Carry-Over Effects of a Freshman Engineering Program as Identified by Faculty Ratings

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Abstract

For seven years, The University of Alabama's College of Engineering has presented incoming freshmen with the opportunity to participate in a non-traditional first year program called TIDE (Teaming, Integration, and Design in Engineering). Components of TIDE that differ from the traditional first year program are cohort grouping, cooperative learning, team design projects, and an emphasis on written and oral communication. Student record data indicates that the program has improved retention in the engineering program but has had minimal effect on achievement. Anecdotal evidence from follow-on teachers, however, suggests that the TIDE program may have soft skill carry-over effects. Upper-class engineering students who participated in the TIDE program may exhibit more confidence, better communication skills and greater team skills than their traditional program counterparts.

To test this hypothesis, engineering faculty who teach downstream design courses that rely heavily on student soft skills were asked to rate past students on a variety of dimensions. Each rater was presented with a list of their past students matched on high school GPA and ACT/SAT scores. These students were not identified to the raters as either TIDE or traditional students. Ratings for each skill were completed on a rubric-style scale designed to ensure consistency of rating meaning across raters. All data was collected during the 2000-01 academic year. A discussion of the analysis and implications will be presented.

Introduction

The importance of non-technical "soft" skills in the engineering workplace is well documented. Evans et al.[1] surveyed 737 engineering alumni on the relative importance of 10 attributes of engineering graduates, and on the perceived competency of recent engineering graduates with respect to each attribute. Summarizing the results the authors state, "This is indicative of the mounting evidence that employers, especially those that have joined the quality revolution, are desperate for people who do not have to learn on the job how to fit into a team-centered culture where communication, interpersonal skills, and professionalism, are as important as technical skills."

Lonsdale et al.[2] have developed a capstone design course that develops soft as well as technical skills. Results of a survey of 410 engineering alumni showed the greatest discrepancy between the importance of a skill and the preparation they received in college was in communication skills and team skills. The authors also quote a report on surveys of engineering deans and engineering employers[3], "eight out of ten industry respondents place a high value on the importance of teamwork in engineering while only one in four felt new graduates were well-prepared in this area."

In an address to the 1993 ASEE Centennial Conference, Kent Black[4], CEO of Rockwell International, provided comments on an industry view of engineering education. He points out that American companies are facing still competition from global companies that "value flexible teams with multi-talented members, and have little use for multiple tiers of management." He also states, "For engineers, what's *technically* possible is no longer key. They are now members of product teams, using quality function deployment to match customer desires to possible designs. They participate in cross-functional teamwork and life long learning."

Downing[5] analyzed surveys from 188 engineering alumni on the importance of specific non-technical skills, possible curricular changes to better prepare students in those skills, and preferred methods of improving those skills on the job. He found that alumni considered listening, decision making, problem solving, verbal communication and time management to be the most important skills to function effectively in team-based work environments.

And finally, Lewis et al.[6] present a method for assessing the acquisition of team skills on student teams. They point out that while many engineering educators give team assignments, "Often missing is a systematic focus on helping students acquire team competence. Rarer still are systematic attempts to evaluate student learning of teaming skills and competencies."

Overview of TIDE Program

The TIDE freshman-engineering program grew out of a prototype freshman program developed as part of the NSF-sponsored Foundation Coalition (FC), of which the University of Alabama (UA) was a partner. The four thrusts of the Foundation Coalition were curriculum integration, active learning, technology in the classroom and assessment. Curriculum integration at UA necessitated cohort scheduling because the content of the new integrated FC math, science and engineering courses, although equivalent to the traditional curriculum as a whole, were different individually than their traditional counterparts. Thus, students were required to take either all of the FC courses or none of them.

Active learning was usually implemented in the classrooms by means of team exercises. Students were assigned to the same four-person teams for all of the four courses (chemistry, mathematics, physics and engineering). Team homework assignments and projects were also frequently assigned. Although teamwork was not one of the primary four thrusts of the FC, students did a tremendous amount of teamwork. On average, students received approximately eight hours of team training. The TIDE freshman curriculum emphasized other skills besides teamwork, including use of computers, written and oral communication and open-ended design projects.

Methodology

In order to better understand TIDE student's internalization of program principles, the Soft Skill Assessment Inventory (SSAI) was developed. The SSAI is an eleven-item five-point rubric given to a group of instructors for rating soft skill attainment of past students. The instrument contains one scale for each of the eleven areas the TIDE program intends to impact; team skills, initiative, problem solving, written communication skills, verbal communication skills, ability to complete tasks, leadership abilities, use of computers to solve problems, verbal presentation skills, engagement in life long learning, and degree of flexibility. The research team developed detailed descriptions of the one, three and five anchor points that were distributed to a select group of colleagues for validation.

Twenty-six engineering professors were recruited to rate past students on their attainment of each of the soft skills in the instrument. These professors were selected because they had taught courses that incorporated team projects. The professors were given a chart of their old students and a copy of the rubric for reference. A researcher met face to face with the raters and explained the rubric and chart. Raters were asked to review the documents and were encouraged to ask clarification questions. The raters were instructed to forego review of students for whom they had no memory or only a fleeting memory. The raters were to only review those students they remembered quite well. Raters were not told that the study was designed to look at the differences between TIDE and non-TIDE students in order to avoid rater bias.

A total of 189 students from incoming freshman years of 1994 through 1998 were included in the original sample. Each student name was given to at least three different raters. Student ratings were kept for analysis if they contained more than one rating per student and there was no missing data on any of the items. The averages of multiple ratings for each student were calculated to give a single rating score on each item per student.

Fifteen out of 26 raters returned completed forms in a timely manner. The final sample consisted of 109 students, 56 who participated in the traditional freshman year curriculum and 53 who were part of the experimental TIDE program. The final sample contained 70 males and 39 females. Eighty-three percent of the sample was white, twelve percent black and five percent were from other racial categories.

Results

Psychometric Properties of the SSAI

Since the SSAI is a researcher-developed instrument, it is important to look at the psychometric properties to get a sense of its reliability and validity. A Cronbach alpha reliability coefficient was computed to assess the reliability or internal consistency of the SSAI. Cronbach's Alpha[7,8] statistic is used to determine the internal consistency of an instrument when only a single sample of scores is available. Ideally, consistency is determined by using two parallel forms of the instrument given to the same sample at different time intervals. In many cases, this is not feasible; therefore, the alpha is a good estimate of test-retest consistency. The computed

Cronbach alpha level of 0.9484 is indicative of a highly reliable instrument. Therefore, we can be reasonably assured that multiple administrations of the SSAI would yield similar results.

Item to total score correlation coefficients were computed to better understand the extent to which each item is a good predictor of the total score. In the case of the SSAI, all Person Product Moment item to total score correlation coefficients were both high and statistically significant (see Table 1).

Table 1: Item to total correlation coefficients of the SSAI

		Total Score
Total Score	Pearson Correlation	1.000
	Sig. (2-tailed)	.
Team Player	Pearson Correlation	.806**
	Sig. (2-tailed)	.000
Initiative Level	Pearson Correlation	.865**
	Sig. (2-tailed)	.000
Life Long Learning	Pearson Correlation	.818**
	Sig. (2-tailed)	.000
Verbal Presentation Skills	Pearson Correlation	.753**
	Sig. (2-tailed)	.000
Use Computers to Solve Problems	Pearson Correlation	.793**
	Sig. (2-tailed)	.000
Leadership Abilities	Pearson Correlation	.873**
	Sig. (2-tailed)	.000
Ability to Complete Tasks	Pearson Correlation	.876**
	Sig. (2-tailed)	.000
Written Comm Skills	Pearson Correlation	.771**
	Sig. (2-tailed)	.000
Verbal Comm Skills	Pearson Correlation	.832**
	Sig. (2-tailed)	.000
Problem Solving Skills	Pearson Correlation	.838**
	Sig. (2-tailed)	.000
Degree of Flexibility	Pearson Correlation	.715**
	Sig. (2-tailed)	.000

**. Correlation is significant at the 0.01 level (2-tailed).

A principle components factor analysis with varimax rotation was undertaken to explore the underlying factor structure of the SSAI. Factor analysis is a method employed to better understand the underlying structure of an instrument. The covariation between observed items within an instrument can be explained by their commonality with a single underlying factor, or sub-scale. Furthermore, the factor analysis allows an instrument with multiple items to be reduced to a handful of factors composed of individual items. One method for mathematically extracting the commonalities between items is a principle components method. Once extracted, it is useful to mathematically rotate factor axes in multidimensional space to better understand the factor simple solution. The varimax rotation is a method employed to rotate factor axes.

Although a complete discussion of factor analysis is beyond the scope of this paper, the reader is encouraged to read one of the many statistical texts devoted to this process.[9,10]

A two-factor solution that explains 74% of the variability within the instrument was chosen as the simple solution. The two factors had eigenvalues of 7.295 and 0.835 respectively. Factor 1 consists of seven items which contain soft skills that are most helpful in individual working situations. This sub-scale that we named Individual Based Skills, contains the items Problem Solving Skills, Use of Computers in Problem Solving, Ability to Complete Tasks, Initiative Level, Verbal Presentation Skills, Verbal Communication Skills, and Written Communication Skills. Factor 2, which we called Teaming, is made up Degree of Flexibility, Team Player, Life Long Learning, and Leadership Abilities. This sub-scale can be seen to contain skills that could enable a student to better work in teams and groups (See Table 2)

Table 2: SSAI rotated component matrix.

Rotated Component Matrix[a]

	Component	
	1	2
Problem Solving Skills	.865	.286
Use Computers to Solve Problems	.822	.257
Ability to Complete Tasks	.763	.456
Initiative Level	.760	.446
Verbal Presentation Skills	.733	.286
Verbal Comm Skills	.631	.546
Written Comm Skills	.607	.469
Degree of Flexibility	.193	.871
Team Player	.379	.797
Life Long Learning	.479	.704
Leadership Abilities	.576	.675

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

The reliability coefficient, item-to-total score correlation coefficients, and the factor analysis all indicate that the SSAI is a reliable instrument with good evidence of validity. We feel confident that the SSAI is a good instrument to use in exploration of the soft skill attainment of past engineering students.

Differences Between Groups

To test our hypothesis that previous TIDE students would be seen by professors as having a greater degree of soft-skill attainment than previous students in the traditional curriculum, a *t*-test was conducted using the total SSAI score , and both sub-scales of the SSAI.

The test of group differences showed no statistical significance at the 0.05 alpha level for differences between the total SSAI score (*t* = -0.607, *df* = 107, α = 0.545), the Individual Based Skills subscale (*t* = -0.195, *df* = 107, α = 0.845), or the Teaming subscale (*t* = -1.234, *df* = 107, α = 0.220).

Table 3: Group means and standard deviations on the SSAI.

		N	Mean	SD	SE Mean
Total Score	TIDE	53	41.91	7.05	0.9691
	Traditional	56	41.08	7.20	0.9617
Individual Based Skills	TIDE	53	26.55	4.44	0.6103
	Traditional	56	26.38	4.89	0.6540
Teaming Skills	TIDE	53	15.35	2.87	0.3943
	Traditional	56	14.70	2.66	0.3561

Differences between the individual items on the SSAI were explored to determine if any single soft-skill attainment was statistically significant between the TIDE and traditional groups. Since the individual Likert-type items can be accurately described as ordinal level data, the Wilcoxon W non-parametric test was used to assess group differences. The Wilcoxon procedure ranks all observations of both groups in order to determine if the summed ranks of one group is significantly different from the summed ranks of the second group. Our hypothesis is that the ranked soft-skill assessments of the TIDE students will be higher than those of the traditional students.

Table 4 shows that the only individual soft-skill item that had significantly different summed ranks was the Team Player item (*W* = 2653.50, *z* = -2.615, *p* = 0.009). Although not significant at the .05 level, the Leadership Abilities item was the nearest to approaching significance in favor of TIDE students (*W* = 2878.00, *z* = -1.239, *p* = 0.215). Likewise, the Written Communications Skills item was approaching significance in favor of traditional students (*W* = 2713.00, *z* = -1.246, *p* = 0.213).

Conclusions

The SSAI was developed as an evaluation tool to better determine the degree to which the TIDE program was directly related to student soft-skill attainment and carry-over. The SSAI was found to be highly reliable with strong evidence of validity.

The results indicate that, overall, TIDE students were not given higher ratings than traditional students for soft-skill attainment. TIDE students did rate significantly higher on one individual scale, the Team Player scale. Two other items approached a significant difference: TIDE students rated higher on Leadership Abilities and traditional students rated higher on Written Communication.

Table 4: Wilcoxon tests for each item on the SSAI.

	Group	N	Mean Rank	Sum of Ranks	Z Statistic	p-value
Team Player	Traditional TIDE	56 53	47.38 63.05	2653.50 3341.50	-2.615	.009**
Initiative Level	Traditional TIDE	56 53	53.57 56.51	3000.00 2995.00	-0.489	.625
Life Long Learning	Traditional TIDE	56 53	56.69 53.22	3174.50 2820.50	-0.581	.561
Verbal Presentation	Traditional TIDE	56 53	52.00 58.17	2912.00 3083.00	-1.046	.296
Use of Computers to Solve Problems	Traditional TIDE	56 53	54.87 55.14	3072.50 2922.50	-0.046	.963
Leadership Abilities	Traditional TIDE	56 53	51.39 58.81	2878.00 3117.00	-1.239	.215
Ability to Complete Tasks	Traditional TIDE	56 53	56.17 53.76	3145.50 2849.50	-0.400	.689
Written Communication	Traditional TIDE	56 53	58.61 51.19	3282.00 2713.00	-1.246	.213
Verbal Communication	Traditional TIDE	56 53	52.96 57.15	2966.00 3029.00	-0.700	.484
Problem Solving Skills	Traditional TIDE	56 53	56.27 53.66	3151.00 2844.00	-0.434	.664
Degree of Flexibility	Traditional TIDE	56 53	54.11 55.94	3030.00 2965.00	-0.306	.759

The TIDE program attracted students interested in team work, provided them with basic training in how to work in teams, and then supplied ample opportunities for them to work in teams both in and out of class. Several years later, professors rated the former TIDE students higher as team players and in leadership abilities. Because the TIDE students were volunteers and the students in the control group were not, we were not able to distinguish whether the TIDE program simply attracted students with more interest and ability in teamwork or the TIDE program instilled better team skills than the traditional curriculum. The authors' personal experience recruiting students for TIDE and teaching those students suggests both effects were operative. Although frustrating from a research standpoint, the results are clear from an administrative standpoint: the TIDE program supplies industry with students possessing better team skills.

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