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A Comparison of Two Engineering Outreach Programs for Adolescents

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Abstract

There is continued growth and development of outreach programs designed to increase pre-college students' awareness and understanding of engineering as a profession and as a career. These outreach programs vary in format and in the groups targeted for participation but maintain the same fundamental goal of increasing participant knowledge of engineering. Many of these outreach programs also maintain the implicit goal of increasing the participants' knowledge and attitudes toward college. The additional resources and funding that are commonly allocated to support outreach programs frequently involve documenting accountability which motivates evaluation of program impact. Therefore, many outreach events include program evaluation to assess impact on the pre-college participants' knowledge and perceptions of engineering, but they have not included the assessment of program impact on college attitudes. In this outreach program evaluation study, we examined the impact of two residential engineering outreach events on the participants' engineering perceptions and attitudes and their college attitudes. Our results indicate a number of personal variables were predictors of college attitude, but we failed to expose any variables as indicators of engineering perceptions and attitudes. Analysis of the pre-post survey scores revealed a significant change in engineering perceptions and attitudes ($p < .01$), but no significant change in college attitude ($p = .07$). We also exposed a differential impact by outreach event. Results, implications, limitations, and directions for future research are discussed.

Engineering Outreach Programs for Adolescents

Research on the perceptions of engineering commonly held by children and adults reveals limited understanding or misconceptions of the profession [17]. Because children are essential to the future of the profession, their limited knowledge and misconception of engineering are of particular concern [17]. Efforts to increase children's knowledge and resolve their misconceptions of engineering could take place in the classroom as part of the K-12 curriculum. However, this may be hindered by the likelihood that teachers may potentially hold the same limited understanding and misconceptions of engineering as the general public [16], [9]. This condition is exacerbated by the lack of teacher experience with authentic research or engineering endeavors. The likelihood that teachers hold limited knowledge of and have limited experience with engineering provides justification for pursuing other options for increasing the understanding of engineering in children.

Recognizing the possibility that teachers have limited preparation for effectively increasing their students' understanding of engineering, many colleges of engineering are taking action. Numerous engineering schools and colleges are developing and offering engineering education outreach programs as a method for increasing pre-college students' knowledge of the profession [9]. Jeffers and colleagues report on the widespread offering of engineering outreach programs, on the diversity of forms these programs can take, and on the broad spectrum of students the endeavors may serve.

The growing popularity and increasing amount of resources being allocated to implement engineering outreach programs has motivated program accountability mandates. This has led to a rising expectation that colleges of engineering will evaluate their outreach programs to gather the data required to empirically document program effectiveness. It is anticipated that program evaluation of engineering outreach endeavors will determine the extent to which these endeavors are increasing student knowledge of engineering and meeting other program related goals.

The expectation that outreach programs undergo evaluation motivated our research. In this project we investigated the impact of two engineering outreach residential programs designed for pre-college teens. Of foremost interest was the influence of the outreach programs on the participating adolescents' perceptions and attitudes toward engineering, which was the primary goal and content of these two events. Although previous research on outreach program effectiveness for increasing adolescent participants' knowledge of engineering has been reported in the literature, the wide variations in the content, format and audience for these endeavors justifies continued research in this area. However, there is a gap in the literature regarding the impact of outreach programs on the participating adolescents' attitudes toward engineering, making our research

rather unique. Further, our study also makes a unique contribution to this body of knowledge through evaluation of the impact of these two outreach programs on the participants' attitudes toward college. To our knowledge, no other engineering outreach program evaluation study has reported empirical data detailing the impact of these endeavors on participating pre-college teens' attitudes toward college.

Our report begins with an exploration of current research on teens' attitudes and perceptions of engineering. We then move into a presentation of various engineering outreach programs. We discuss the variables influencing adolescents' perceptions of college, developing a case for assessing these variables in engineering outreach events. This discussion is followed by a presentation of our research questions, methodology, analysis and results. We conclude with a discussion of outcomes, limitations, implications, and directions for future research.

Review of Literature

Teens' Attitudes and Perceptions of Engineering

Utilizing funding provided by the National Science Foundation, the National Academies of Engineering (NAE) conducted a large scale research project investigating adolescent and adult conceptions and attitudes toward engineering [17]. In this investigation the NAE research team gathered a wide range of quantitative and qualitative data from over 1000 adolescent and adult participants to determine their perceptions of what engineers do, their understandings of the qualifications for being an engineer, their ranking of engineer as a job choice, and the terms they commonly associate with engineers and engineering [17]. A secondary goal of this investigation was to conduct an intervention study by examining the impact of positive engineering messages on the participants' perceptions of engineering.

The outcome from the NAE [17] study indicated that younger adolescents tended to hold very limited understandings of engineering. In addition to limited knowledge, the participating younger teens also communicated misconceptions of engineering. For example, many of the younger teens associated engineering with work on engines or machines. The investigation revealed older teens had somewhat better understanding of engineering, holding greater knowledge and fewer misconceptions, but still perceived the profession as isolating and boring and were more likely to consider engineers as "nerdy" than the adults who participated in the study. Aside from their perceptions of engineering, the NAE investigation revealed teens were lured toward careers in engineering by the potential monetary benefits of the profession. The NAE research also found that some teens were attracted to the profession based on the idea that engineers "make a difference."

The NAE [17] report details variations in responses between different groups of teens. For example, the research found detectable differences between the perceptions of teenage males and females. Even though the overall trends in perceptions and thoughts about engineering for male and female teens were relatively the same, females tended to hold less positive perspectives of engineering as a career and were less knowledgeable about engineering than their male peers. In essence, the young men and women had similar views of engineering as a whole, but there were elements in which the young women were more extreme (less positive) in their perceptions. However, the study also revealed evidence indicating that adolescent females do feel women can become engineers if they choose, but many did not see themselves selecting engineering as a career. The potential for detecting variations in perspectives of engineering based on personal variables or characteristics (such as sex, age, grade level, socio-economic status) provides justification for gathering demographic data along with perceptions of engineering data when evaluating the effectiveness of engineering outreach programs.

Part of the NAE [17] research involved investigating the impact that messages and examples of engineering had on the misconceptions individuals hold of the profession. The adolescent participants who were exposed to relevant examples of engineers' work, experienced positive alterations in their attitudes and increases in their understanding of engineering as a profession. The impact of being exposed to examples of the work of engineers resulted in a differential response between males and females. In addition, the results revealed differential responses between ethnic groups. This indicates that interventions, such as engineering outreach programs, may have differential impacts on participants based on personal characteristics. Again, these results provide justification for gathering and analyzing personal variables or characteristics with respect to measures used to assess the impact of outreach programs on the participants' perceptions

of engineering.

The NAE [17] research report makes apparent the limited knowledge and misconceptions teenagers hold about engineers and engineering. The report also details how perceptions and attitudes toward engineering may be altered through exposure to explicit, brief, and focused interventions that detail the profession. Teens' relatively malleable perceptions of engineering underscore the importance of assessing the effectiveness of engineering awareness interventions to determine the extent to which these endeavors influence teens' perceptions and attitudes toward engineering. The NAE's exposure of relationships between teens' personal variables (sex, age, and ethnicity) and their perceptions of engineering provides support for collecting demographic data when assessing intervention impact. The results of the NAE research also confers justification for developing and offering engineering education interventions, such as outreach programs, to increase teenagers' knowledge and understanding of engineering.

Outreach Programs

Outreach programs have become a popular, widely utilized approach for exposing pre-college students to STEM professions, providing these students with information about STEM career options, and recruiting them into STEM degree programs [11], [19], [20]. Many outreach programs have been developed to introduce students to engineering concepts. A review of engineering outreach endeavors for adolescents by Jeffers and colleagues [9] named, summarized, and classified the intervention methods of over 50 programs. Some of the engineering outreach programs that have achieved widespread recognition and have established records of success include: *Discover Engineering* [1], the *Engineering Link Project* [15], the *Secondary Schools and QUT Engineering Activity Kits or SQUEAK* program [4], the *Detroit Area Pre-College Engineering Program* [14], *Camp REACH* [5], and the *WIMS for Teens Program* [14]. The widespread adoption or adaptation of engineering outreach programs make evident the anticipated effectiveness of these endeavors as effective methods for increasing student awareness and understanding of engineering.

The structure of engineering outreach programs varies widely, ranging from brief 1 to 2 hour demonstration sessions that expose participants to some aspect of engineering to more extensive, multiple week summer programs that immerse participants in engineering experiences [14]. Program content also tends to vary widely. Some programs might concentrate on specific areas or fields of engineering [14], while other programs may provide content that engages participants in much more in-depth engineering education experiences [1]. Many of the engineering outreach programs target specific student populations such as minorities [14], females [1], or middle school students [5]. The variations in targeted student populations and the range of engineering program content are indicators of the diversity found in the design, development, and implementation of engineering outreach programs. Regardless of the design, all engineering outreach programs tend to have the same goal: *increase student understanding of mathematics, science, and engineering* [9].

Research on the effectiveness of these outreach programs at achieving their goals has revealed increases in participants' knowledge of engineering concepts, in their awareness of engineers' work, in their skill levels, and in their levels of interest in pursuing engineering careers [1], [5], [12]. In addition to detecting significant increases in participants' cognitive outcomes, some program studies have also assessed impact on affective measures and report increases in participants' interest, self confidence, and efficacy [8]. The impact of these outreach programs on the participants' knowledge, awareness, and attitude toward engineering provides justification for integrating this content into engineering outreach events and assessing the participants on these variables to determine program impact.

Impact on Attitudes toward College

It is common for pre-college engineering outreach programs to explicitly focus on the salient issues associated with student awareness and understanding of engineering. However, many of these outreach programs (particularly campus-based residential programs) also expose students to an implicit college culture curriculum by providing opportunities for the participants to interact with college faculty, students, and activities [5], [14]. For example, in many residential outreach programs, students stay on campus in residence halls, utilize college food services, and have access to other campus services. However, these programs rarely provide college counseling or present explicit content on the importance of a college education to becoming an engineer. This does raise the question regarding the effectiveness

of the implicit curriculum on the participants' attitude toward college.

In their longitudinal study of early adolescents' college plans and their subsequent college enrollments, Eccles, Vida, and Barber [6] report that their participants' college attendance was predicted by family income, parents' educational level, GPA, and the number of mathematics courses they had taken in high school. The work of Eccles et al. illuminates some of the variables related to college attendance and their potential influence on an adolescent's educational pathways. Many of these variables come into play beginning as early as 6th grade. This suggests that middle school and junior high level students engaging in engineering outreach programs could benefit from explicit exposure to content addressing college opportunities, benefits, and culture. Further, the importance of college to careers in engineering provides justification for assessing outreach participants' attitudes toward college. This data could be used to guide the development of outreach content and to determine the level of intervention necessary to influence the participating students' attitudes toward college.

In a separate report on the variables influencing pre-college students' educational pathways, Eccles and colleagues [7] proposed a model portraying the interaction between key personal variables as predictors of students' educational choices. In addition to the variables already discussed, the Eccles et al. model integrates the influence of the perceived value of academic tasks, their academic ability self concepts, and prior academic achievement [7]. The Eccles et al. model makes apparent the wide range of personal variables that interact to influence adolescents' educational choices which may or may not lead to their college enrollment. The identification of these college pathway indicator variables and their interaction provides justification for assessing pre-college students' personal variables when surveying this population on their attitudes toward college. Therefore, an examination of pre-college teens' attitudes toward college in conjunction with their attitudes and perceptions of engineering is critical for determining the long term impact of engineering outreach interventions.

Our Research Project

Our objective for this research project was to determine whether the explicit engineering content and implicit college and higher education awareness content presented in two engineering outreach programs altered the participating secondary students' perceptions and attitudes towards engineering and college. The two outreach events engaged two different populations of students, yet maintained the same goals of increasing awareness and understanding of engineering and raising participant career and educational interest engineering.

Research Questions

The research questions guiding our investigation were:

1. *Was there a relationship between student personal variables and their pre-test scores for attitude toward engineering and attitudes toward college?*
2. *Did the scores for attitudes toward engineering change from pre to post engineering awareness outreach event?*
3. *Did the scores for attitudes toward college change from pre to post engineering awareness outreach event?*
4. *Was there a differential change in participants' perceptions of engineering and their attitude toward college scores in relation to the attended engineering outreach event?*

Methods

Participants

Our study participants were recruited from the teenagers who took part in the e-Girls and e-Camp College of Engineering outreach events. The demographic measures for our participants by outreach event are presented in Table 1.

It is important to note that the participants from the two outreach events differed significantly on several measures. Our independent samples t-test revealed the participants in the two outreach event groups differed significantly by age, grade level, and number of science and mathematics classes taken since 6th grade. A chi-square analysis revealed significant differences between the two outreach event groups only for gender, indicating the distributions of ethnicity, English as the first language, and the environment that the participants identified as home were essentially the same between groups.

Instruments

Attitude Toward College. To assess our participants' attitude toward college we used an extant instrument, the *College Attitude Inventory* [10]. The validity and reliability of the original instrument was established using minority and disadvantaged youth participating in a two-week

Outreach Event		Demographic Measure							
	Gender M/F **	Ethnicity	English First Lang. Y/N	Age M (S)**	Grade Level M (S)**	GPA M (S)	Number of Math classes Since 6th grade M (S)**	Number of Science classes Since 6th grade M (S) **	Where do you live
e-Camp	19/15	Asian 3 Hispanic 11 White 18 Other 2	29/5	14.03 (.67)	8.88 (.98)	3.50 (.56)	3.12 (.98)	3.15 (1.05)	Country 7 Town 13 City 14
e-Girls	0/38	Asian 3 African Amer. 1 Hispanic 3 White 29 Other 2	36/2	15.47 (.76)	10.50 (.73)	3.71 (.42)	4.24 (1.26)	4.24 (1.32)	Country 4 Town 9 City 25

* Groups differ at $p < .05$
** Groups differ at $p < .01$

Table 1. Engineering Outreach Program Participant Demographics by Event

summer outreach program focused on science concepts. The sample in the validation study included 75 participants ranging in age from 14-19 years with a mean of 16.5 years and were nearly equally distributed by gender. Based on the results from their first field trial, Johnson and Vopava modified the *College Attitude Inventory* to include the 30 Likert scale items that can be found its published form. Johanson and Vopava report a Cronbach's alpha of .86 based on their second field test with 67 participants. The *College Attitude Inventory* asks participants to respond to statements like "A college education is necessary to be a success in today's world" on a five point Likert scale with 1 representing "Strongly Disagree" to 5 which represents "Strongly Agree." The instrument contains both forward and reverse phrased statements. We used all 30 items and the corresponding Likert scale from the *College Attitude Inventory* in our study.

Perceptions and Attitudes toward Engineering. To assess our participants' perceptions and attitudes toward engineering, we used an extant instrument we developed from previous research to assess k-6 teachers on this construct. We developed this scale based on the *Pittsburgh Freshman Engineering Attitudes Survey* [PFEAS] [2] and our knowledge of the general public's perceptions of engineers. Although the sample populations for these two studies are arguably very different, the survey items are presented in simplified terms that are more readily understood for a younger study group. Items ask participants to respond on a five point Likert scale (from 1 – "Strongly Disagree" to 5 – Strongly Agree") to forward and reverse phrased statements such as "Engineering would be a rewarding career" and "From what I know, engineering is boring." There are 29 items on our measure of perceptions and attitudes toward engineering scale. In our previous studies, we achieved a Cronbach's alpha measure of reliability .71 indicating an acceptable level of internal reliability [16].

Outreach Program Events

Our investigation studied the impact of two engineering outreach events, e-Camp and e-Girls. Both of these outreach events were offered during the summer by a college of engineering located in a university in the western United States. Both events had similar goals; to increase student awareness and understanding of engineering and potentially influence their selection of engineering as a career. This was explicit in both events. Less explicit to both events was content exploring the culture and experience of college. Although the camps had similar goals, the population from which the par-

ticipants were recruited and the activities they engaged in at the camps did vary. Below we present additional details for each of the outreach events.

e-Camp. This engineering education outreach event was designed for students exiting 8th and 9th grades. During this event, participants were teamed with currently enrolled engineering majors who acted as facilitators and mentors. The engineering majors did not receive formal training prior to the event to prepare them to work with the participants. The participants engaged in a series of planned activities that allowed them to explore topics such as robotics, rocketry, and water resources, as well as take part in a design competition. A combination of hands-on activities with projects involving self discovery, cooperative learning, critical thinking, and problem solving were used to engage students in highly interactive engineering lessons. This was a residential program in which the participants spent two nights on campus in a college dormitory and were engaged in approximately 15 hours of engineering curriculum. A camp registration fee was required (although scholarships were available) which covered the cost of the engineering events, food, housing and recreational activities.

e-Girls. This outreach event was promoted as a "two-day adventure for girls exploring engineering and technical careers and opportunities" which also engaged the participants in about 15 hours of engineering curriculum. Although the goals of this program were essentially the same as the e-Camp event, the targeted audience and some of the activities differed. This program was a free overnight program for girls completing 9th and 10th grade. Enrollment was limited to 40 girls. Workshops were led by Society of Women Engineers professionals and college students. The workshop content included explorations of topics such as: biomechanics of footwear, packaging and the environment, welding, virtual worlds with ALICE development software, solving forensic mysteries, physics of rock climbing/rope walking, and career choices. As with the e-Camp, the e-Girls participants were teamed with college student facilitators who acted as both guides in the program and mentors.

Data Collection

All participants of both outreach events were pre- and post- tested on demographics, attitudes toward college, and their perceptions and attitudes toward engineering. The pre-test occurred immediately following student check-in and registration. The post-test occurred immediately after the final session prior to check out and departure. Data collection took place in a computer lab on the campus using the web-based Zoomerang survey software [13]. Participants completed an assent form, followed by the demographic survey, the attitude toward college survey, and finally the perceptions and attitudes to engineering survey. We requested participants to enter the last five digits of their phone number as a unique code allowing us to track and group responses by individual. We post-tested the participants on their demographics to provide a consistent survey experience and to provide us with the opportunity to resolve potential data erroneous entries.

Once data collection was complete, we conditioned our data, reversing the participants' responses for the reversed phased items. We then created composite scores for our measures by summing the responses to the instrument items and used these composite values for our analysis.

Results

Instrument Reliability

We began our analysis with a determination of the reliability of our two instruments. Our reliability analysis of our measure of attitude toward college (*College Attitude Inventory*) was revealed to have a Cronbach's alpha of .85 which indicates good to high level of instrument reliability and is nearly identical to the value reported in the instrument validation study [10]. Our reliability analysis of our measure of perceptions and attitudes toward engineering was revealed to have a Cronbach's alpha of .75 which indicates a moderate to good level of instrument reliability, and is slightly higher than the value previous reported [16]. Given these values for our instruments' reliability, we progressed with our analysis under the assumption that our instruments produced consistent results.

Pre-Outreach Event

Once we established our instruments' reliability, we conducted an independent samples t-test to determine if there were significant differences between the two outreach samples in response to the engineering attitudes and perceptions and college attitudes surveys. Our results revealed the pre-test composite scores for the two surveys did not differ significantly between the e-Camp and e-Girls participants ($p > .10$). We then computed the average score for

the two surveys to determine the participants' baseline attitudes and perceptions toward engineering and attitudes toward college. Our analysis revealed attitudes toward college had a mean of 3.86 (S = .39) which is significantly above "undecided" (3 on our Likert scale) $t(71) = 18.80$, $p < .01$. Our analysis also revealed attitudes and perceptions of engineering to have a mean of 3.49 ($S = .28$) which is significantly greater than "neutral" (3 on our Likert scale) $t(71) = 15.05$, $p < .01$. These results indicate that the participants entered the outreach events with positive attitudes toward both college and engineering.

Demographic Differences

Our first research question asked: *Was there a relationship between student demographics and their pre-test scores for attitude toward engineering and attitudes toward college?* To answer this question we computed regression correlations using age, grade level, GPA, number of math classes taken, number of science classes taken, attitudes toward college, and perceptions and attitudes toward engineering as the variables. Our analysis revealed GPA (grade point average) was significantly positively correlated with attitude toward college $r(72) = .55$, $p < .01$, such that participants with higher GPAs had more positive attitudes toward college. Our analysis also revealed the number of science classes a participant had taken since 6th grade was significantly positively correlated with their attitudes toward college $r(72) = .24$, $p < .05$, indicating that participants who had taken more science courses held more positive attitudes toward college. Further, our correlational analysis revealed a significant positive correlation between the participants' attitude toward college and their perceptions and attitudes toward engineering, $r(72) = .40$, $p < .01$, indicating as the participants' attitudes toward college increased there was a corresponding increase in their perceptions and attitudes toward engineering. Our analysis also revealed a similar relationship between the number of science and mathematics courses, $r(72) = .87$, $p < .01$. The results of the correlation calculations are presented in Table 2.

We continued this analysis with the calculations of several ANOVAs using gender, race, parents' completion of high school, and location of their home (country, town, city), as factors of attitude towards college as well as perceptions and attitude towards engineering as the dependent variables. Our analysis revealed a gender difference for attitude toward college, $F(1,70) = 4.12$, $p < .05$, such that females had significantly higher attitude scores than the males. Our analysis also revealed a location of home difference for attitude toward college, $F(2,69) = 3.62$, $p < .05$. Our post hoc analysis revealed the greatest difference in attitude to be between those who identified city compared to those who identified country, with the city dwellers holding higher attitudes. All other analyses were revealed to be non-significant. See Table 3 for means and standard deviations used in the analysis.

Change in Engineering Perceptions and Attitude

Our second research question asked: *Did the scores for attitudes toward engineering change from pre to post intervention?* To answer this question we applied the paired samples t-test using the repeated measure, pre

	Age	Grade	GPA	Math Classes	Science Classes	College Attitude	Engineering Perception Attitude
Age	--	.85**	.18	.69**	.63**	.17	-.06
Grade		--	.09	.61**	.66**	.14	-.08
GPA			--	.06	.09	.55**	.11
Math Classes				--	.87**	.10	-.12
Science Classes					--	.24*	-.08
College Attitude						--	.40**
Engineering Perception Attitude							--

* Sig at .05, ** Sig at .01

Table 2 Correlation Table with Demographics and Pre-Outreach Event Scores

and post, of student perceptions and attitudes toward engineering. Our analysis revealed a significant change, $t(71) = 7.54$, $p < .01$, such that post intervention scores were significantly greater than the pre scores. Our pre-test scores had a mean and standard deviation of 3.49(.28) and post-test mean and standard deviation of 3.74(.30). Again, this is on a five point Likert scale ranging from "1" being lowest possible value and "5" being highest possible value. The effect size for this change was revealed to be .49 partial eta squared. This outcome indicates that the outreach programs positively influenced the participants' perceptions and attitudes toward engineering, as their post-test scores were significantly more positive than their pre-test scores.

Change in Attitudes toward College

Our third research question asked: *Did the scores for attitudes toward college change from pre to post intervention?* To answer this question we again applied the paired samples t-test using the repeated measure, pre and post, of student attitudes toward college. Our analysis revealed a marginally non-significant change, $t(71) = 1.87$, $p = .066$. Although marginally non-significant, this result does suggest that the engineering outreach programs may be having some influence on students' attitudes toward college. Our pre-test scores had a mean and standard deviation of 3.86(.39) and post-test mean and standard deviation of 3.92(.*40*). As before, this is on a five point Likert scale ranging from "1" being lowest possible value and "5" being highest possible value.

Influence by Outreach Program

Our fourth research question asked: *Was there a differential change in participants' perceptions of engineering and their attitude toward college scores in relation to the attended engineering outreach event?* To determine the answer to this question; we conducted a repeated measures ANOVA using our pre and post event measures of attitude toward college and perceptions and attitude toward engineering as the dependent variables and the outreach event attended by the participants as the factor. Our analysis revealed no differential effect for attitudes toward college based on the attended outreach event $F(1,70) = .001$, $p = .98$, indicating that the participants shifts of college attitudes were independent of the intervention event they attended. See Table 4 for the pre and post test means and standard deviations for Attitudes toward College for e-Girls and e-Camp.

Personal Characteristic	N	Attitudes Toward College
		M(*SD*)
Males	19	3.71(.36)
Females	52	3.92(.39)
Country	11	3.67(.42)
Town	22	3.78(.40)
City	39	3.96(.35)

Table 3. Means and Standards Deviations for Attitudes toward College by Personal Characteristic

Our analysis for perceptions and attitudes toward engineering revealed a differential effect for outreach event, $F(1,70) = 17.96$, $p < .01$, such that the students attending e-Girls had a significantly greater gain in perceptions and attitudes engineering scores than the e-Camp participants. A paired samples t-test was conducted for each event group using the pre and post-test engineering attitude scores as the variable. The results revealed significant changes for both e-Camp, $t(33) = 2.92$, $p < .01$, and for e-Girls $t(37) = 8.46$, $p < .01$. These results make evident the significant changes in attitudes toward engineering scores experienced by both groups. It also further exposes the differential gains in engineering perception and attitude scores between the e-Girls and e-Camp participants. See Table 4 for the pre and post test means and standard deviations for Attitudes toward Engineering for e-Girls and e-Camp.

Discussion

In this research project we set out to determine the influence of two engineering residential outreach programs on the participating adolescents' perceptions and attitudes toward engineering and attitudes toward college. Brief outreach programs to increase adolescents' understanding and awareness of STEM content and professions continue to expand [9]. Yet, to our knowledge, research on the influence of engineering outreach programs on the participating adolescents' perceptions and attitudes toward engineering as well as their attitudes toward college has not been reported in the literature.

Measure	Outreach Event	N	Pre-Test Score	Post-Test Score
			M(*SD*)	M(*SD*)
Attitudes toward College	e-Camp	34	3.81(.38)	3.87(.37)
	e-Girls	38	3.91(.40)	3.97(.43)
Attitudes toward Engineering	e-Camp	34	3.51(.26)	3.63(.24)
	e-Girls	38	3.47(.29)	3.83(.32)

Table 4 . Pre and Post Means and Standard Deviations of Attitudes toward College and Attitudes toward Engineering

The Influence of Personal Differences

We began our analysis with an examination of demographic relationships to their pre-outreach event college attitudes and engineering attitudes and perceptions. We found the participants' grade point averages to be significantly correlated with their attitudes toward college. This would suggest students who are more successful with school in terms of grade achievement are more positive in their attitudes toward post-secondary education. Our analysis also detected gender, the number of science courses since 6th grade, and location of the participants' homes were also indicators of attitude toward college. The correlation between college attitude and engineering attitude and perception scores further support the significance of this finding and the importance of explicitly addressing college culture content. The relationship between attitudes and gender is consistent with the demographics indicating that a higher percentage of females than males are entering and completing post-secondary education [18]. Thus, females are more likely to attend post-secondary education, and according to our data females at the secondary level that attend outreach programs also appear to hold a more positive attitude for doing so. The reasons pre-college adolescent females hold more positive attitudes toward college than their male peers is an excellent direction for future research.

Our finding that the location of the participants' home as an indicator of college attitude, may be a manifestation of the variations in career opportunities and ambitions within the communities from which our sample was drawn. The considerable rural agricultural industry in the region, from which some of our participant sample was drawn, provides a significant amount of the employment opportunities for the rural populations. Therefore, our participants' who identified their homes as being located in rural communities may be more inclined to pursue employment in agriculture. Many jobs in this field do not require a college degree. Therefore, many of our participants who were from rural communities may not have perceived a need for college, and as a result, held less positive attitudes about college. In contrast, many of the professions in the urban environment require at least some post-secondary education. Therefore, participants from urban environments may be more inclined to perceive a need for college to pursue accessible and familiar careers and as a result hold more positive attitudes toward college. The collection of data to elucidate the reason adolescents from these different communities varied significantly in their attitudes toward college is an excellent topic for future research.

Our analysis revealing the number of science classes as a predictor of attitude toward college while the number of math courses was not found to be a predictor is rather perplexing, especially given the significant correlation between the number of math and science courses the participants had taken since 6th grade. We speculate the reason for this phenomenon has to do with the structure of the math and science curriculum. Currently students usually enroll in the same sequence of mathematics courses and there are seldom opportunities for students to enroll in more than a single mathematics course at a time because the courses are offered sequentially. Further, students are typically required to enroll in at least one mathematics course each year up to their senior year in order to complete their high school graduation requirement and to meet many college entrance requisites. Therefore, we can assume that most of our study participants had taken the same number of courses relative to their grade level. The lack of variability in the number of math-

ematics courses a participant might choose to take would not change despite their college attitudes. However, the higher level of flexibility within the science curriculum to allow students to take multiple science courses, many of which do not require students to take courses sequentially, and the lower levels of required science courses for graduation (when compared to mathematics courses) may lead to greater variability in the number of science courses the participants had taken. Therefore, it is possible that our sample captured the variability in secondary students' enrollment in science courses, and revealed that those who took more science had a corresponding more positive attitude toward college. The lack of a definitive explanation for this condition warrants further investigation into this phenomenon.

We found it very interesting that none of the personal variables were predictors of engineering perceptions or attitudes. This was especially perplexing given the relatively strong correlation between the participants' engineering perceptions and attitudes and their college attitudes. Although the participants' responses were significantly above center on our two study measures relative to the instruments' corresponding Likert scales, the engineering attitudes and perceptions did not have the same relationship with the demographic variables as attitude toward college. This may be due to the notion that the participants were more familiar with their feelings and knowledge of college than they were with their perceptions and attitudes toward engineering. The full explanation for this condition requires additional data collection and more extensive research.

Pre-Post Outreach Event Changes

Both of the outreach events we investigated explicitly explored engineering issues, careers, and professional activities; therefore, we expected our analysis to reveal significant increases in engineering perceptions and attitudes, as was found in our study. Our results make evident the importance of explicitly addressing engineering issues and content as necessary for increasing the outreach program participants' understanding and awareness of engineering as a profession. This condition and outcome is further reinforced by our results indicating that the participants' implicit exposure to the culture of college through their attendance of the engineering outreach event did not significantly impact their attitudes toward college (at the .05 level of significance). This suggests that the college awareness curriculum in these outreach events may need to be modified if we are to achieve an increase the participants' attitudes toward college to the same extent that we influenced their perceptions and attitudes toward engineering. It may be that an explicit presentation of content on the value of post-secondary education, implications of attaining a college degree, and culture of college is necessary to induce a significant change in attitude toward college. These results are consistent with what we know about how people learn and effective instructional strategies [3].

Outcome by Outreach Event

There were several significant differences between the participants in the two outreach events, including gender, age, grade level, and number of science and mathematics classes taken since 6th grade. Since we detected a relationship between some of these measures and attitudes toward college it is possible that the differences detected between the groups may be the results of spurious relationships. However, our analysis did not find a significant change in attitudes toward college, nor differential changes in college attitudes by outreach event participants. However, our analysis did reveal a differential result for engineering attitudes and perceptions. Our inability to detect any pre-event differences between groups on this measure or expose any personal predictor variables for this measure allows us to be confident in our attribution of the sources of these outcomes. It is apparent the curriculum for the e-Girls event had a greater impact on the participants' engineering attitudes and perceptions than the e-Camp event. Although the goals and content of the two programs were essentially the same, the impact of the events was significantly different. Perhaps it was the manner in which the content was presented or variations in the mentors, variations in activities, or simply a reflection of the variations within the participants' engagement and learning between the two events. The reason for these differences is a topic for the program evaluation that we plan to conduct on the next cycle of these outreach events.

Limitations

There were several limitations to our research. Although we pre- and post-tested the participants with extant instruments with established reliability and validity, the data are self-reported, which makes them subject to the limitations associated with data bias and accuracy. To resolve this limitation in our next

round of research, we are considering exit interviews of a subset of event participants. The participants attending the two outreach events differed on several demographic and academic measures, which suggest there are likely additional influential variables that we may not have fully accounted for that could have potentially influenced our results. This is a condition that we have little or no control over but recognize and report as a limitation of our research and will attempt to attend to in future research. Our samples were self-selected to participate in the two outreach events; therefore, we did not have the investigative rigor associated with random assignment. Again, because of the nature of these outreach programs we do not have the opportunity for random assignment; yet, we feel it is necessary to acknowledge this situation as a limitation of our research. Finally, although the goals and content of the two events are relatively the same, the manner in which the activities take place, who interacted with the participants as mentors, and the experience of the mentors working with secondary adolescent students differed between events. In our next cycle of this research, we will take steps to closely align the interactions, curriculum and instruction for e-Day with the e-Girls event since our data demonstrated it had a larger impact on the participants' engineering perceptions and attitudes.

Conclusion

In our research we set out to determine the impact of two engineering outreach events on the participating adolescents' college attitudes and their engineering attitudes and perceptions. We found that the events led to positive increases in the participants' engineering perceptions and attitudes but had no impact on their college attitudes. This provides further evidence for the importance of explicitly presenting content to assure impact on targeted constructs. This may be even more important in brief outreach events in which contact time is limited and in situations in which the participating adolescents have limited understanding of the learning environment in which they are immersed. Consistent with previous research with inservice teachers [16], we found empirical evidence indicating that focused and appropriate short-term engineering outreach events can have positive influences on perceptions and attitudes of engineering. This empirical evidence provides support for the merit of outreach events and adds to the justification for continuing to develop and offer these events for a broad spectrum of learners.

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