evident from Figure 8, which is that the program and comparison groups both performed more poorly than the NESP students during the Spring and Fall 2008 semesters, when program support was unavailable. In Fall 2007, comparison students performed less well than program or NESP students, and the effect sizes were still of medium size, with differences of 0.40 and 0.47, respectively. The difference between the program and NESP students in Fall 2007, on the other hand, was of negligible effect size, with program students performing only about 0.08 *SD* below the normal students. These effect size results support the hypothesis that program support had a beneficial effect on performance.

A related research question was, "What is the relationship between support programs to performance?" The aforementioned results partially answer the question by indicating that both the ICE and SAGE programs affected student performance together. However, of particular interest was whether the ICE program affected performance, so the above analysis was replicated with the subsample of students who participated in either ICE or both ICE and SAGE, and their matches (an analysis of ICE-only students was not possible because there were less than 10). GPAs were reweighted to reflect the new groupings, and all tests of the assumptions were satisfactory.

A full-factorial repeated-measures general linear model was again run to compare the three groups over the three semesters, treating both semester and group as within-subjects independent variables (GPA was measured repeatedly over three semesters; and group member selection was based on matching). A significant effect for group was found (Pillai's Trace = .202, F (2, 31) = 3.914, p = .031, observed power = .662), and also for semester (Pillai's Trace = .525, F (2, 31) = 17.141, p < .001, observed power = .999). The interaction between group and semester was significant at the .05 level (Pillai's Trace = .292, F (4, 29) = 2.995, p = .035, observed power = .725), and explained a larger portion of the variation in GPA (partial η^2 = .29) between semesters and groups.

Planned comparisons were again carried out with the sequential Bonferroni procedure [29]on the same 18 pairs of groups formed by the group x semester combinations (summarized for this analysis in Table 6; Table 5 provides *M*s, *SD*s, and.95*CI*s for each group). Results were the same for the program group: the first semester (Fall 2007) mean GPA was significantly (α = .05) higher than the second and third semesters (Spring and Fall 2008, respectively), but no significant difference was found between the second and third semesters. However, although the overall trends remained similar, there were some differences in the pattern of significant contrasts. For example, for ICE students, just the program group mean GPAs was significantly higher in the first semester than the comparison group mean GPA; there was no significant difference between the comparison group and the NESP group in the first semester. However, by the second semester, the comparison group mean GPA had dropped far enough to become significantly lower than the NESP group mean GPA, but not the program group. The program and comparison groups were not significantly different in the second semester. Although the program group continued to have a significantly lower mean GPA than the NESP group in the third semester, and the comparison group did not. Again, no significant difference was observed between the program and comparison groups in the third semester. Figure 9 illustrates the trend lines of each group's GPA over the three semesters.

				95% Confidence Interval	
Group	Semester	*M*	*SE*	Lower Bound	Upper Bound
ICE	Fall 2007	3.258	0.102	3.051	3.465
	Spring 2008	2.781	0.143	2.490	3.072
	Fall 2008	2.394	0.167	2.054	2.733
Comparison	Fall 2007	2.748	0.128	2.488	3.008
	Spring 2008	2.543	0.178	2.180	2.906
	Fall 2008	2.432	0.189	2.048	2.817
NESP	Fall 2007	3.115	0.114	2.884	3.347
	Spring 2008	3.061	0.129	2.799	3.323
	Fall 2008	2.984	0.135	2.710	3.259

Table 5. Weighted GPA by group and semester for the ICE subsample (N=99).

Paired comparison	Mean difference	t	|Critical t|
1. 1,1-1,3	0.893	5.422 *	3.044
2. 1,3-3,3	-0.609	-3.695 *	3.044
3. 1,1-1,2	0.586	3.558 *	3.044
4. 2,2-3,2	-0.551	-3.342 *	2.987
5. 1,1-2,1	0.546	3.312 *	2.918
6. 2,3-3,3	-0.450	-2.731 *	2.918
7. 2,1-3,1	-0.410	-2.490	2.918
8. 1,2-3,2	-0.391	-2.372	2.918
9. 1,2-1,3	0.307	1.864	2.849
10. 2,1-2,2	0.201	1.217	2.813
11. 2,1-2,3	0.189	1.147	2.773
12. 1,2-2,2	0.160	0.971	2.726
13. 1,3-2,3	-0.159	-0.963	2.672
14. 3,1-3,3	0.149	0.906	2.607
15. 1,1-3,1	0.135	0.821	2.527
16. 3,2-3,3	0.089	0.541	2.420
17. 3,1-3,2	0.060	0.365	2.263
18. 2,2-2,3	0.893	5.422	–

Table 6. Summary of sequential Bonferroni planned contrasts ($\alpha = .05$). The first number of each pair member indicates group membership (1 = program, 2 = comparison, 3 = NESP), and the second number indicates semester (1 = Fall 2007, 2 = Spring 2008, and 3 = Fall 2008). Contrasts are sorted in order of observed magnitude (part of the procedure). Significant contrasts are indicated by '*.' Critical *t*-values were given by [30]. Observed *t*-values were computed with $MS_{error} = 0.448$ and $df = 128$ [29].

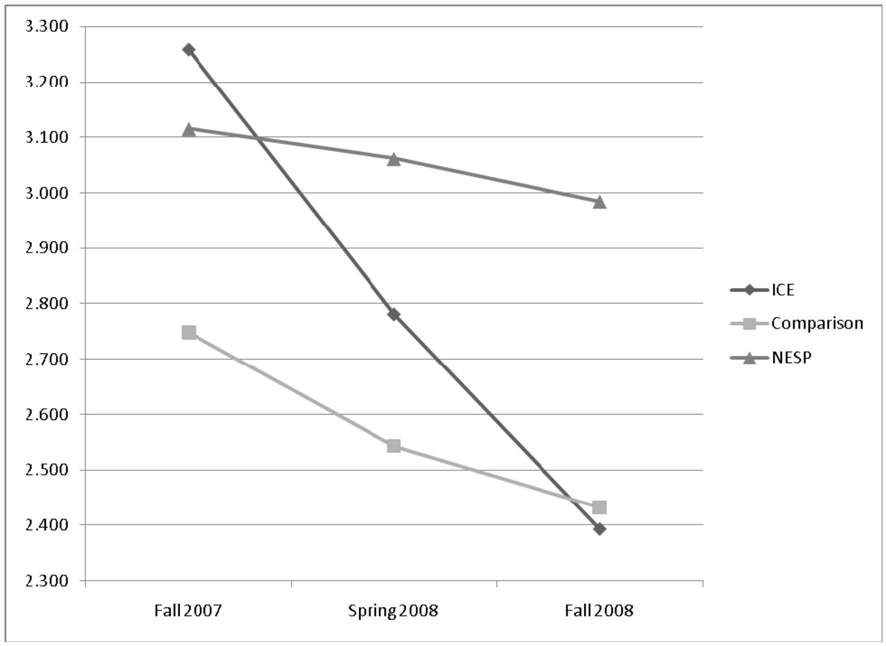

Figure 9. Estimated marginal means of GPA of each group for each semester.

Group 1: ICE students; Group 2: comparison students; Group 3: NESP students. Semester 1: Fall 2007; Semester 2: Spring 2008; Semester 3: Fall 2008. (Total $N = 99$, 33 in each group).

Two trends similar to the previous analysis are apparent when examining Figure 9: 1) all three groups declined in GPA in each semester, and 2) the ICE group declined most steeply. As supported by results in Table 6, the decline in GPA was insignificant for the comparison and NESP students, but significant for the program students. However, two differences from the previous analysis are: 1) the ICE group actually performed better than the NESP students in the first semester, although the difference was not significant statistically or practically; and 2) ICE group performance was significantly less than NESP group performance in the third semester, but the matched comparison group performance was not (although it was close). In addition, this year-long decline had a large practical effect of 0.89 grade points, or almost .89 *SD.* This is good evidence that the program students performed less well after program supports were removed, similar to the results of the previous analysis for all program students.

As before, the program and comparison groups both performed less well than NESP students during the Spring and Fall 2008 semesters, when program support was unavailable (see Figure 9). However, unlike before in Fall 2007, comparison students performed significantly less well than ICE or NESP students. In particular, there was a large effect size difference of 0.70 *SD* between the ICE and comparison groups. The results of this second analysis focused on ICE students are even stronger than those of the previous analysis, and lend greater support to the hypothesis that the programs, and in particular ICE, had a beneficial effect on performance.

C. Pre-Post Assessment

Students were administered a questionnaire regarding their 1) view toward engineering, 2) perceived abilities/skills, and 3) perceived barriers (see Appendix).

Table 5 and Figure 10 show pre-post assessment results of views toward engineering. At the .05 percent level, three out of five factors were statistically differentiated. Certainty of major and affinity for chemistry were increased, but affinity for physics was decreased after the ICE program.

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	Interests_pre - Interest_post	.00000	1.00000	.16440	-.33342	.33342	.000	36	1.000
Pair 2	Certaint_pre - Certain_post	-.48649	1.04407	.17164	-.83460	-.13837	-2.834	36	.007
Pair 3	Math_pre - Math_post	.05405	.84807	.13942	-.22871	.33681	.388	36	.701
Pair 4	Chem_pre - Chem_post	-.32432	.85160	.14000	-.60826	-.04039	-2.317	36	.026
Pair 5	Phys_pre - Phys_post	.81250	1.17604	.20790	.38849	1.23651	3.908	31	.000

Table 4. Pre- post assessment of views toward engineering.

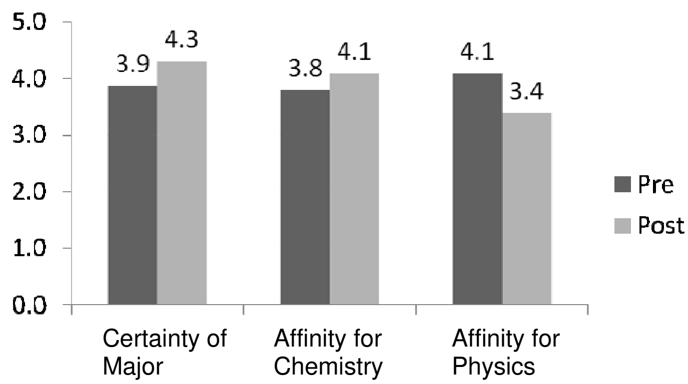

Figure 10. Change of view toward engineering.

As shown in Figure 11, significant increases ($p < .05$) were found in study skills, ability and affinity for CAD, writing, and robotics. At the same time, students anticipated they would need to increase their study hours. Self-efficacy of studying physics was decreased. There was no change in motivation, willingness to work in groups, and willingness to ask for help.

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	Math_pre - Maht_post	.08108	1.11501	.18331	-.29068	.45284	.442	36	.661
Pair 2	Chem_pre - Chem_post	-.10811	1.02154	.16794	-.44871	.23249	-.644	36	.524
Pair 3	Phys_pre - Phys_post	.43750	1.16224	.20546	.01847	.85653	2.129	31	.041
Pair 4	CAD_pre - CAD_post	-1.15000	1.30888	.29267	-1.76257	-.53743	-3.929	19	.001
Pair 5	Compu_pre - Compu_post	.19355	1.60040	.28744	-.39348	.78058	.673	30	.506
Pair 6	Writing_pre - Writing_post	-.27027	.80445	.13225	-.53849	-.00205	-2.044	36	.048
Pair 7	Robot_pre - Robot_post	-1.55000	1.19097	.26631	-2.10739	-.99261	-5.820	19	.000
Pair 8	Study_pre - Study_post	.13514	1.05836	.17399	-.21774	.48801	.777	36	.442
Pair 9	TimeMgm_pre - TimeMgm_post	.18919	1.22106	.20074	-.21793	.59631	.942	36	.352
Pair 10	Motiv_pre - Motive_post	-.08108	.92431	.15196	-.38926	.22710	-.534	36	.597
Pair 11	Group_pre - Group_post	.16216	.95782	.15746	-.15719	.48151	1.030	36	.310
Pair 12	Help_pre - Help_post	.00000	1.05409	.17329	-.35145	.35145	.000	36	1.000
Pair 13	Self_pre - Self_post	-.11111	1.11555	.18592	-.48856	.26634	-.598	35	.554
Pair 14	StudyHr_pre - StudyHr_post	-7.46774	9.20682	1.65359	-10.84483	-4.09065	-4.516	30	.000

Table 5. Pre-post assessment of self-assessed abilities and skills.

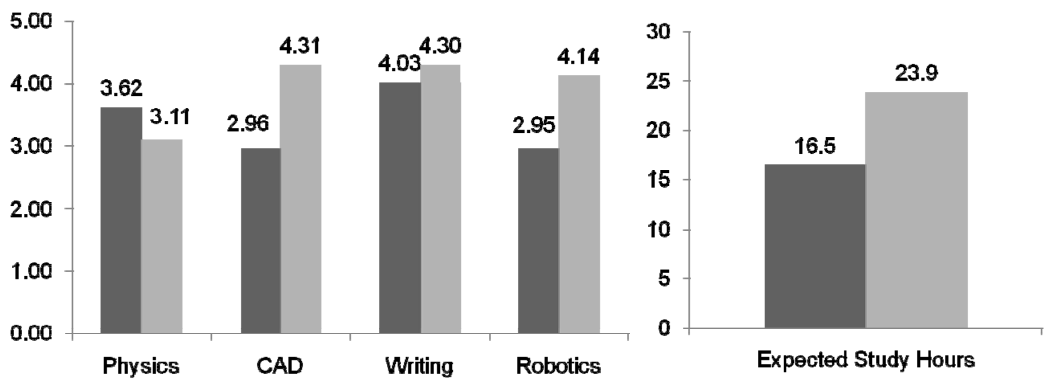

Figure 11. Change of self-assessed ability and skill.

ICE program participants perceived that the most challenging barrier of being a successful engineering student was an intense course schedule. Difficulties with time management, poor high school preparation, ability to compete with top students, and financial stress followed.

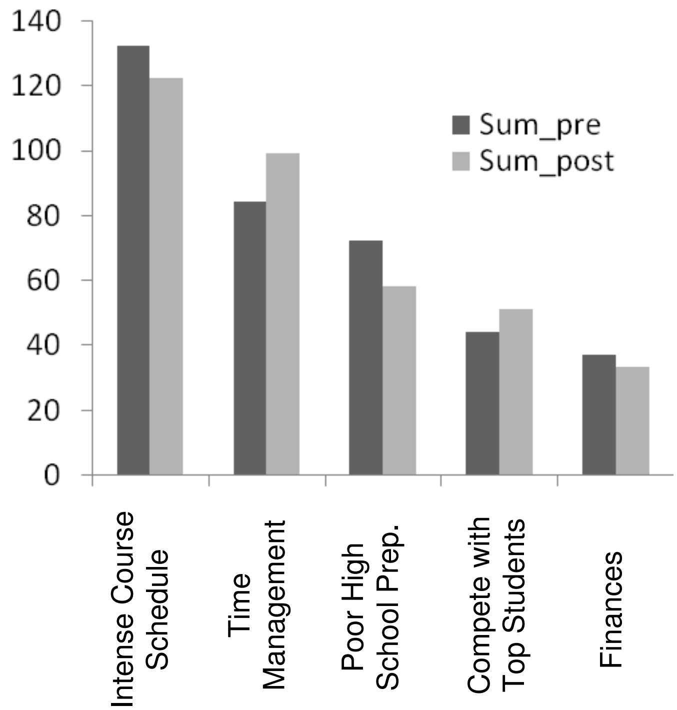

Figure 12. Top five perceived barriers.

D. Focus Group Interviews

In order to cultivate an in-depth understanding of influences of the support program, focus groups were conducted at the conclusion of ICE with six to eight students per group. The major themes concerned what the students learned, how the program helped to prepare students for the fall, and social aspects of the program. The students emphasized that they learned differences between studying for high school and college.

> "I realized that uh, I know everybody tells you it's not like high school, but you can't ever really make that decision until you get here. But I realized that in high school I really didn't need to do my homework, I could just sneak by, I could do whatever needed just to get a B, I was fine with just a B. and I realize now that I can't do the same things in college because I won't get a B I'll get an F. I know this helped out a lot, but at the same time this program was a little more challenging than my first year of college, because like my math was a 6 week program so we were doing a lot more every night than I'll probably be doing in my first probably year in actual college."

Intensive course, hard to manage time, and difference from high school were common to focus group students. Compete with other smart students were also noticed.

> "Yeah, I was actually kinda nervous, cause I thought that if I came here, I'd be really stupid compared to everybody else, and I thought that in the Engineering program there

> were people that are super smart, and I like just barely got in. That's how I felt, then I was like there's people like me in this program that work the way I work, need help like I need help. I was expecting to be like bombarded with super brilliance."

Isolation from home is another critical challenge for some students. A student explained her first experience of 'being independent' as

> " The really challenging part is being on your own for the first time, it was a lot better to be on my own in June before school started, then when class actually starts, because here you don't have a mom and a dad to do things for you, you don't have anyone protecting you, it's just you, if something needs to be done you have to go do it…, so you have to be, you have to grow up and go do it, to get it over with."

Students frequently stated that ICE provided them with a reality check, and exposed them to the importance of socialization and learning from others.

> " I think it also taught us we can't learn everything by ourselves, you know it's one thing to stay up until four o'clock in the morning trying to study for three subjects as opposed to just meeting with two other people and going over stuff together, because I think that if you go, if you study with someone else, they help you see also what you need to study, because they can ask you something, and you can be like, oh it's, but then if you don't remember you'll realize, oh maybe I should go over that, opposed to studying by yourself, you be like, oh I already know how to do that I'll just skip that chapter, and go onto this, you'll just gloss over stuff because you think you know it but you might not"

Throughout the social learning process in strong relationships with peers, the students felt that they truly bonded and learned how to work in teams.

In summary, they expressed that they learned many things from the ICE program and they felt they were well prepared to start their first semester in the College of Engineering.

> "I was nervous coming here August 22 when classes starts, then getting to know campus, and finding all my classes, would have been pretty overwhelming, because you have to buy books and there's so much to do and I got all that taken care of already, all I have to do is move in."

> "We're like Uber (German "Super") prepared."

> "We're so prepared."

> "We're college students."

IV. Discussion

The comparison of GPAs between the matched samples of program, comparison, and traditional students provided good evidence that participation in ICE and/or SAGE had a beneficial effect. The trend over time of semester GPAs demonstrated a statistically significant decline in mean program student GPA from having the same level as other students admitted to the university without reservation to having the same level as other students admitted under similar conditions but not benefitting from the programs. The decline not only had statistical significance, but also practical significance, as shown by the decrease in mean GPA of over half-a grade point, or nearly one full standard deviation. Several possible alternative explanations to program participation can be ruled out because of matching, including group differences in high school achievement (ACT scores and HSPR), proportion of first generation students, proportion of students from low-sending counties (a proxy for differences in high school resource availability), racial/ethnic make-up, gender proportions, and mean credit hours taken. Weighting individual GPAs by GPA credit hours also rules out group differences in semester course loads as an alternative explanation. The second comparison of GPAs focused on just those students who participated in ICE and their matches, and the results were even stronger, an indication that the ICE program may be particularly effective. Both comparisons point to a great need to extend program supports beyond the first semester of enrollment.

One possible interpretation of the results is that, given the much steeper decline in semester GPA for the program students relative to the comparison students, program students may be better off without participating. However, as discussed in the next paragraph, several comparison group students with low GPAs in the first semester were not included in the analysis because they were missing GPAs for the second and/or third semester. It is difficult to know how different the comparison of trends would look if data were available for these comparison group members, and would caution against concluding that the ICE and SAGE programs did more harm than good. Another element that argues against such an interpretation is the fact that when the program group included those students who participated in SAGE only, a Fall 2007 program, the trend line was steeper than it was when the program group did not include them. One might expect the opposite if the explanation for the decline was giving students an initial false hope, since ICE, a summer program, occurred before SAGE. Further research should break the research groups into more specific categories in order to examine differences between ICE-only, SAGE-only, and ICE-and-SAGE participants. Alas, one limitation of this study was that there were not enough ICE-only students to conduct such an analysis.

Another limitation of these results is the relationship of Fall 2008 missing data with lower Spring 2008 GPAs in comparison group students. An obvious explanation is that such students had dropped out before the Fall 2008 semester, but less apparent is the reason that there was not a similar pattern for the other two groups. There is greater variability in the GPAs of comparison group students than the other two groups in each of the three semesters, and the lowest GPAs of the comparison groups were lower than the other two groups, increasing the likelihood of dropping out of the university. The lower GPAs may also indicate differences in motivation between the comparison group and the other two groups, which partially explains why those students did not participate in ICE and/or SAGE. One way to account for this possibility is to measure motivation in the three groups and use it as a matching criterion, or as a statistical covariate. Interviews with eligible nonparticipants could also provide insight into why such students chose to forego the programs (e.g., cultural differences, or social pressures).

From pre-post test assessment and focus group interviews of support program participants, we could draw some positive changes after the program. Increasing of confidence of 'Certainty of Major' and 'Affinity for Chemistry' shows that the support program provides proper contents to increase motivation of studying selected major, math, and chemistry. However, a decrease in the variable, 'Affinity for Physics' shows that providing inappropriate learning contexts might influence students' preference to the subject. Even though the levels of concern to barriers of studying engineering were reduced, 'Time Management' and 'Compete with Top Students' were increased. This showed that during the support programs, students experienced issues controlling their time and competing with others. However, many students expressed that they could identify 'reality' of the engineering college, and this is one of main objectives of the ICE program.

V. Conclusion

The limitations of this study highlight the need for tracking students throughout their academic tenure and into their professional careers, and not only those students who participate in our programs. All students should be tracked so that comparisons can be made between program and non-program students on relevant variables, which would allow more valid assessments of program effectiveness. Such tracking need not be overly intrusive or burdensome—strategically constructed instruments can make questionnaires much less daunting—and may reveal insights into the academic experiences of non-program students, as well, benefitting everyone in the system.

Besides tracking, the results of this study also point to a significant weakness in the overall strategy of engineering outreach nationwide: one-time funding of new programs. Program sustainability is of paramount importance, as is institutional commitment to long term interventions. Engineering education programs must increase their commitments to support programs for underrepresented populations beyond the first semester of enrollment or the first grant of start-up funds. Support programs must be in place throughout students' academic careers, and must be funded on a permanent institutional basis. Especially in the current economic climate, such programs cannot continue to rely on soft money.

From the results of pre-, post assessment and focus group interviews, students expressed many positive changes during support programs. However, researchers need to cultivate more in-depth understanding of their changes by tracking their academic careers.

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Appendix. Pre-post Assessment Questionnaire.

This Student Pre-Assessment questionnaire will be administered online through a university secure website, Web Services' Toolbox, whereby each student will be requested to use their university ID and password to log in.

The purpose of this pre-assessment is to obtain information at the beginning of ICE program in order to learn how you view yourself as a new engineering student at the University.

I. Views toward Engineering/Technical Subjects

Choose a number with 1 being Not at all and 5 being Very much. If you have had no experience with a particular area, choose NA for Not Applicable.

No.	Questions	Scale					
1	How interested are you in becoming an engineer?	1	2	3	4	5	NA
2	How certain are you of your particular major in engineering?	1	2	3	4	5	NA
3	How much do you like math?	1	2	3	4	5	NA
4	How much do you like chemistry?	1	2	3	4	5	NA
5	How much do you like physics?	1	2	3	4	5	NA

II. Abilities and Skills

Rank your abilities and skills in the following areas by choosing a number with 1 being the lowest and 5 being the highest. If you have not had any exposure to a particular area, such as robotics or working in groups, choose NA for Not Applicable.

No.	Questions	Scale					
1	Math	1	2	3	4	5	NA
2	Chemistry	1	2	3	4	5	NA
3	Physics	1	2	3	4	5	NA
4	CAD	1	2	3	4	5	NA
5	Programming	1	2	3	4	5	NA
6	Writing	1	2	3	4	5	NA
7	Circuitry	1	2	3	4	5	NA
8	Study skills	1	2	3	4	5	NA
9	Time management	1	2	3	4	5	NA
10	Motivation	1	2	3	4	5	NA
11	Working in groups	1	2	3	4	5	NA
12	Asking for help	1	2	3	4	5	NA
13	Being a self-starter	1	2	3	4	5	NA
14	In preparing for your first semester as an engineering student, how many total hours a week do you envision yourself studying?	_______________________ hours					

15	Did you have a written time management plan in high school?	Yes __________ No _________
15a	If you answered Yes to question 15, please provide a brief description of the plan and whether you found it to be beneficial. If you answered No, please move on to the next question.	____________________________
16	Have you worked in groups during high school?	Yes __________ No _________
16a	If you answered Yes to question 16, please provide a brief description of your experience and whether you found it to be beneficial. If you answered No, please move on to the next question.	____________________________

III. Adjustment to College of Engineering and the University

What do you envision as the most pressing challenges in your first semester at the University? Choose all that apply.

___ Insufficient high school preparation
___ Intense course schedule
___ Balancing school and social activities
___ Balancing school and work
___ Overall time management
___ Homesickness
___ Making new friends
___ Finances
___ Being on your own for the first time
___ Being in classes with diverse students
___ Health issues
Other: Please specify ____

IV. View toward ICE program

List three things you hope to gain from ICE Program in order of importance ("a." being the most important).
a.
b.
c.

V. View toward College of Engineering and the University

List three things you are most looking forward to this fall as a first-year engineering student in order of importance ("a." being the most important)
a.
b.
c.