High School Extracurricular Activities and Camps Related to Engineering, Math and Science: Do They Help Retention and Performance in Engineering? (Fundamental)

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Abstract

After the call to increase the number of engineers graduating from college, many K-12 schools, organizations, colleges, businesses and individuals began programs designed to increase interest in fields related to science, technology, engineering and math (STEM). This study used survey data from two cohorts at a large metropolitan research institution to investigate whether students who participated in STEM related camps or extracurricular activities performed better in engineering school and if they were more likely to be retained in engineering. The data showed participation in a summer STEM camp increased the likelihood of being retained for one year, but did not increase the probability of retention in later years. The results of analysis on participation in camps and extracurricular activities and performance were mixed. There was no significant difference in GPA for those who did and did not attend a STEM camp. Students who participated in math or science related extracurricular activities did have a statistically higher first and seventh semester GPA compared to students who did not participate in these types of activities. There was no significant difference in first or seventh semester GPA for students who did or did not participate in extracurricular activities related to engineering or computer science.

Introduction

As a result of the call to increase the number of engineers graduating from college, engineering colleges, such as the study site, were motivated to engage in more community outreach to promote interest in engineering at the K-12 level. Outreach at this college included engineering focused summer camps, assisting with after school programs and training K-12 teachers to run engineering related programs during and after the school day. Programs implemented after school and during school hours included Engineering is Elementary and In the Middle of Engineering.

Other organizations, businesses and government agencies were also motivated to participate in and finance STEM related activities and camps to help increase interest and skills in STEM related fields technology and ultimately increase the number of engineers in the workforce[1]. Some activities and camps targeted underrepresented groups such as females and African Americans. Organizations, including K-12 schools, musuems, universities, scouting groups and corporations as well as individuals have designed interesting activities and camps to introduce students to the amazing and fun aspects of STEM. Some activities have been integrated into the formal K-12 education; other activites were designed as informal voluntary extracorricular activites that take place after school or during the summer.

Girls Who Code, an organization founded in 2012 by an individual with the mission to "close the gender gap in technology" [2], is a good example of a program designed to address the

need to increase the number of females in computer science. Since its founding, multiple technology and nontechnology companies have partnered with Girls Who Code including Microsoft, IBM and Cover Girl. Girls Who Code has after school clubs for girls in 6 -12th grade and seven week summer camps for girls in grades 10 and 11.

FIRST Robotics hosts competions with robotic challenges and has grown into an international competition with over 400,000 participents[3] is a good example of an organization that has worked to interest K-12 students of all sexes in robotics. Many teams are part of extracorricular activites offered by their middle and high schools.

There is evidence in the literature that participation in extracurricular activities and camps can impact student's career and college major choice [4-7]. However, few papers show whether the benefits of participation extend to performance and retention once the student has started college. This study is focused on students who in high school participated in extracurricular activities or camps related to science, computer science, math or engineering (including robotics). Specifically, this study investigates the relationship between participation in voluntary high school STEM activities and camps, and performance and retention in an engineering program at a large metropolitan research institution. This paper does not investigate formal pre-engineering activities and programs that are part of the K-12 curriculum.

Related Literature

Camps

Research in career and college major choice supports that interest is a strong influence when selecting a field of study and profession[8]. Evidence also supports interest in engineering influences students decision to study engineering [9,10,11]. Studies have shown participation in STEM related camps has increased interest and attitudes towards science and technology, particularly for underserved populations[4]. In a study of middle school students, students who had participated in a science summer camp were more likely to later indicate that they were considering careers in science or an engineering field[5]. Similar results were found based on data collected from students who in middle school had attended a STEM summer camp held at Virginia Tech. Based on the campers' field of study in college, the researchers concluded that the camp helped increase enrollment in engineering, science and math related fields[6].

A follow-up study of students who attended an engineering camp at the University of Utah showed that after attending the camp students thought more positively about engineering than they did before the camp[7]. The organizers of the camp also reported success in the main goal of the camp that was to recruit more students into the engineering department at the University of Utah.

Although these camps might help increase interest in engineering, results of a study at Purdue do not seem to support that students who attend these camps perform better in engineering and math courses. In the Purdue study 32% of the 229 participants indicated that

they had attended an engineering related camp while in high school. Analysis showed no significant difference in performance in two engineering and two math courses between students who had and those who had not attended a camp[12].

Extracurricular Activities

Research into the benefits of participation in extracurricular activities (ECAs) has been grounded in multiple models including social capital model, development model and leading-crowd hypothesis[13]. These models support various motivations for participation, such as being part of a group or team, being with like-minded people, learning, or doing an activity that is enjoyable. It is also important to realize that some students are motivated by external forces such as parents and what might look good on a college or scholarship application.

Research into STEM related ECAs has shown a relationship between participation and academic achievement, interest, and career choice[14], as well as improved collaboration skills[15]. A study focusing on participants in FIRST Robotic clubs showed students indicated the following benefits: improved communication and interpersonal skills, ability to apply academic skills to real world problems, interest in serving others, improved self-confidence and team work, increased interest in science and technology and science and technology careers[16].

In the previously mentioned study at Purdue, researchers also investigated whether students who had participated in engineering related extracurricular activities outperformed students who had not participated. Their analysis again showed no significant difference in performance in two engineering or math courses between students who had (17%) and had not participated (83%) in engineering related extracurricular activities[12].

Research Questions

The current study sought to build on the results of the previously mentioned Purdue study and determine if students who while in high school participated in certain types of STEM extracurricular activities or camps received higher GPAs in engineering or were more likely to be retained in engineering than students who did not participate. The following research questions were investigated:

RQ1: Is there a difference in performance level, as measured by GPA, between engineering students who did and did not participate in STEM camps or ECAs?

RQ2: Are engineering students who participated in STEM camps or ECAs more likely to be retained in engineering than students who did not participate?

Method

Procedure

Since 2010 first year engineering students at a large metropolitan public research university have taken a survey during the first week of classes. Survey questions covered multiple areas and included multiple indices and changed slightly each year based on the research team requests. Students completed the survey during class time in a required Introduction to Engineering course. No rewards or credit were given for participation. Survey results were confidential and participants were not known to the researcher.

The data used in the current study pertained to student responses in 2012 and 2013 as to whether they had participated in certain ECAs in high school or if they attended certain types of summer camps. The questions on the survey related to ECA and STEM camp participation changed slightly between the 2012 and 2013 surveys. The questions on the 2012 survey asked more specifically if the students had participated in camps or ECAs by subject (math, science, computer science and engineering); the question on the 2013 survey just asked if they had participated in any STEM related activity or camp. Thus we have more specific data for the 2012 cohort.

The 2012 survey contained the following question, *Have you ever participated in any of the following extracurricular activities outside of regular school hours?* followed by four activity areas (math, science, computer science and engineering (including robotics). The same question in the same format was asked about summer camps/programs outside of regular school activities.

In 2013 the question was modified to shorten the survey. It only asked the following 2 questions, thus not allowing for discernment between the focus of activity or camp.

- *Have you ever attended any summer camps related to math, science, engineering or computer science (including robotics)?*
- *Have you ever participated in any extracurricular activities related to math, science, engineering or computer science (including robotics)?*

Performance and retention data were taken from student records and supplied by the university's Office of Institutional Effectiveness in Institutional Research. The data were related back to the students' survey responses through an assigned research ID.

Participants

The participants were first-time full-time engineering students at a large metropolitan public research university in the fall of 2012 or 2013. The 2012 cohort had 434 students and 408 completed the survey (94% response rate). The 2013 cohort had 505 students and 473 completed the survey (94% response rate). Both cohorts were predominantly Caucasian with no other group representing over 5%, predominantly male (22% female in 2012 and 20% in 2013), and

overwhelmingly traditional students (app. 99% directly out of high school). The average composite ACT scores were 28.3 in 2012 (*SD* = 3.16) and 28.5 in 2013 (*SD* = 3.17).

When looking at 2012 and 2013 cohorts together, students who had participated in STEM ECAs had statistically higher ACT subject and composite scores ($p<.05$ for all) than students who had not participated. Some of the mean differences were quite small (see Table 1). The students who had participated in STEM related camps had statistically higher ACT composite scores and subject scores except for English (see Table 2).

Table 1. *ACT and High School GPA Differences for Students Who Did and Did Not Participate in STEM Related ECAs*

	ECA Participation	*n*	Mean	Std. Deviation
High school GPA	No	358	3.75	.30
	Yes	491	3.78	.31
ACT Composite	No	358	28.0	2.99
	Yes	492	28.8	3.21
ACT English	No	343	28.3	4.21
	Yes	475	28.9	4.23
ACT Math	No	343	28.7	3.08
	Yes	475	29.6	3.33
ACT Reading	No	343	28.4	4.27
	Yes	475	29.4	4.33
ACT Science	No	343	28.3	3.44
	Yes	343	28.3	3.44

Table 2. *ACT and High School GPA Differences for Students Who Did and Did Not Participate in STEM Related Camps*

	Camp Participation	*n*	Mean	Std. Deviation
High School GPA	No	666	3.76	.30
	Yes	199	3.79	.32
ACT Composite	No	665	28.3	3.06
	Yes	201	29.1	3.29
ACT English	No	639	28.5	4.15
	Yes	193	29.1	4.42
ACT Math	No	639	29.0	3.22
	Yes	193	29.6	3.32
ACT Reading	No	639	28.8	4.26
	Yes	193	29.7	4.33
ACT Science	No	639	28.6	3.53
	Yes	193	29.3	3.68

The average high school GPAs for students who did and did not participate in ECAs and camps are also listed in Tables 1 and 2 for comparison. The university records included weighted GPA, but truncated the recorded GPA at 4.0. Therefore, all submitted GPAs over 4.0 are reduced to 4.0, resulting in about 40% of the students having a recorded 4.0 high school GPA.

Analysis

GPA and Participation in ECA or Camp

Since details as to the subject matter of ECA or camp were available for the 2012 cohort, analysis was done on each type of ECA or camp to determine if the students who participated in different types of ECAs or camps had higher GPAs than students who did not participate. When doing analysis with the 2012 cohort data, first and seventh semester cumulative GPAs were available. The distributions of first semester and seventh semester cumulative GPAs for the 2012 cohort were tested for normality using the Shapiro-Wilk test. As is frequently the case when analyzing GPA data, the results showed the GPA data were not distributed normally ($p < .001$ for both tests). Therefore a nonparametric test, Kruskal-Wallis, was used to determine if the distributions of the GPAs of students who did and did not participate in camps and activities were significantly different.

Analysis on GPA and participation was also performed on the 2013 data. Here there were no details as to the type of ECA or camp available so the analysis just looked at whether the student had participated in any STEM related camp or ECA. Again the Kruskal-Wallis test was used.

Retention and Participation in ECA or Camp

Logistic regression was used to determine the difference in the probability of persistence in engineering between students who did and did not participate in any STEM ECA or camp. To increase the power of the test, 2012 and 2013 data were analyzed together in one model when looking at one and two year retention. Since the three year retention numbers were not yet available for the 2013 cohort, only 2012 cohort data was used in the analysis for three year retention. For the analysis all variables were considered categorical and the value =1 was considered the reference. All analyses were performed in SPSS revision 23.

Results

Summary Data

As mentioned previously, due to the formulation of the survey questions in 2012, there is specific data on the subject matter of the ECAs and camps the students in the 2012 cohort participated in, but not for the ECAs and camps the students in the 2013 cohort participated in.

Table 3 shows the number and percentage of students who responded that they had participated in certain ECAs or camps before coming to college. Many students had participated in more than one ECA or camp (see Tables 4 and 5). Forty-five percent of the engineering students had not participated in a STEM activity and 4% of the students indicated that they participated in camps related to all four areas: science, math, computer science and engineering. Students were more likely to have participated in a STEM ECA (55%) than a STEM camp (21%). Only 37% of the students had not participated in either a STEM activity or camp.

Table 3. *2012 Cohort - Participation in Camps or ECAs by Type*

	ECA		Camp	
	Number of Students	Percent	Number of Students	Percent
Math	167	41%	51	13%
Science	159	40%	45	11%
Engineering	92	23%	52	13%
Computer science	58	15%	16	4%
Any	209	55%	85	21%

Table 4. *2012 Cohort – Number of Camps and ECAs*

	ECA		Camps	
Number of Types	Number of Students	Percent	Number of Students	Percent
0	169	45%	312	79%
1	72	19%	45	11%
2	85	22%	25	6%
3	35	9%	9	2%
4	17	4%	6	2%

Table 5. *2012 Cohort – Total Number of ECAs and Camps Students Participated In*

Total Number of Types ECAs and Camps	Number of Students	Percent
0	135	37%
1	79	21%
2	82	22%
3	35	9%
4	19	5%
5	9	2%
6	4	1%
7	2	1%
8	4	1%

Data from the 2013 cohort looked similar to the summary data from the 2012 cohort. In the 2013 cohort 60% of the students indicated they had participated in an ECA (see Table 6), 25% a camp and 64% of the students had participated in either a STEM camp or ECA (see Table 7).

Table 6. *2013 Cohort - Number of Students Who Participated in ECAs and Camps*

	ECA		Camp	
	Number of Students	Percent	Number of Students	Percent
Did not participate	190	40%	354	75%
Did participate	283	60%	116	25%

Table 7. *2013 - Cohort Participating in None, Either or Both STEM Activities and Camps*

	Number of Students	Percent
None	167	36%
Either	209	45%
Both	94	20%

In the 2012 cohort, a higher percentage of females had participated in both STEM ECAs and camps. The same was true for the 2013 cohort (see Table 8).

Table 8. *Percent of Males and Females Who Participated in Any STEM Camp and ECA*

	Percent of Females	Percent of Males
2012 Any ECA	62%	54%
2012 Any Camp	29%	19%
2013 Any ECA	62%	59%
2013 Any Camp	30%	23%

Participation and GPA

Results of the Kruskal-Wallis tests for the 2012 cohort data are in Tables 9 and 10. There was no significant difference in GPAs related to whether students did or did not participate in any type of camp. There was a significant difference in first and seventh semester cumulative GPA only between students who did and did not participate in math or science related ECAs. The GPA data for students in the 2013 cohort (see Tables 11 and 12) showed no statistical difference in the distributions of first and fifth semester cumulative GPAs when looking at students who did and did not participate in camps or ECAs.

Table 9. *Results of Kruskal-Wallis Test Comparing GPA after **First Semester** (2012 Cohort)*

	ECA			Camp		
Focus	Yes	No	*p*	Yes	No	*p*
Math	**3.03**	**2.62**	**<.001**	3.00	2.76	.102
Science	**2.80**	**2.70**	**.013**	2.97	2.76	.106
Engineering	2.74	2.76	.764	2.86	2.77	.448
Computer Science	2.75	2.77	.828	2.57	2.79	.666
Any	**2.86**	**2.63**	**.044**	3.00	2.73	.093

Table 10. *Results of Kruskal-Wallis Test Comparing GPA after **Seventh Semester** (2012 Cohort)*

	ECA			Camp		
Focus	Yes	No	*p*	Yes	No	*p*
Math	**3.28**	**3.03**	**.001**	3.19	3.13	.145
Science	**3.23**	**3.07**	**.033**	3.20	3.13	.224
Engineering	3.07	3.15	.402	3.16	3.14	.569
Computer Science	3.10	3.14	.861	2.78	3.16	.753
Any	3.18	3.07	.094	3.14	3.13	.211

Table 11. *Results of Kruskal-Wallis Test Comparing GPA after **First Semester** (2013 Cohort)*

	GPA after First Semester		
	Yes	No	*p*
ECA	2.90	2.86	.397
Camp	2.85	2.90	.693

Table 12. *Results of Kruskal-Wallis Test Comparing GPA after* ***Fifth Semester*** *(2013 Cohort)*

	GPA after fall 2015		
	Yes	No	*p*
ECA	3.09	3.07	.669
Camp	3.10	3.08	.620

Participation and Retention

Students in the 2012 cohort who had participated in ECAs related to math, engineering or computer science had higher one, two and three year retention rates in engineering than students who had not participated (see Table 13). This was not true for students who participated in computer science ECAs. Students who participated in any type of STEM related camp had higher one, two and three year retention rates than students who did not participate (see Table 14). In the 2013 cohort the one year retention in engineering rate was slightly higher for students who participated in activities and camps, but the two year rate was slightly lower (see Table 15).

Table 13. *2012 Cohort – Percent Retained in Engineering Rates for Students Who Had and Had Not Participated in ECAs*

	Participated			Did Not Participate		
ECA Focus	1 year	2 year	3 year	1 year	2 year	3 year
Math	74.9	65.3	61.7	69.2	56.5	52.7
Science	74.8	64.8	59.7	69.3	57.7	54.8
Engineering	73.9	59.8	58.7	69.3	59.0	54.7
Computer Science	70.7	53.4	53.4	71.3	61.3	57.0

Table 14. *2012 Cohort – Percent Retained for Students Who Had and Had Not Participated In Camps*

	Participated			Did Not Participate		
Camp Focus	1 year	2 year	3 year	1 year	2 year	3 year
Math	74.5	66.7	58.7	70.9	59.1	56.3
Science	82.2	71.1	66.7	69.8	58.5	55.4
Engineering	80.8	63.5	61.5	69.9	59.0	55.6
Computer Science	81.3	62.5	62.5	70.9	59.7	56.4
Any						

Table 15. *2013 Cohort – Percent Retained for Students Who Had and Had Not Participated In Camps and Activities*

	Participated		Did Not Participate	
	1 year	2 year	1 year	2 year
Activity	75.3	65.0	74.8	65.8
Camp	78.5	64.7	74.3	65.3

Logistic regression to determine if participation in STEM related ECAs or camps increased the likelihood of being retained for one and two years was performed using 2012 and 2013 data together. The analysis for the three year retention only used the 2012 cohort since three year retention was not available for the 2013 cohort. The results showed students who had participated in a STEM related camp had a higher probability of being retained for one year (see Table 16). Based on the confidence interval of the odds ratio, students who had participated in a STEM related camp had between a 1.6% and 21% higher probability of being retained than someone who had not participated in a STEM related camp. This did not hold true for the two and three year retention rates where analysis showed no statistical difference in probability of being retained for students who did and did not attend a STEM camp (see Tables 17 and 18). Analysis investigating the relationship between participating in ECAs related to STEM and one, two and three year retention rates showed no statistical difference in the probability of being retained for one, two or three years (see Tables 14, 15 and 16).

Table 16. *Results of Logistic Regression for 1 Year Retention*

	B	*S.E.*	*Wald*	*df*	*Sig.*	Exp(*B*)	95% C.I.for EXP(*B*)	
							Lower	Upper
Camp	0.406	0.199	4.162	1	**0.041**	**1.500**	**1.016**	**2.215**
ECA	0.054	0.160	0.113	1	0.737	1.055	0.771	1.444
Constant	0.891	0.121	54.129	1	0.000	2.438		

Table 17. *Results of Logistic Regression 2 Year Retention*

	B	*S.E.*	*Wald*	*df*	*Sig.*	Exp(*B*)	95% C.I.for EXP(*B*)	
							Lower	Upper
Camp	0.153	0.174	0.780	1.0	0.377	1.166	0.829	1.638
ECA	0.098	0.147	0.445	1.0	0.505	1.103	0.827	1.470
Constant	0.438	0.112	15.299	1.0	0.000	1.549		

Table 18. *Results of Logistic Regression 3 Year Retention*

	B	*S.E.*	*Wald*	*df*	*Sig.*	Exp(*B*)	95% C.I.for EXP(*B*)	
							Lower	Upper
Camp	0.326	0.260	1.578	1.0	0.209	1.386	0.833	2.307
ECA	0.247	0.212	1.353	1.0	0.245	1.280	0.844	1.940
Constant	0.051	0.163	0.096	1.0	0.756	1.052		

Discussion

Based on the number of students who indicated they had participated in a STEM camp or ECA (63% in 2012, 64% in 2013), K-12 schools and other organizations are doing a good job providing STEM ECAs and camps. Women were more likely than men to have participated in a STEM camp or activity, which might be a result of the effort to increase diversity in the engineering field.

The results of the analysis on GPA and participation in STEM camps matches that of the Purdue study [12] in showing that students who participated in STEM camps did not earn higher GPAs in engineering than students who did not participate. When looking at all ECAs together (cohort 2013), the analysis also matches the Purdue study in showing no difference in first and fifth semester cumulative GPAs between students who did and did not participate in STEM ECAs.

Since the 2012 cohort data allowed us to look at specific topics of ECAs, analysis showed that students who participated in science and math related ECAs did have a higher first and seventh semester cumulative GPA compared to students who did not participate in these types of ECAs. Due to the design of this study it is not known if the higher GPAs are a result of the participation in these ECAs in high school or if the math and science skills of students who chose to participate in these activities were higher. Either way, participation in math and science ECAs might be useful as a selection factor if the goal is to have students who can do well in engineering school and other programs that rely heavily on math and science.

The logistic regression results showed that students who had attended a STEM related camp had a statistically higher probability of being retained after one year, but not after two or three years. Post analysis on the 2102 cohort showed 11 of the 47 students who left engineering between year 1 and year 2 had attended a camp. The average cumulative GPA of the students who left engineering at this time and had attended a camp was 1.81 compared to 2.37 for students who had not attended a camp. Seven of the 11 students left the university, 3 transferred to Arts and Sciences and 1 transferred to Education. Based on the number of students with GPAs below 2.0, many of these students left engineering and the university due to low GPAs. It is not known if their interest in engineering was also impacted. The data suggests that STEM related camps can have an impact on retention in engineering if the students attending these camps can also receive acceptable grades.

While K-12 STEM camps and extracurricular activities are important tools to increase interest in engineering, they will not by themselves increase the number of engineers graduating from college. There is a relationship between performance and interest that has been characterized in the Step-Out to Stars Engineering Retention Framework[17] that needs to be present for students to be retained in engineering. Interest alone will not get a student through engineering school. In one study, students in the Stars quadrant (high GPA, high interest) were retained for the first year at a rate of 94%, while students in the Step-Out quadrant (low GPA,

low interest) had a first year retention rate of 21%. Other research and theoretical models have also concluded that performance and interest are highly related to retention in engineering [18,19].

As with all studies it is important to view the results in the context of the data collection method. Since data on participation in camps and activities was collected via survey there is potential that participants misinterpreted the questions or that their answers did not accurately represent what happened. The data collected was gathered from one university; before the results are applied to other groups of students it is important to determine if the groups are similar. It is also important to understand that this study did not attempt to understand the impact of STEM ECAs and camps on students' interest level or desires to study engineering. Despite these concerns the results add to our understanding of the relationship between STEM ECAs and camps and performance and retention in engineering.

Conclusion and Future Research

In the previously mentioned paper with the Step-Out to Stars Framework, 29% of the students were in the quadrant labeled Strugglers (high interest, low grades). It is apparent from the post analysis in the current study that some students who had attended camp were earning low grades and left the university on academic probation at the end of two years. This might have contributed to the lack of significance of camp attendance in the two and three year retention rates.

Additional investigation is needed to clearly understand the impact of STEM ECAs and camps on performance and retention in engineering. Knowing more about student's motivation to participate in ECAs and camps as well as their level of engagement would be valuable to help understand the results of this study. For example, if a student participated based on strong encouragement from parents or solely to add to college and scholarship applications, his/her participation might not impact his/her interest or probability of being retained. Meanwhile a student with intrinsic motivation based on interest or being with like-minded people might have a higher probability of being retained.

The purpose of this study was narrow and in no way is intended to reflect all the benefits of participation in STEM camps and ECAs. As previously mentioned, the literature contains references to multiple benefits not related to engineering performance or retention. While considering STEM camps and ECAs as an avenue to increase the number of engineers in the workforce, it is important to spark students' interest; it is also necessary to emphasize the importance of mastery of mathematics and science concepts as well as time management and study skills.

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