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The Effect of Summer Engineering Camps on Students' Interest in STEM Based on Their Age (Work-in-Progress)

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Introduction

STEM fields play an important role in the United States' economy and will continue to in the future [1]. However, although STEM jobs are being created, the number of students interested in those careers is not sufficient [2]. Due to the shortage of skilled STEM workforce, there exists an ongoing need for better ways to get students to participate and become more involved in STEM.

The cause of lack of interest for students going into STEM is one that many researchers have inquired about. One possibility could be the way that students perceive the STEM fields. Some of the stereotypes of people in STEM is that they have a low self-esteem and are socially uncool or uninteresting [3]. Another possibility could be that of how one sees themselves in the field and their capability in STEM [4]. While in another view, the negative influence or lack of influence from STEM role models discourages students [5]. So, the causes of students not going into STEM fields vary greatly. Thus, by looking at what students find as positive factors into why they like STEM, researchers can figure out positive ways to increase the number of STEM employees.

This study will take a closer look at the possible factors that lead to increased interest in STEM fields among 7^{th}, 8^{th}, and 9^{th} graders. To conduct this study, data from 2017, 2018, and 2019 summer outreach camps to increase student interest in STEM were analyzed.

Program Description

Students and teachers from multiple school districts were invited to attend a week-long summer engineering camp in Utah in the summers of 2017, 2018, and 2019. The camps were designed to increase student interest in STEM and are part of a 7-year grant funded by the Department of Education as part of the GEAR UP program. Detailed description of those camps is available in previous work by the researchers [6]

Participant demographics for student participants is shown in Table 1 below. As can be seen in the table, the participants were about evenly split between the three grades and there was about an even split between male and female.

Table 1. Demographics of student participants

By grade level	Number (%)	By gender	Number (%)	Total
7^{th} grade	32 (26.67%)	Female	55 (45.83%)	120
8^{th} grade	44 (36.67%)	Male	65 (54.17%)	
9^{th} grade	44 (36.67%)			

Data Collection

On the first day of the engineering camp, the students completed a pre-survey that included demographic information and the STEM-CIS (Career Interest Survey) based on the work of Kier, Blanchard, Osborne, & Albert [9]. The STEM-CIS consisted of 44 questions that took the form of a 5-point Likert scale from 'Strongly Agree' to 'Strongly Disagree'. The 44 questions were divided up into four sets of 11 questions based on the four areas of STEM. An example question is "*I am interested in careers that involve engineering*".

The same survey was given pre- and post- camp. In addition, the post-camp survey included questions asking the students to rate the activities they completed during the camp. In the pre and post surveys, and in daily journals, qualitative data was collected. In 2017, the questions included, "*Name in order the three biggest influences on your choice of career in the future", "I would like you to write about your experience with STEM (Science, Technology, Engineering, and Mathematics) fields", "Are you interested in a STEM (Science, Technology, Engineering, and Mathematics) career? Why or why not?"* In 2018, another question was added: "*What made you choose to come to this camp?*" In 2019, another question was added: "*What is your perception of STEM careers and their importance?*"

Results

Qualitative Data

The qualitative data was obtained from the responses of the open-ended questions. The researchers read the data and agreed upon four main themes that influenced students' interest in STEM the most. Using the coding software MaxQDA, the researchers coded the data and then compared the codes and achieved an inter-rater reliability of over 0.9. The frequency of each of the themes was recorded (see Table 2)**.** The themes are arranged in descending order from highest to lowest frequency.

Table 2: The frequencies of the four most predominant themes that influence students' interest in STEM (some students mentioned a theme more than once, and this was counted).

Factor	7th Grade			8th Grade			9th Grade			All
Main Themes	Pre	Post	Both	Pre	Post	Both	Pre	Post	Both	Total
Interests	46	34	80	50	51	101	100	45	145	326
Future	37	27	64	54	42	96	103	58	161	321
Relationships/ People	38	45	83	62	66	128	52	43	95	306
Educational Experiences	16	9	25	34	35	69	90	48	138	232

Looking at the four main themes, the most common one was "*Interests*" with a total of 326 responses. Following "*Interests"* were "*Future, Relationships/People",* and "*Educational Experiences"* having 321, 306, and 232 responses respectively. Some examples coded under the theme "*Interest*" were, "*I love how i can make things to feel accomplished and hands on activities which get me to think through things,*" by a 7th grader, and "*liked it so much because i really care for the environment a lot so testing the air to see if it is actually even good for you,*" by a 9th grader.

To get an overall sense of what some of the other responses were like for themes other than *Interests*, a few standout comments are given here. "*Future"* examples are, " *I feel like I could enjoy it for the rest of my life as a career,*" by an 8th grader. Whereas some examples from the theme "*Relationships/People"* are, "*My math teacher last year (Mr. Davis the best teacher ever) got me interested in math which i usually hate,*" from a 7th grader and "*My family and friends,*" by a 9th grader.

Finally, examples from the theme "*Educational Experiences"* include, "*I have had very positive experiences with STEM. I really enjoy them and have learned a lot from them. They have made me realize the possible career choices that I have and want,*" by an 8th grader and "*I love engineering so this is my 3rd engineering camp and i take a bunch of college engineering classes as well,*" by a 9th grader.

In the table below we provide the rank (sorted by total mentions) of the four main themes for each grade. We abbreviate *Educational Experiences* with *Education*, and *Relationships/People* with *Relations*.

Table 3. Each of the four main themes, ranked by total mentions (by grade).

Rank (by total mentions)	**7th grade**	**8th grade**	**9th grade**	**Overall**
1st	Relations	Relations	Future	Interests
2nd	Interests	Interests	Interests	Future
3rd	Future	Future	Education	Relations
4th	Education	Education	Relations	Education

It is worth noting that the 7th and 8th graders have the exact same ranking order for the four main themes, in particular, with *Future* and *Educational Experiences* coming in last, but for 9th graders *Future* skyrockets to 1st and *Relationships/People* plummets from 1st to 4th. Being the first year of high school in most schools, 9th grade is often a time when students begin to consider career options, as well as a life on their own (away from parents). The bold reversal of theme rankings witnessed in this data is a testament to the tremendous stresses that 9th graders face as they begin their journey towards entering college and starting a career.

Quantitative Data

The analysis in this section used Microsoft Excel and R to calculate means, perform paired two sample t-tests, Mann-Whitney-Wilcoxon (MWW) tests, and ANOVA tests. The statistical analysis was done to determine whether grade level (age) affects the level of interest gained in various STEM fields as a result of the camps.

The table below gives the mean interest in each of the STEM fields before and after the camp. The mean interest was greater post-camp in every instance.

Table 4: Mean interest in various STEM subjects *before/after* the camp.					
	Science	Technology	Engineering	Math	STEM
7^{th} grade	3.84/4.03	4.00/4.25	4.00/4.13	3.78/4.13	3.91/4.13
8^{th} grade	3.86/4.02	4.16/4.20	3.98/4.11	3.66/3.86	3.91/4.05
9^{th} grade	3.93/4.00	4.14/4.16	4.05/4.14	3.55/3.59	3.91/3.97

The analysis from the t-tests and the MWW tests builds on the mean analysis from above which showed cursory increase in interest among every grade level (for every STEM field). The P-values from these tests are given below in Table 5.

Table 5: P-values for "Increased interest in STEM fields after attending the camp" (Two sample t-test/Mann-Whitney-Wilcoxon)					
	Science	Math	Technology	Engineering	STEM
7^{th} grade (2017 camp)	0.132/**0.033**	**0.001**/**0.003**	**0.015**/**0.018**	0.101/0.120	**0.000**/**0.001**
8^{th} grade (2018 camp)	0.090/0.095	0.059/**0.033**	0.321/0.337	0.102/0.108	**0.022**/**0.022**
9^{th} grade (2019 camp)	0.292/0.223	0.344/0.347	0.428/0.470	0.220/0.245	0.227/0.146

Most of the significant increases in interest were among the younger 7^{th} graders (7 out of 10 significant results). The 8^{th} graders had 3 out of 10 significant results, and the 9^{th} graders had no significant results. A fair conclusion would be that younger STEM (prospective) students were more positively influenced by the STEM camp than their older counterparts.

The final analysis uses the ANOVA test. For each grade level (7^{th},8^{th},9^{th}) we extract a column from the data which contains each student's increase in interest in, say "Science". Then the ANOVA test is run on these three columns to determine if they are identical. The P-values for each STEM field are given below in Table 6.

Table 6: ANOVA analysis. (P-values)					
	Science	Technology	Engineering	Math	STEM
7^{th},8^{th},9^{th} grade levels	0.801	0.337	0.951	0.231	0.254

Therefore, the ANOVA analysis did not provide evidence that any grade level in particular had a larger increase in interest from the camp. This conclusion stands at odds with our brief look at the means from earlier, as well as with the t-tests and MWW tests.

Conclusion

The qualitative data identified four main themes which influence students' interest in STEM. The most influential overall were *Interests* and *Future*. A close examination shows a sharp reversal was seen in the data when moving from 7^{th} and 8^{th} graders (middle schoolers) to 9^{th} graders (high schoolers). The theme *Future* was ranked 3^{rd} for middle schoolers but 1^{st} for high schoolers.

Also, *Relationships/People* was 1^{st} for middle schoolers but 4^{th} for high schoolers. This stark contrast draws attention to the shifting priorities that students experience as they grow older and begin preparing for college, and after that, a career. Younger students seemed to place more importance on their relationships with parents, teachers, etc when it came to what influences their interest in STEM. On the other hand, older or high school students place more importance on their future career plans as what influences their interest the most.

The quantitative data paints a different, but not contradictory, picture. All grade levels seemed to gain interest in STEM from attending the camps, but it was the 7^{th} graders who benefitted the most, with 8^{th} graders next, and 9^{th} graders last. The linear formation of the grades indicates that it is important to have opportunities for younger students in STEM since that is when they are most likely to benefit from said opportunities.

Looking at all the data, the camps appear to have a stronger impact on younger pre-high school students. On the other hand, 9th graders were less likely to be swayed, less likely to receive influence from family based on adolescent development [7]. Those students have also started thinking more about the future than their younger counterparts. The results suggest that this type of outreach is more effective at serving younger students and that earlier intervention is more likely to achieve the desired results of increasing student interest in STEM.

Future research would look at analyzing larger samples of data and or potentially looking at other factors that were not discussed in this work. A likely future research would be to look at students in elementary school and compare them with middle and high school students to find what differences are among those age groups when it comes to interest in STEM.

References:

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