



# **A career as an Engineer: Participant Perception and Attitude before and after an Engineering Summer Camp for Project Discovery Talent Search students at \_\_\_\_\_ University (Evaluation)**

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## **Abstract**

This paper reports the experiences and findings from an engineering summer camp for low-income and first-generation college-bound high school students held at Western Carolina University in July 2021. The aim of the camp was to motivate the students to consider college education and a career in engineering. Further rationale for this camp is described, and an overview of the camp program and demographics provided. A pre- and post-intervention survey was also designed and described in this paper to assess participant perception and attitude towards an engineering education and career, which consists of a mix of both quantitative and qualitative responses. The pre- and post-camp results of the survey are reported and some statistical conclusions drawn. One noteworthy, albeit disappointing, result is that no statistically significant evidence was observed of improvement in participant perceptions towards the difficulty of an engineering education over the course of this summer camp. However, this is due in part perhaps to the relatively low number of camp participants and thus small sample size, though there was a slight improvement in interest toward an engineering career. Further discussion is given on the effectiveness of the camp's aims, on some general camp design and planning lessons learned by the organizers in conducting the camp, and on the survey methodology and results.

## **Introduction**

Continued demand and growth in the workforce in the fields of STEM (Science, Technology, Engineering and Mathematics) are projected to grow over the next decade [1], [2], in line with trends that had already began in the last decade [3], [4] where the number of employment opportunities in STEM fields grew at a rate three times faster than in other fields [5]. A shortage of engineers in the workforce in the United States was also documented by [6].

Despite the growing job market for STEM-related occupations, studies show declining interest and literacy among students in the United States to pursue careers in STEM fields [5], leading to a deficit in STEM graduates in the next decade [7]. As a result, a concerted effort to invest in STEM education has been undertaken in the United States [8], for example, in the formulation of the Next Gen Science Standards developed to improve K-12 STEM education [5], [9].

Several reasons why students are reluctant to pursue STEM courses in college have been documented [10], for example, due to lack of quality preparation in mathematics and science in K-12 educational systems, financial and technological difficulties, lack of adult role models knowledgeable or affiliated with STEM careers, or psychological impediments (the perception that it has excessive difficulty or educational requirements). Socio-economic status was found to strongly correlate with interest and participation in STEM fields early in life [7]. Among underrepresented groups like racial minorities, women and students with disabilities, additional challenges include financial and technological difficulties [2], [6], [9], [11], [12], [13], lower admission test scores [11], racial or gender discrimination [14], [15], [16], [17], perception of

limited professional and personal growth opportunities in these fields [14], lack of suitable mentors [13], [14], [16], [17] and self-reinforcement of low academic and professional expectations from peers [18].

Students began making decisions about their abilities and career choices at least by adolescence and even as early as elementary age [7]. STEM-focused summer middle and high school camps have increased in popularity in recent years from the nationwide investments in STEM education [19]. These summer camps are historically a multi-prong approach to attract and promote STEM disciplines for future science and engineering students [3]. Numerous studies have shown the positive impact on attitude and self-confidence of participants toward science and engineering fields in out-of-school interventions like summer camps for both middle and high school students [20], [21], [22], [23], [24], especially for students with low starting interest in these fields [25], [26].

In this vein, a non-residential engineering-themed summer camp at Western Carolina University was organized in 2021 geared towards exposing high school students, especially from disadvantaged backgrounds in the western North Carolina region to an engineering career. Western Carolina University is a regional comprehensive university providing a leading role helping with workforce development to serve economically distressed rural regions of the state [27]. Most of the counties surrounding the university fall within an economically distressed or most distressed classification according to the North Carolina Department of Commerce [28].

The aim of this summer camp, named “Exploring Engineering”, was to motivate participants to choose college education and engineering as a career path. Participants for this camp were recruited via Project Discovery, which is a Talent Search project hosted at Western Carolina University. Project Discovery is a federal grant program of the US Department of Education [29] which identifies and assists individuals from disadvantaged backgrounds who have the potential to succeed in higher education, with the aim of increasing the number of youths from disadvantaged backgrounds who complete high school and enroll in and complete their postsecondary education. The program publicizes the availability of financial aid and assists participants with the postsecondary application process by providing academic, career and financial counseling. The project serves seven target high schools in western North Carolina with demonstrated need for project services.

At least two thirds of Talent Search participants are required to be both low-income and potential first-generation college bound students. To be considered low-income, students must come from families whose income is below 150% of the federal poverty line or be considered an independent student for financial aid purposes. To be considered a potential first-generation college student, neither parent may have a bachelor’s degree or higher. Students are recruited from target schools served through the grant beginning in middle school and continue to participate until completion of secondary education and entry into postsecondary education. The Exploring Engineering camp was made open to any rising 10th-12th grade program participants. Student participants were recruited from all target high schools.

The summer camp program activities were designed as active learning activities though without demonstration of any learning outcomes that correlate with deepening of engineering knowledge or skills, and was intended more to introduce engineering as a choice of study and career to those

who may have had little previous exposure to this field and/or generate interest in this field. Thus, emphasis was placed on the fun, creative side of engineering.

This camp was conducted on-site and for the first time at Western Carolina University and was organized by the current authors, comprising staff from Project Discovery, student assistants and three faculty from the School of Engineering and Technology. For two of the faculty (Nelson Granda-Marulanda and Joseph Tang), this was also the first time conducting an engineering camp.

To study the effectiveness of the camp in meeting its goals, a simple pre- and post-intervention questionnaire was designed with the aim of better understanding some factors that influence and affect participant perception, attitude, and motivation towards an engineering career. The results of this study will add to the community of education research to further the understanding of pre-college interventions and enhance future interventions in engineering summer camps for participants of similar background with the ultimate aim of increasing the number of low-income and/or first-generation students who will enroll in engineering degrees.

### **Camp program**

The allotted time for the camp was five days during regular working hours in a non-residential format, which is a popular format in other STEM camps [18]. Although during the COVID-19 pandemic many camps either were cancelled or moved to virtual format [30], [31], [32], by the week of the summer camp it was possible to host it in-person on campus in accordance with state and institutional guidelines on health and safety. Masks were still required to be worn, but there was no social distancing requirement nor limitation on room occupancy. The main locales of activity were in the Belk Building where the College of Engineering and Technology is headquartered.

Most camp activities were designed such that they could be easily implemented, with inexpensive, common materials and using available facilities and equipment, in line with the format of other camps [33]. Anecdotally, the camp faculty leaders felt that this camp struck the correct balance between too little and too much preparation.

Required materials were purchased with funds from the Talent Search grant. A welcome orientation on the first day of the week was given, following which the participants were shown the Qualtrics link to the pre-camp questionnaire. This survey was expected to only require 15 minutes completion. All the planned activities of the camp were planned to occur during 9:00 am to 5:00 pm daily during the week of July 19th to July 23rd. The post-camp questionnaire was administered on the last day after completion of all activities.

One of the camp activities centered around a major design project of building a robotic car with robotic car kits ordered from Amazon (Figure 1). The kit selected was the “Freenovo 4wd car kit FNK0041”, since included all the necessary parts to be self-contained, programmed using Arduino and remote operated capability via a smartphone using Bluetooth. An integrated, open-ended design project seems to have best overall outcomes as far as learning effectiveness and future engineering self-confidence goals [24]. Students were first introduced to Arduino circuits for programming the cars. Then, worked in teams to assemble and test the car kit following instructions that were prepared specifically for the camp. There was also a lesson module on building solid models in a Computer Aided Design (CAD) program, with students learning basic

extrusions, revolutions and sweeps with the aim of designing attachments to be 3D-printed and placed on their cars for the final-day competition.

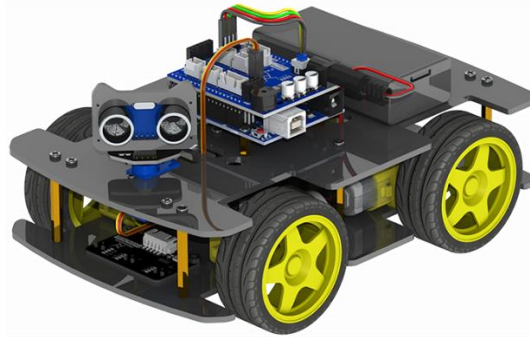


Figure 1 Car kit. Freenovo FNK0041

One competition was to design the best bumper to knock down as many bowling pins as possible with forward car motion only. The second competition was to design lances to pop balloons in an obstacle course and which were also attached to other cars, where the winner was the car which popped the most balloons. A third competition centered around a second design project which was the classic popsicle bridge building with limitations on the number of sticks and glue used, bridge width and length and unsupported span. The bridges were demolished with an available tensile tester and the highest strength/ratio bridge was deemed the winner.

In addition to design-focused activities, two recent engineering graduates were invited for lunch-time lectures on their experiences finding and working at their current jobs. These graduates also reflected on experiences on studying an engineering degree and fielded questions from students. Nelson Granda-Marulanda also gave a lecture on studying for an engineering degree and modern-day environmental issues and challenges facing engineers. The summer camp schedule is shown in Table 1.

Table 1 - Exploring Engineering Summer Camp schedule

	Thursday, July 15	Friday, July 16	Monday, July 19	Tuesday, July 20	Wednesday, July 21	Thursday, July 22	Friday, July 23
9:00:00 AM - 10:00 AM	PREPARATION DAY - WORK WITH STUDENT ASSISTANTS	PREPARATION DAY - WORK WITH STUDENT ASSISTANTS	Orientati on, "before" survey given	Work on building robotic cars - Scott	Introduction to the Robot Competition - Brainstorming Solutions	Work on Robot Competition - CAD Modeling, 3D Printing, Robot Programming	Last minute work on any projects
10:00:00 AM - 11:00 AM	SET-UP AND TEACH THEM TO DO THE	SET-UP AND TEACH THEM TO DO THE	Build a simple circuit				

11:00:00 AM-12:00 PM	ACTIVITIES	ACTIVITIES	LUNCH - Former student - A career in engineering	LUNCH - Faculty - Sustainable Engineering	LUNCH	LUNCH	LUNCH - Former student - A career in engineering
12:00 PM - 1:00 PM			More simple circuits and Arduino intro	Using the Arduino to control devices	Outdoor Activities - Disc Golf, Cycling, Hiking, swimming	Bridge Design/Build	Demonstrations: Robot Competition, Destroy Bridges, Show off projects, "after" survey given
1:00 PM - 2:00 PM							
2:00 PM - 3:00 PM			Intro to the robot kits - begin the build	Introduction to Inventor	Using Inventor for Assembly modeling and 3D printing	Work on Robot Competition - CAD Modeling, 3D Printing, Robot Programming	Optional Campus Tour with family
3:00 PM - 4:00 PM							
4:00 PM - 5:00 PM			Cleanup and Setup for next day - Student Assistants	Cleanup and Setup for next day - Student Assistants	Cleanup and Setup for next day - Student Assistants	Cleanup and Setup for next day - Student Assistants	Cleanup - Student Assistants

11 students participated in the camp. Although more participants were desired, it was felt among camp staff in retrospect that this was a manageable staff/student ratio. Demographics of the camp participants are given in Table 2. The racial distribution for this cohort may have been a reflection of the overall demographic distribution of western North Carolina [34] where nearly 90% of inhabitants are white, and perhaps also from the disproportionate impact of the COVID-19 pandemic on underrepresented groups [35].

Table 2 - Camp participant demographics

Number of participants	11
<b>Gender distribution</b>	
Male	5
Female	6
<b>Ethnicity distribution</b>	
More than one race reported	3
White	7
Hispanic	1
<b>Age distribution</b>	
Rising sophomore	3
Rising junior	7
Rising senior	1

### Survey design

Surveys to measure student responses pre- and post-intervention using Likert-scales are popular and have been deployed in other similar STEM-themed camps [9], [24], [26], [33], [36], [37]. The survey was intended to be preliminary and exploratory at this stage due to the expected low number of participants and this being the first time an engineering summer camp was conducted at Western Carolina University. Given the aims of Project Discovery to serve disadvantaged groups, it was desired to measure career influences, attitudes and perceived difficulties of entry to engineering study and choice of career. Survey questions from previous literature were used in an attempt to focus the survey questions in a more specific and directed manner. Both quantitative and qualitative data were to be collected.

To reduce respondent burden and make the survey simpler for participants to complete, some questions were repeated both pre- and post-survey even if expected to not vary in a statistically significant manner, which has also been practiced in past surveys [6]. The pre-camp survey questions are given in Table 3.

Table 3 - Pre-camp survey questions

Question number	Question	Question type
1	My parents/guardians encouraging me to consider a career in engineering	Quantitative (5 point Likert)
2	I am interested in a career in engineering	Quantitative (5 point Likert)

3	I think a degree in engineering will be hard for me	Quantitative (5 point Likert)
4	I think a degree in engineering will be expensive for me	Quantitative (5 point Likert)
5	You are likely to get a good job if you're an engineer. "Good job" means a job that provides enough economic support for you and your family as well as a job you enjoy and is meaningful for you.	Quantitative (5 point Likert)
6	Why do you want to come to this camp?	Qualitative
7	In order, who are the three biggest influences in your choice of career, and what is their relationship to you?	Qualitative

The post-camp survey questions are given in Table 4.

Table 4 - Post-camp survey questions

Question number	Question	Question type
1	My parents/guardians encouraging me to consider a career in engineering	Quantitative (5 point Likert)
2	I am interested in a career in engineering	Quantitative (5 point Likert)
3	I think a degree in engineering will be hard for me	Quantitative (5 point Likert)
4	I think a degree in engineering will be expensive for me	Quantitative (5 point Likert)
5	You are likely to get a good job if you're an engineer. "Good job" means a job that provides enough economic support for you and your family as well as a job you enjoy and is meaningful for you.	Quantitative (5 point Likert)
6	Why do you want to come to this camp?	Qualitative
7	In order, who are the three biggest influences in your choice of career, and what is their relationship to you?	Qualitative
8	What was the most challenging activity? And why?	Qualitative
9	What will you remember the most out of this camp? And why?	Qualitative
10	What would you like to have spent more time on? And why?	Qualitative



11	What do you think are the required skills for a successful engineering team? And why?	Qualitative
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The pre- and post-camp surveys were approved by the Western Carolina University Institutional Review Board (IRB) and parental consent was given before surveys were administered. Coercion or undue influence to complete the survey as camp participant recruitment was not connected or related to this research project and participants were not graded nor would have different treatment if choosing to participate or not in the survey. The consent form and surveys were administered with an anonymous Qualtrics link which students could complete either on their smartphones or on the computers in the classroom. Given the small survey population, observing any significant change between pre- and post-camp statistics for the whole group was desired.

### Survey results and discussion

Only n=10 respondents to the pre- and post-camp surveys were recorded. With such a small population, typical assumptions of normality and large sample sizes are difficult to justify, and only simple statistics are reported. The Likert scale coding is shown in Table 5. The pre-camp quantitative raw data and totals are reported in Table 6 and 7.

Table 5 - Likert scale codes

Strongly disagree	1
Somewhat disagree	2
Neither	3
Somewhat agree	4
Strongly agree	5

Table 6 - Pre-camp survey quantitative raw data results

	Q1	Q2	Q3	Q4	Q5
<b>Student</b>					
1	3	3	4	2	3
2	3	4	4	4	5
3	3	4	3	4	5
4	3	5	3	3	5
5	4	3	4	5	5
6	4	4	3	3	4
7	1	3	4	5	4
8	5	5	4	4	3
9	4	4	3	3	4
10	4	5	1	2	4
<b>Means</b>	3.4	4	3.3	3.5	4.2

Table 7 - Pre-camp survey quantitative totals

<b>Totals</b>	Q1	Q2	Q3	Q4	Q5
Strongly disagree	1	0	1	0	0
Somewhat disagree	0	0	0	2	0
Neither	4	3	4	3	2
Somewhat agree	4	4	5	3	4
Strongly agree	1	3	0	2	4
No. disagree or more	1	0	1	2	0
No. neutral	4	3	4	3	2
No. agree or more	5	7	5	5	8

That most respondents are interested in engineering (question 2) is likely due to the selection effect from Project Discovery’s targeting of participants who already possess interest and aptitude for engineering, which was also observed in other STEM-themed camps [38]. About half of the students perceived difficulty in studying engineering (questions 3 and 4), but most believed that engineering was a good career choice (question 5).

It is desirable to test for correlation between the survey questions if possible. However, this depends on how one Likert scale results as interval or ordinal, which is subject to interpretation and in turn depends on the survey construct [39]. Assuming an ordinal scale, potential nonlinearity and a small sample size leading to likely non-parametric distribution of results [40], the Spearman rank correlation [41] is a suitable statistical test for correlation among survey variables for the current survey. However, due perhaps to the low sample size, no significant correlation in responses among any of the survey variables was measured.

5 respondents self-reported wanting to learn about a career as an engineer (question 6). Some representative responses were (i) “I decided to come to this camp because of the experience. I’ve been debating whether going into engineering is a good option for me, my other one being medicine, so I’m hoping this camp will provide an insight of what all I can expect.” (ii) “I wanted to explore what engineer do and have a better understanding of the difficulties and joy engineers face. This also helps me decide what I’m doing for college”. For question 7, most students cited close family like parents and siblings for largest influences in career choice, schoolteachers or wrote names but did not disclose the relationship to the participant.

The post-camp quantitative raw data and totals are reported in Table 8 and 9.

Table 8 - Post-camp survey quantitative raw data results

	Q1	Q2	Q3	Q4	Q5
<b>Student</b>					
1	3	5	4	4	5
2	3	4	4	3	3
3	3	4	4	4	5

4	3	4	3	3	4
5	1	2	4	5	5
6	4	4	5	4	5
7	4	4	4	5	5
8	5	4	4	4	4
9	5	5	3	3	4
10	3	4	4	3	5
Means	3.4	4	3.9	3.8	4.5

Table 9 - Post-camp quantitative totals

<b>Totals</b>	Q1	Q2	Q3	Q4	Q5
Strongly disagree	1	0	0	0	0
Somewhat disagree	0	1	0	0	0
Neither	5	0	2	4	1
Somewhat agree	2	7	7	4	3
Strongly agree	2	2	1	2	6
No. disagree or more	1	1	0	0	0
No. neutral	5	0	2	4	1
No. agree or more	4	9	8	6	9

Comparing between Tables 7 and 9, 2 more participants self-reported as being interested in engineering post-camp than pre-camp (question 2). 3 more participants thought engineering was hard (question 3). 1 more participant thought engineering was expensive (question 4). 1 more participant thought engineering was a good career choice (question 5). The increase in participants believing that engineering was hard was observationally corroborated during the lectures given by recent graduates where some student questions focused on the importance of being good at mathematics or making decisions in finding internships or jobs.

No significant statistical correlation was found again among survey variables. Given the small sample size and resulting likely non-parametric distribution of results, a Mann-Whitney U test [42] was performed to measure any change in pre- and post-camp means for each survey question. No statistically significant change was observed.

For question 6, the same number of respondents self-reported attending the camp with the motivation to know if engineering would be a viable career. A representative response was (i) “I came to this camp to get an overview of the field of engineering, mostly thinking that the options would be quite narrow. In fact, I’m leaving camp knowing/being a lot more informed about the broad and wide range of options (when it comes to jobs) of engineering. I’m thankful to have

been here, for the experience was wonderfully amazing! I'll definitely look into making a living out of engineering!"

For question 7, most respondents again self-reported close family members as the largest influence on career choice, though there was a change in one student who reported the student assistants in the camp. For question 8, 4 participants reported the popsicle bridge building being the most challenging activity, others reported other activities like learning CAD and programming the robot cars. Representative responses were (i) "The bridge, had to put it together in a way that gave the most support with limited supplies" (ii) "The bridge, the teamwork portion and guessing what would be the best support".

For question 9, 5 respondents self-reported that it was the relationships that they would remember the most out of the camp - with the student assistants, professors, or other participants. Others reported that it was the robot building. Representative responses were (i) "The relationships I've made/people I've met, as well as the professors! I feel like this is because they made the experience much more enjoyable." (ii) "The discussion as they were filled with advice and meaningful lessons" (iii) "Building the robots, it was my favorite part".

For question 10, 5 respondents self-reported that they would have liked to spend more time on the robotic cars, one reported learning CAD and the others reported the bridge project. Representative responses were (i) "I would have liked to spend more time working on designing our car modifications, but unfortunately we were running out of time" (ii) "The bridge cause ours was a bit janky" (iii) "3d modeling because there are so many possibilities with the program".

For question 11, many respondents reported more than one required skill for being in a successful engineering team, leading to overlap in results. 2 participants mentioned patience being a required skill, 3 reported mathematics skills and 3 reported creativity. Representative responses were (i) "I believe the required skills for a successful engineering team include cooperation, patience, and concentration. These skills are key when working in teams so that everyone benefits, work gets done on time, and the task is evenly distributed among teammates. Unfortunately, I feel like some of our teams lacked these qualities, hence the reason we were unable to do better." (ii) "Patience and good attitude, cause people have different understanding of things" (iii) "Math because you have to be able to solve equations to see if the things will work how you want".

## **Conclusions**

Demand for STEM-related jobs is on the rise in the United States. To address the need to attract more college-bound high school students to STEM fields in the western North Carolina region, an engineering summer camp in 2021 was conducted for the first time by Project Discovery at Western Carolina University in collaboration with faculty from the School of Engineering and Technology. A survey was administered to assess participant attitudes and perceptions toward an engineering education and career both pre- and post-camp.

Some mistakes in the survey methodology and design were found upon post-camp analysis of the survey data. In addition to group statistics, paired samples or repeated measures data should have also been collected to measure change in results among individual respondents pre- and post-intervention. If administered again, the survey should be redesigned to continue to protect

respondent anonymity but allow performing of this study. Question 7 should have enforced tighter controls on requiring disclosure of the nature of the relationship of the personal influences to respondents regarding career choice.

From the qualitative data, it seems that many participants value the relationships formed in the camp, with professors, student assistants and other students. These relationships can, and did, lead to new self-reported significant sources of personal influence on career choice. However, the strongest sources of influence on career choice still come, unsurprisingly, from close family members.

Disappointingly, statistically significant improvement from pre- to post-camp perceptions regarding the difficulty (academic or financial) of an engineering education was not observed. Instead, an increase among respondents who perceived difficulty in an engineering education was observed. However, there was some improvement in interest toward an engineering career.

These results were hampered by the small sample size of this cohort of participants and perhaps also by the experiences of participants during the camp. Though this could suggest redesigning camp activities in (among other ways) a less intellectually demanding direction, or also survey redesign, other researchers have also noted the difficulty of making overarching claims about the efficacy of camp curriculum structures [24].

More work on designing summer camp programs, if not also more summer camps in subsequent years combined with longitudinal tracking of students over time, may yield more definitive data suggesting successful addressing of both the aims of Project Discovery and the, more ultimate, institutional and nationwide aims of motivating more individuals to choose college education and an engineering career.

Future research can also consider different research methods to collect data for any next iteration of this program for collection of richer data, for example by use of more qualitative research methods. It would also be helpful to gather additional forms of data beyond pre-/post- surveys, for example, using a research question, influenced by findings from prior literature, to determine more specific information being sought, which should inform the research design. Another example could be that the authors could follow up at different intervals after the camp is concluded with the participants to evaluate their interest to pursue a STEM career, especially engineering, in the future.

If this camp could be continued in the next year, another effect that could be measured is the impact on student perceptions of study and career choice in engineering due to the COVID-19 pandemic, especially on subgroups like women and minorities, to contribute to the growing body of literature on this topic [43].

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