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The Influence of Early STEM Career Exploration as Related to Motivation and Self-determination Theory

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Abstract

A science, technology, engineering, and mathematics (STEM) summer intervention program is the setting for a career-exploration research study with over 30 adolescent students in a low-income community. Using motivation and self-determination theory as a framework, the impact of early exposure to engineering and mathematics career opportunities is examined. In the larger study we utilized mixed methods to analyze how changes in middle school students' affective characteristics may be linked to their future career decision-making after participating in an integrated science, technology, engineering, and mathematics academic/ career summer camp. Using a case study methodology, we examine three of the students in detail regarding their changes in self-reported future academic major choices and career goals utilizing measures of motivation, self-efficacy, and self-determination.

Interview data provides qualitative evidence that participants' experiences during camp may indeed impact their short-term outlook towards their informed decision making and motivation related to pursuing STEM careers. Repeat participants (two or more years) are highlighted as case studies and their survey and interview input is analyzed to determine to what extent, if any, students attribute changes in motivation to their summer camp experiences. Select comments that might reveal insights related to the participants' ethnicity and/or gender are presented, given that the student participants represent a majority demographic of low income and historically underrepresented populations in STEM.

Introduction

A report from the U.S. Department of Commerce Economics and Statistics Administration Office of the Chief Economist (Noonan, 2017a) confirms the positive impact to individuals and to the nations' economy that U.S. Science, Technology, Engineering and Mathematics (STEM) workforce contributes. STEM workers experience higher lifetime incomes, lower unemployment rates, and preparation for a broader range of careers. STEM occupation workers reached 9 million in 2015, representing a growth from 5.5 to 6.1 percent of all workers. This growth rate of 24 percent over the last ten years was much higher than the 4 percent growth rate of non-STEM occupations. However, an insufficient number of Americans choose STEM professions therefore, predictions of shortages of STEM professionals are being realized.

While there is great opportunity in STEM occupations, women and members of minority groups make up a disproportionately low share of the STEM workforce. In 2015, while women represented 47 percent of all U.S. jobs they only held 24 percent of STEM jobs (Noonan, 2017b).

African Americans (reported as Blacks) represent 12 percent of the workforce but only 5 percent of the STEM workforce and LatinX (reported as Hispanics) represent 16 percent of the workforce but only 6% of the STEM occupations workforce (National Science Foundation, 2017). Despite some progress in the last twenty years, these wide gaps in both educational attainment and STEM occupation representation remain a challenge to address all along the STEM pipeline.

The student population composition in the state of Texas is shifting significantly. The percentage of students who are Hispanic is rapidly increasing in K-12 schools. For example, in 2010, Texas schools served approximately 2.4 million Hispanic students, compared to about 1.6 million White students. An increasingly diverse student population coupled with larger percentages of economically disadvantaged students adds to the challenges faced by teachers and university faculty.

Early academic experiences in math and science and exposure to STEM careers is essential in addressing the numerous factors that contribute to unequal participation of minorities in science education. Too many students and parents are reported to believe that STEM subjects and careers are too difficult, boring or exclusionary (PCAST, 2010). Therefore, the research aim of this study was to examine the potential influence of early STEM career exploration experiences upon three middle school adolescents who attended the program, chosen as representative of students who had attended camp just one summer, two total summers and three total summers. We use a mixed methods approach including a survey to collect quantitative data and a case study methodology to closely review the content learning, motivation shifts and indicators of strengthening self-efficacy of these students.

This study involves students from a majority LatinX community who participate in a summer pre-engineering program. The author designed program and study was guided by Yosso’s (2006) Community Cultural Wealth framework that includes six forms of cultural wealth: aspirational, linguistic, familial, social, navigational, and resistant. The participating community’s funds of knowledge and cultural wealth were acknowledged and influenced every aspect of the program and research methodology. Furthermore, critical race theory informs the approaches we recommend when working with LatinX communities. Rather than assuming to employ peripheral tactics that include popular culturally relevant themes (such as music, language, or token symbols), we utilize a deeply committed approach and a pedagogy and research methodology based on critical race theory in education with the components posited by Solórzano and Yosso (2000): 1) the centrality and intersectionality of race and racism, 2) the challenge to dominant ideology of color-blindness and objectivity, 3) commitment to social justice, 4) value and centrality of experiential knowledge, and 5) use of interdisciplinary perspectives.

Overview of STEM Career Engagement Approaches

Throughout the last decade, researchers have recommended that career exploration and awareness begin before high school (Castellano et. al, 2002; Fouad, 1995; O'Brien, et. al, 1999). A study that used nationally representative longitudinal data suggests that to attract students into the sciences and engineering, we should pay close attention to children’s early exposure to science at the middle and even younger grades (Tai et al., 2006). The concept of elementary school career education has gained momentum in recent years. According to Ediger (2000, p. 2), “the elementary school years are not too early to begin to achieve a vision of what one desires to do in life contributing to the world of work.”

Youth Motivation Theory

The influence that a school’s setting has on student motivational beliefs should not be underestimated. School’s influence impacts students’ motivation through various ways such as classroom structural mechanisms, teacher instructional practices, and positive interpersonal relationships with teachers and peers. A recent study indicates that females’ interest in math and science was mainly sparked by school-related activities, while most males recounted self-initiated activities (Wang & Degol, 2013; Maltese & Tai, 2011).

Motivation “is an internal state that arouses, directs, and sustains students' behavior. The study of motivation by science education researchers attempts to explain why students strive for particular goals when learning science, how intensely they strive, how long they strive, and what feelings and emotions characterize them in the process." (Glynn & Koballa, 2006).

Operationalized for middle school students, the middle school participants’ reasons for “wanting to” do something were investigated. In Martinez Ortiz et al. (2017), the above definition was used to analyze participants’ motivation. Participants reported how excited they were to conduct projects and experiments. One student reported “I think it was just really fun to launch them (rockets) because my group worked really well, and I was just proud that I built something like that.” The camp provided a setting for participants to experience science, engineering, and mathematics creatively. Some participants were surprised that the projects were those that engineers do and considered options in engineering careers (Martinez Ortiz, Rodriguez, Warshauer, Torres, Scanlon, & Pruett, 2017).

Self-Determination and Self-Efficacy

Most researchers suggest that self-efficacy leads to interest. According to Bandura’s model there are four learning experiences leading to self-efficacy, performance accomplishments, vicarious learning, social persuasion and physiological stimulation (Betz, 2007). Self-Efficacy is a person’s belief about his or her capabilities to produce designated levels of performance that exercise influence over events, e.g., accomplish or succeed in a task or situation (Bandura, 1997).

Operationalized for middle school students, participants’ words were investigated for instances when they felt they “could” do something. In the previous study, participants seemed to feel very sure of themselves and their abilities in mathematics and/or science and they challenged themselves by choosing to take advanced courses in their curricular plans (Martinez Ortiz et al., 2017).

Intrinsic motivation is not the only correlation to self-determination. Self-determination also correlates to educational phenomenon such as optional functioning, personality integration, social development, internalization of extrinsic motivations and personal well-being (Reeve, Hamm, and Nix, 2003; Deci & Ryan, 1985b, 1987, 1991, 2000; Deci, Vallerand, Pelletier, & Ryan, 1991;

Grolnick & Ryan, 1987; Ryan & Deci, 2000; Sheldon & Kasser, 1998; Vallerand, Fortier, & Guay, 1997).

Self-Determination "is the ability to have choices and some degree of control over what we do and how we do it." (Reeve, Hamm, and Nix, 2003). Using the definition for self-determination, operationalized for middle school students, instances where participants had decided they "would" do something were investigated. In a previous related study, participants had a sense that the path towards a STEM field would involve intense study, college, and learning about science and math. In the words of one participant, "…you need to go with your goals, and stick to them, until you've passed it, and go for greater, like foremost and beyond." (Martinez Ortiz et al, 2017).

The Pre-College Summer Intervention Program

The pre-engineering program during which this study was conducted, provided STEM learning experiences for young students, teachers, and their families. The objectives of the program were 1) to increase the number of underserved and underrepresented students in STEM who participate in pre-engineering & mathematics program activities, 2) to increase participation of STEM pre-service and in-service teachers in targeted professional development opportunities with K-12 engineering and STEM standards-aligned curriculum, and 3) to provide skills to parents/caregivers to work with and encourage their children in STEM activities and programs. The Future Aerospace Engineers and Mathematicians Academy (FAMA) pre-engineering program was composed of integrated year-round programming elements. Some were unique to this program, others were offered as additional supplemental educational opportunities for the student and teacher participants. Figure 1 below depicts the four major elements of the model.

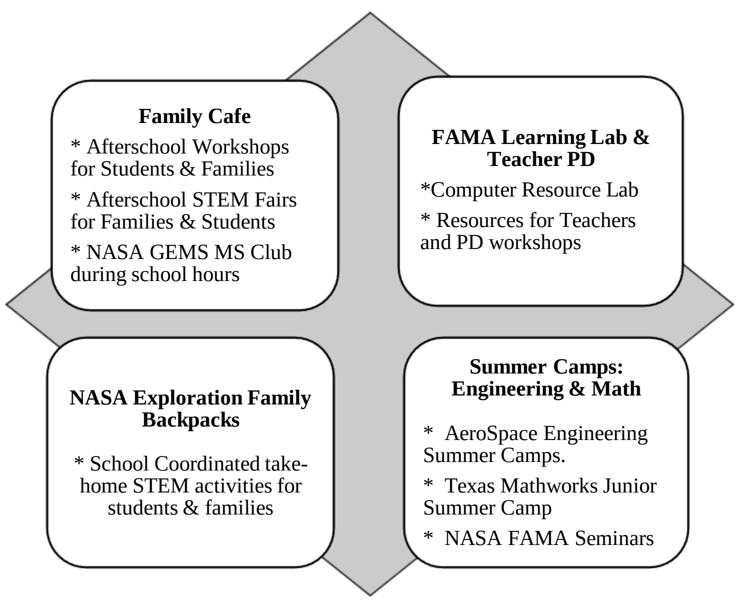

Figure 1- The Pre-Engineering Program Model and its Elements

The Summer Camp

The FAMA eighth-grade summer pre-engineering summer camp program is a six-day, 36 hour academic and career introduction program for adolescents. Students in San Marcos Consolidated Independent School District (SMCISD), a low social economic status, majority LatinX student community were invited to participate. Each summer, at least one week-long camp was offered for students in grades 3-8th, each with a distinct theme per grade-level. The eighth-grade theme was "rocketry and algebraic reasoning." Each camp is organized to include a morning teambuilding activity, a STEM career awareness module, an algebraic reasoning model, a science content module, and an engineering module. The curriculum was developed by Martinez Ortiz (2015) as an integrated program that embeds NASA science and engineering hands-on activities along with a variety of career awareness readings, videos and online resources as guided by science and math learning standards for eighth grade. The content was delivered by an instructional team consisting of a teacher, a college pre-service teacher, and a high school camp counselor. The topics shown in table 1 provide an overview of the content covered in the 8th grade FAMA rocketry camp:

Table 1

Team Building	Gracious Space/Sacred Circle; What's in a Name?; Space Charades; Who are we?- discussing motivation and identity; Team technology treasure hunt
Science	The physics of falling objects; Introduction to Newton's laws; Celestial bodies in the solar system; Physics of rocketry
Mathematics	Variables and expressions; Math games online to practice pre-algebra skills; Solving algebraic equations;
Engineering	Engineering design process; 3-2-1 Puff rocket activity; Design pop rockets; Design and build a space elevator;
Careers	Discuss lack of racial and gender diversity in STEM careers; Exploring careers at NASA; The many fields of engineering careers; Building and launching Estes rockets; Career research and presentations

The research study will only focus on the particular feedback of selected eighth grade students as a direct result of their robotics summer camp experience.

Research Objectives

While the overall objective of this youth focused research is to engage youth in authentic STEM experiences related to earth and space science and to inspire and captivate learners to develop a keen interest in STEM careers, the research objectives for this study are much more focused. In this study, we examine if participants' experiences during an intensive but short-term camp experience may indeed impact their short-term outlook towards their informed decision making and motivation related to pursuing STEM careers. We seek to determine to what extent, if any, students attribute changes in motivation to their summer camp experiences.

We state our research questions as follows:

1. To what extent, if any, do students attribute changes in motivation, self-efficacy, and self-determination toward STEM studies and/or careers as a result of their summer camp experiences
2. To what extent, if any, do students attribute changes in content awareness of mathematics, science, engineering as a result of their summer camp experiences
3. To what extent, if any, do students attribute changes in their subject matter understanding as a result of their summer camp experiences.

Study Methodology

The methodology employed in this study was an embedded case study (Yin, 2003). In this design, three eighth grade students serve as cases. Each embedded case study includes qualitative video data from a structured interview, and quantitative survey responses from two administered surveys. These three presented student cases were selected from a data set of forty-five middle school students who participated in an intensive six-day (40 hour) summer pre-engineering learning experience in Summer 2017. For our cases, we selected a representative student who attended one summer, two summers, and three summers. The rationale for this purposeful selection of cases was to investigate the students' perspective of their motivation, self-efficacy, and career choices and possible differences with multiple experiences at the camp.

Video and Audio Research Case Study Analysis

Video recording technology has been used since the late 1930s by the great Margaret Mead as an ethnographic approach for collecting data in the social sciences (Goldman, 2007). Over 75 years later, the availability of video and audio recording technology has allowed the researcher incredibly advanced, low cost tools to capture authentic data sets of learners thinking, speaking, and doing. Certainly, in the last 45 years, educational researchers have also embraced video and audio records as legitimate data. But the power lies not only in the data, but in the analysis methodology that allows the researcher the ability of authentic reexamination. So, it is life recorded but, unlike life, video and audio offer the advantage for slowed down and multiple revisiting that allows nuanced analysis (Goldman & McDermott, 2007). Robust data analysis is then drawn from a direct experience that includes not only the words of the research subject but a true and deep examination of the accompanying actions and nuanced and complex gestures of the participants.

Data collection

Each interview was conducted at the end of the camp session on a one-on-one basis with a student and a trained interviewer for approximately 20 minutes. A script was prepared by the research team and the interview consisted of two parts. The first part was a clinical interview with the student enacting a task related to the content of the program session; in this case rocketry. The intent was to investigate how the students attributed their content awareness and subject matter understanding to the camp. Examples of questions in part 1 included: (1) Are there any kind of special considerations that NASA engineers and scientists need when they are launching people into space?; (2) Where does the fuel come from, or what do you need fuel for? And (3) Please explain Newton's Laws of Motion, if you wish, use the props provided here- a ball, a cup, and toy car.

The second part was a semi-structured interview pertaining to the students' affective characteristics of motivation, self-efficacy, and self-determination toward STEM careers. Examples of questions in this portion of the interview included: (1) What do you think about taking advanced classes in math and science?; (2) Are you confident in your ability to succeed in those classes in high school?; and (3) Do you think in the future you might be an engineer, mathematician, or scientist?

The sessions were captured on video and audio and were transcribed by the research team. The data was then analyzed for the constructs in our research questions, namely motivation (self-determination and efficacy), content awareness, and science concept understanding using our operationalized codes and expert codes that corresponded to the surveys used in the quantitative analysis of our larger study.

Coding the videos

Concepts and categories were defined by the research team as part of a text coding methodology using a basic set of a priori codes based on theoretical constructs but expanded as the text is analyzed (Crabtree & Miller, 1999) and examined for concepts and categories that more fully capture the students' interview responses. Since our population of interest is comprised largely of LatinX students, we referenced asset-based theoretical frameworks developed by LatinX scholars such as Moll (2001), Solórzano (2000), and Yosso (2005) and were guided by these in analyzing students' interview transcripts to identify common themes.

We used the operationalized codes for each of the affective constructs as mentioned earlier:

(1) Motivation – students wanting to do something e.g. want to become a nuclear engineer.
(2) Self-efficacy- students believe they can do something e.g.can become a nuclear engineer
(3) Self-determination- students would do something, e.g. will become a nuclear engineer.

Aligned to the quantitative analysis in our larger study, we use Table 2 below to outline our framework for our three research questions with the initial coding and levels.

Table 2

Student Interview- Coding Framework		
0,1,2,3	MG	Motivation - general impression of the camp / desire to attend
0,1,2,3	MSTEM	Motivation- motivation towards a STEM career / visualization of self in a STEM career
0,1,2,3	Ctx-Rockets	Context awareness- connecting rocketry to the real world

0,1,2,3	Cnt- Math	Content awareness- identification of integrated mathematics themes in the camp
0,1,2,3	Cnt-Science	Content awareness- recall and understanding of broad science concepts
0,1,2,3	Cnt-Engineering	Content awareness- understanding what it means to be an engineer
0,1,2,3	Cnt-Technology	Content awareness- understanding what technology is
0,1,2,3	Science-Newton	Science Concept Understanding- Newton's laws
0,1,2,3	Science-Rocket Vocab	Science Concept Understanding- rocketry vocabulary
0,1,2,3	Careers-STEM	Career Awareness- general discussion of STEM career
Levels of expressed understanding		
0	insufficient discussion to make determination	
1	low level of understanding or awareness	
2	good level of understanding or awareness	
3	strong level of understanding or awareness	

Qualitative data analysis

The following section is a summary presentation of our three cases of student participants in the same grade level summer camp experience (8th grade Rocketry 40 hours). We begin with background information about the three students and what we know about them through the initial camp application. Each student name shown is a pseudonym. Not all data is presented, only sufficient and the same type, to represent each student's understanding and opinions.

<u>Troy</u>

Troy is a 13-year-old rising 8th grade male student in one of SMCISD's two middle schools. This is his second year to attend the camp. The highest level of education of at least one of his parents is a four-year degree. His parents indicated that Troy's favorite subject in school is mathematics and they believe Troy would enjoy pursuing a career as an engineer or computer scientist. They believe that as parents, they are extremely influential in their child's career path. Troy reports science as his favorite and at the application of the camp time, he indicated that he would like a job as a mechanical engineer. In his camp application, Troy stated that his reason for wanting to attend this camp was *"…it definitely will help in advancing the skills/education needed to pursue the degree I want."*

Motivation

While interviewing Troy, he talked about his growing motivation towards a career in engineering as a result of the camp. He reported that "… *before I knew engineering, I wanted to be an astronaut. I still do want to be an astronaut. It's a small dream [* and now*] … I'm thinking of mechanical* and *biological engineering."*

Troy also revealed his worry about not fitting in socially, since he didn't feel like he is the type to enjoy being in groups. He said, *"...because I was always afraid I'd be, like, no, I'm going to be called stupid and stuff like that."* But Troy found that he enjoyed the small group size at camp, and the friendly students as people he could relate to. When asked about the theme of the camp, he primarily focused on teamwork and cooperation. He appreciated the groupwork and time spent on sharing and reflecting at the start of each day's session.

Content Awareness

Troy was very excited to talk about rockets. He displayed a high level of understanding about rockets and NASA's missions. His musings included the following comments expressed in an animated matter: *"Most of the rockets right now at this era are meant to go to the space station to refill fuel, or to resupply it, or to deliver new astronauts. Most of the time what it's about as far as I know of or to deliver new satellites. [And the materials you need for rockets is] …sixty amounts of steel or titanium or whatever to make the base of the rocket, because titanium is lighter and more heat resistant."* He also expressed understanding regarding engineering design challenges, and NASA missions involving rockets and the importance of knowing math and science to solve these challenges: *"Now, if you're really good at math you can calculate and [know the ocean] waves are going to be like this at this point about this time, so, I need to land right here about now and then you land."* Then he also commented on the science, *"Well the chemical engineers who design the rocket fuel- need the science that way they can combine the chemicals together like instead of just using gas only for rocket fuel they can use gasoline and, like thermal nitrate or something like that."*

Specific Science Learning

Troy had a very good understanding of the Newton's three laws. He provides a solid explanation of Newton's first law, and second law and only confuses himself a little bit as he tries to discuss acceleration and deceleration as part of his supporting evidence while explaining Newton's third law. Troy also does an excellent job in identifying the various parts of a model rocket. As part of the interview, he is presented with an exploded parts diagram of a model rocket. A word bank is provided and Troy is encouraged to speak and explain a bit of what he knows about each part. The following are some highlights of his out-loud thinking.

> *"Now the nose cone is used for aerodynamics. So, it also holds in the parachute and the band that is used to snap out and release the parachute."*

> *"…the fine is used to make sure the rocket stays on course on its… [as it's] going into the air because if it didn't have fins on rockets, then it would go and it would turn and just fall over."*

> *"…the parachute is used to slow your acceleration. Now, you can do that with a board or anything like that. The reason a parachute works so well is that if you have a square, it*

doesn't trap air. It pushes against it. If you have an oval, it traps the air inside and continues pushing as it does down. That's what a parachute is used for."

In summary, Troy attributes the camp environment and culture as contributing to his sense of belonging to a team that does engineering. His determination to be an astronaut and also pursue engineering appears to be a result of the camp informing him of career options. Enjoyment in being a part of a team contributes to the positive experience. He displays understanding of the scientific content presented at the camp and displays this understanding through his enactment of tasks such as explaining Newton's laws of motion. His awareness of careers in engineering and relating it to such qualities as teamwork and cooperation involved in the field indicate that Troy is motivated and confident that he could pursue a career in engineering or STEM.

Andrew

Andrew is a 13-year-old rising 8th grade male student in one of SMCISD's two middle schools. This was his third year to attend the camp. The highest level of education of at least one of his parents is a graduate degree. His parents indicated that Andrew's favorite subject in school is science and they believe Andrew would enjoy pursuing a career as an engineer or computer scientist. They believe that as parents, they are extremely influential in their child's career path. Andrew reports science as his favorite and at the application of the camp time, he indicated that he would like a job as a mechanical engineer. In his camp application, Andrew stated that his reason for wanting to attend this camp was *"…because it gives me the opportunity to make and befriend new people and learn things I otherwise wouldn't know."*

Motivation

Andrew seems very mature in his perspective of the camp experience. Here he speaks about the teachers and camp planners' point of view:

> *"Well, honestly, I think, um, - even though you're teaching the thing you always have a different approach in how you do it, and you always have different activities, and the people that are, like, I think there is a new teacher- and they bring new experiences. They have a new attitude on things and its really enjoyable."*

Andrew clearly explains the general theme of the week and reveals how participating in this camp directly motivates him in his career preparation, as he is now definitely considering a career in engineering:

> *"This week's camp was about- about space and really the rocket aspect of it and getting there. So, we've been building, like, model rockets and actually rockets that fly using real fuel."*
>
> *"The way they, um, they told us, it's basically saying: If you work hard enough and study, then well, it's not impossible. Um, -people are looking out for engineers seems like a really, really good, fun job.*

He credits the camp for learning more about what engineering is really about.

"Engineers make our life easier. They improve on it, and so, like, airplanes. We can't travel around that fast. Um, - but if- with airplanes we can travel to different states really, like effortlessly. So, their job is to fix stuff that's make it easier, fix stuff that needs fixing, and um, -improve."

Content Awareness

Andrew displays a very strong understanding on the camp content.

"The rockets are used for not really getting people to a certain planet, that's Mars, but that will be a long time. Um, - we don't really send people to, like, any planets like the moon anymore. That was just basically landing on the moon. Now we kind of use it for sending up satellites to take photos of different planets far away. Uh, - getting an up-close photo of different planets that we can't really travel to. Like, Um the one that's traveling around Jupiter, I think."

He also displays a very good understanding of the considerations that engineers need to balance when designing rockets and rocket components:

"Well, engineers got to think about its got to be really air tight so one of the air leaks out, it's got to have a good nozzle on and those kinds of things- um, so it can be aerodynamic through the atmosphere, and it's got to be heat resistant so it doesn't burn up while coming back. It's got to have good fins too, well, to be aerodynamic still, and we got to think about fuel efficiency because that's very costly, the metals, and all that."

Specific Science Learning

Andrew does a good job in explaining Newton's three laws of motion using the props provided, but also extends his understanding to a space context. So, for Newton's third law, - for every action there is an equal and opposite direction-, Andrew explains in the following way:

"So, when they were first having the first spacewalk, they went outside the ISS and tried and tried to fix stuff, tried to fix satellites and stuff. But when they were first out there they were- they were sweating a lot and they were really tired at the end because when they were trying to pull, like, turn the valves and stuff, when you try to turn it there's equal and opposite reaction so there's no- any, like there's anything that would be Earth is not there anymore. So, if you pull it this way it pulls you along with it. So, basically, if I were to do this it would pull my whole body that way."

In summary, Andrew provides a perspective of a camper who has attended in previous summers and appreciates the new aspects of each of the three years that he has attended. Learning new content seems only part of what he enjoys at camp as he points out new teachers provide new experiences for him to grow. In addition, the messaging by the teachers and the camp suggest that with hard work one can aspire to careers in the sciences. He demonstrates a strong content awareness and is able to explain his understanding of Newton's law of motion competently.

<u>Carmen</u>

Carmen is a 12-year-old rising 8th grade female student in one of SMCISD's two middle schools. This was her first year to attend the camp. She is a low-income student, the oldest of five and the highest level of education of at least one of her parents is a two-year degree. Her parents indicated that Carmen's favorite subject in school is science, but they don't know which career Carmen might like to pursue. They believe that as parents, they are somewhat influential in their child's career path. Carmen enthusiastically reported science as her favorite subject but at the application of the camp time, she did not know what kind of job she would like to pursue. In her camp application, Carmen stated that her reason for wanting to attend this camp was *"…because I like STEM and am especially interested in science, engineering, and technology."*

Motivation

Carmen is hesitant in her comments as the interview begins. She does not speak about her career awareness easily, but does indicate that she might like being an engineer:

> *"Because I like building stuff. I like building stuff…like when I got a crank car at Christmas"*

When she is asked if there is any reason she might have thought she couldn't be a scientist, engineer, or mathematician, she agrees that this might have been at a time when she thought that she might not be able to pursue a science career, but she reports that it wasn't the camp that changed her mind. It was herself.

> *"Well, when I wasn't very good at math, but the camp did not change my mind. That was like pretty much the only reason I went to the camp because it was – because it was Science. And Science is my favorite subject.*

Content Awareness

Carmen does not seem very interested in discussing the theme of the camp. She answers a few questions correctly but does not volunteer much in-depth information.

Specific Science Learning

During the review of Newton's Laws, Carmen says she understands and knows the answers, but does not explain her thoughts in a convincing way. However, she is always confident and inquisitive. During the rocketry vocabulary exercise, she correctly selects words from the word bank and discusses some of her choices:

> *"[The nose cone] …it makes the rocket more aerodynamic and stops the pressure from going out the sides."*

> *"[The tail fin] …it keeps it steady as it flies, so that it doesn't go lopsided"*

“[The shock cord is for] …well, when the engine it goes like this, and it the –cord- and it pops this out, cuz you don't want the ‘Nose Cone’ to fly away.

So, - so it this is how the ‘Shock Cord’ does it to keep it from falling off.

Like my team’s rocket, ours absolutely went the highest.

But they had like little tiny strings so you could see where it was.

They went like all the way up, all the way up. Mine went the highest.”

In summary, Carmen completed her first summer at camp. Her main motivation was in doing more science and the camp provided an outlet for Carmen to engage in what she enjoys. One may conclude that with her statement about not doing well in math but enjoying science, Carmen has a sense of self-efficacy in science. Carmen reveals some science understanding through her explanation of concepts but very limited in scope.

Quantitative Data Analysis

The main objective of the FAMA program was to provide students an enjoyable learning experience including at least 36 hours of authentic STEM instruction. The secondary objective was to collect sufficient meaningful data to contribute to the researchers’ objectives regarding the impacts of such experiences with adolescents for whom such experiences are rare. Therefore, great care is required to design a data collection approach that is not obtrusive. The interviews were conducted with all participating eight grade students as discussion of personal understanding is considered a learning opportunity. However, since the total number of eighth grade students who participated in the full program was only a total of eight, the quantitative sample size was limited to those six students who completed both the pre-surveys and the post-surveys. There are certainly limitations when working with small sample sizes as we are limited to examining only the big differences or large effects. Since additional data is also considered, this additional layer of data is analyzed to clarify the trends found in the case study analysis.

Students took the Engineering Motivation Questionnaire (EMQ) adapted from the Science Motivation Questionnaire (Brickman, Armstrong, & Taasoobshirazi, 2011). This survey probed students on the constructs of motivation and self-efficacy using a five-point Likert scale ranging from “Never” to “Always”. They also took the Middle School Students’ Attitude to Mathematics, Science, and Engineering Survey (MSE) (Gibbons et al., 2004). The survey probed participants’ knowledge of engineering careers, exposure to engineering careers, and attitudes and beliefs about engineering. Both surveys were administered to camp participants and six records were paired through a unique identifier for 8^{th} grade students that took the pre and post surveys.

Descriptive and statistical analyses were conducted on the 6 paired 8^{th} grade records. The Wilcoxon signed-rank test was selected for the statistical analysis of the EMQ and the MSE data.

This test is the nonparametric test equivalent to the dependent t-test. As many real-world data, the data obtained through this study did not meet the normality assumption for the t-test. The Wilcoxon signed-rank test is one of the most widely used nonparametric methods as an important alternative to the parametric t-test for giving robust results without the restriction of normality assumption in the population (Shieh, Jan, & Randles 2007).

Findings and Discussion

Data analysis of the MSE and the EMQ showed some promising findings. Students reported an increase in family conversations about engineering jobs in the post MSE survey. Fifty percent of students, 3 out of 6 students, that took the pre-MSE survey stated that they never talked to their parents or guardians about engineering jobs. At the end of the summer camp, only 17 percent of the students, 1 out of 6, reported never having that conversation. Refer to Table 3. These results seem to indicate that the camp experience creates the conditions necessary for conversations at home that might increase family awareness of engineering careers.

Table 3

How many times have your parents or guardians spoken to you about engineering as a possible job when you grow up?		Frequency (Pre)	Percent (Pre)	Frequency (Post)	Percent (Post)
Valid	Never	3	50.0	1	16.7
	1 - 2 times	2	33.3	4	66.7
	Many times	1	16.7	1	16.7
	Total	6	100.0	6	100.0

The EMQ data also reflected some findings worth exploring. When students responded, at the beginning of the camp, to what extend they agreed or disagreed with the statement "knowing engineering will give me a career advantage" only 20 percent of the students, 1 out of 5, answered "always". At the end of camp 60 percent, 3 out of five, answered the same way. Refer to Table 4. The focus on engineering of the camp experience provides an opportunity for students to engage in meaningful career exploration. Exploring engineering careers with relevant hands-on activities helps students reflect on engineering as a tangible career possibility for them.

Table 4

Knowing engineering will give me a career advantage.		Frequency (Pre)	Percent (Post)	Frequency (Pre)	Percent (Post)
Valid	Sometimes	2	40.0	0	0.00
	Often	2	40.0	2	40.0
	Always	1	20.0	3	60.0
	Total	5	100.0	5	100.0

When conducting the Wilcoxon test a 95% confidence level or 0.05 alpha value was sought to maximize power given the small sample size and minimize sample size effects. Results of the Wilcoxon pair-sample tests for the MSE and EMQ for the six paired 8^{th} grade records show no statistical significance. These results could be attributed to the effect of the small sample size.

Conclusion

Research programs such as the FAMA program stress academic enrichment through high quality, challenging curriculum, an approach that continues to be lacking in communities that serve high percentages of historically underrepresented youth in low social economic status communities. In fact, the SMCISD school district is a low performing school district, according to state guidelines, and this pressure to improve the overall school district performance often results in a focus on remediation, a slowing down of the curriculum, and insufficient opportunities for creative, alternative learning experiences that are not directly mapped to a state testing format.

Using an asset-based theoretical framework, we valued the cultural wealth of the LatinX family focus, and therefore, purposely designed a program that would include familial elements that would facilitate the active participation of as many students as possible of all abilities and interests. A partnership with a local community center assured the valuation of the community and facilitated participation by a broad range of families by providing transportation services, leveraging community assets to assure familiarity and trust, and inclusion of teachers and students regardless of ethnicity. As reported, participating students increased the instances of family conversations about engineering jobs and careers because of this summer experience.

A purposeful recruitment of LatinX teachers and teachers with English/Spanish bilingual abilities was employed and resulted in a LatinX representation of 60% of the summer camp instructional staff. In the eighth-grade camp, a male, Latino teacher along with a female pre-service college teacher were selected for their instructional abilities as well as for their strength as role models for the students. Heeding the recommendations of Solórzano and Yaso (2000), this study demonstrates the importance of placing marginalized populations at the center of curricular enrichment design and research initiatives such as this one.

The framework of motivation and self-determination theories additionally served to focus on individual adolescents' growing sense of identity, self-efficacy, self-determination and motivations related to career determination and academic learning. The three cases examined reveal the impact of early exposure to engineering and mathematics career opportunities, real world contexts and relevant academic content.

Since the students who participated in this program self-selected to participate in the program and the study, there is indeed a range of background interest in the context of NASA and rocketry, the level of academic preparation in science and math of each student, and varying degrees of career awareness. Nevertheless, the observed student grasp of the content and awareness of STEM career options was very clear and substantiated by students' own explanations, justifications, and demonstrations. Such experiences led to students stating their confidence in themselves and in their future abilities to pursue STEM careers. The purposeful nature of a learning experience that academically challenged students while offering differentiation for preferred learning modes and emotional and social support was noticed and explicitly attributed by students as adding to their motivation and interest in persevering in STEM academic study and careers.

When looking at the results of the Wilcoxon tests, consideration needs to be given to the sample size effect. The sample size for the Wilcoxon pair-sample test is smaller than the conventional standard of at least 5 times the number of variables. Sample size requirements for this type of rigorous mix-methods research agenda presents a challenge to many scholars. However, using mixed methodology allows for a broader range of analysis.

This mixed methods study is foundational to a larger study that will examine the insights of over 50 students in the FAMA program over 4 years from fourth, fifth, sixth, seventh and eighth grade including up to 15 student qualitative cases and up to 50 surveys for quantitative analysis. This increase in data points will allow for a more accurate and significant discussion and answer to the posed research questions.

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