University of Kentucky

UKnowledge

Theses and Dissertations--Science, Technology, Engineering, and Mathematics (STEM) Education

Science, Technology, Engineering, and Mathematics (STEM) Education

2019

HIGH SCHOOL ENGINEERING STUDENTS' IDENTITIES AND INTEREST IN STEM

Morgan Lane
University of Kentucky, morganrlane416@gmail.com
Digital Object Identifier: https://doi.org/10.13023/etd.2019.454

Right click to open a feedback form in a new tab to let us know how this document benefits you.

Recommended Citation

Lane, Morgan, "HIGH SCHOOL ENGINEERING STUDENTS' IDENTITIES AND INTEREST IN STEM" (2019). *Theses and Dissertations--Science, Technology, Engineering, and Mathematics (STEM) Education*. 13.
https://uknowledge.uky.edu/stem_etds/13

This Master's Thesis is brought to you for free and open access by the Science, Technology, Engineering, and Mathematics (STEM) Education at UKnowledge. It has been accepted for inclusion in Theses and Dissertations--Science, Technology, Engineering, and Mathematics (STEM) Education by an authorized administrator of UKnowledge. For more information, please contact UKnowledge@lsv.uky.edu.

STUDENT AGREEMENT:

I represent that my thesis or dissertation and abstract are my original work. Proper attribution has been given to all outside sources. I understand that I am solely responsible for obtaining any needed copyright permissions. I have obtained needed written permission statement(s) from the owner(s) of each third-party copyrighted matter to be included in my work, allowing electronic distribution (if such use is not permitted by the fair use doctrine) which will be submitted to UKnowledge as Additional File.

I hereby grant to The University of Kentucky and its agents the irrevocable, non-exclusive, and royalty-free license to archive and make accessible my work in whole or in part in all forms of media, now or hereafter known. I agree that the document mentioned above may be made available immediately for worldwide access unless an embargo applies.

I retain all other ownership rights to the copyright of my work. I also retain the right to use in future works (such as articles or books) all or part of my work. I understand that I am free to register the copyright to my work.

REVIEW, APPROVAL AND ACCEPTANCE

The document mentioned above has been reviewed and accepted by the student's advisor, on behalf of the advisory committee, and by the Director of Graduate Studies (DGS), on behalf of the program; we verify that this is the final, approved version of the student's thesis including all changes required by the advisory committee. The undersigned agree to abide by the statements above.

Morgan Lane, Student

Dr. Cindy Jong, Major Professor

Dr. Molly Fisher, Director of Graduate Studies

HIGH SCHOOL ENGINEERING STUDENTS' IDENTITIES AND INTEREST IN STEM

THESIS

A thesis submitted in partial fulfillment of the
requirements for the degree of Master of Science in
Education in the College of Education at the
University of Kentucky

By

Morgan Lane

Louisville, Kentucky

Director: Dr. Cindy Jong, Associate Professor of STEM Education

Lexington, Kentucky

2019

Copyright © Morgan Lane 2019

ABSTRACT OF THESIS

HIGH SCHOOL ENGINEERING STUDENTS' IDENTITIES AND INTEREST IN STEM

With a national push toward improving STEM education, it is imperative for researchers to study what makes students want to pursue STEM education and STEM careers. To learn about this in the context of one high school's engineering program, this study used student interviews to gain insight into how student identities influence their interest and experiences in STEM. Five components of student identities were revealed to be influential on a student's interest in STEM: (1) an early interest/skill in STEM, (2) familial involvement in STEM, (3) self-motivation, (4) gender, and (5) socioeconomic status. Race/ethnicity, peer influence, and teacher influence did not seem to be as influential as anticipated for the participants in this study. The implications from this study can be used to inform STEM education instruction, specifically within engineering programs, in an effort to intentionally improve student experiences with and interest in STEM.

KEYWORDS: identity, STEM interest, high school, engineering pathway

Morgan Lane

12/12/19

HIGH SCHOOL ENGINEERING STUDENTS' IDENTITIES AND INTEREST IN STEM

By

Morgan Lane

_____Dr. Cindy Jong_____
Director of Thesis

_____Dr. Molly Fisher_____
Director of Graduate Studies

_____12/12/19_____
Director of Graduate Studies

TABLE OF CONTENTS

List of Tables iv
Introduction 1
Background and Rationale 1
Research Questions 1
Literature 2
Influences on Interest in STEM 2
Racial and Ethnic Minority Students in STEM 4
Gender Disparities in STEM 5
Methodology 8
Participants 8
Engineering Pathway 10
Data Collection 11
Data Analysis 13
Results 13
Early Interest/Skill in STEM 13
Familial Involvement in STEM 15
Self-Motivation 17
Gender 18
Socioeconomic Status 21
Race/Ethnicity 22
Peer Influence 23
Teacher Influence 23
Discussion and Implications 24
Limitations 27
Conclusion and Future Research 28
Appendix 29
References 31
Vita 33

LIST OF TABLES

Table 1.1, Demographics of Crestmore High School 9
Table 1.2, Demographics of Crestmore High School's Engineering Pathway 9
Table 1.3, Participant Breakdown..... 10
Table 2.1, Initial Interest in STEM 15

Introduction

Background and Rationale

It is known at a national level that minorities have been underrepresented in the STEM workforce for decades. While the representation gaps in the STEM labor force have narrowed greatly, minorities are still not represented proportionally based on the U.S. population. According to the National Science Board (2019), the percentage of women in STEM has doubled in 20 years, with a 29% representation in Science and Engineering careers and a 40% representation with Science and Engineering degrees. Unfortunately, these numbers do not match the 52% of women represented in the national population (National Science Board, 2019). Similarly, the percentage of racial/ethnic minorities in STEM (African American, Hispanic/Latino, and American Indian/Alaska Native) has quadrupled since 1993. However, the National Science Board (2019) stated, "They are underrepresented in S&E occupations (13%) and degrees (16%) relative to their proportion of the U.S. residential population age 21 or older (28%)". This study was created out of an interest in addressing questions regarding these minority misrepresentations on a smaller scale.

With the push at the national level to close representation gaps in STEM, STEM education has become even more prevalent. As the need for authentic, engaging STEM education opportunities increases, the need to learn more about STEM programs being implemented successfully increases. In this study, students enrolled in a high school engineering program provide insight into how their identities influence their experiences in STEM. The research questions being investigated include:

- How do the identities of high school engineering students influence their continued interest in pursuing a STEM-related pathway?

- How do the identities of high school engineering students influence motivation to pursue post-secondary STEM-related opportunities?

Literature

Influences on Interest in STEM

In a general study, Sadler et al. (2012) were interested in researching the effects on STEM career interest and how it changes during high school. By conducting a retrospective study, where a national random sample of 6,000 college students was surveyed regarding career interest, the researchers gained insight into gender differences and predictors associated with STEM career interest in high school. It was concluded that, "Students' career interest when entering high school is the strongest predictor of their career interest when leaving high school" (Sadler et al., 2012, p. 423). It was also found that high grades in middle school math indicated an interest in STEM at the end of high school. Both of these findings imply the importance of an early interest in STEM for high school students.

Similarly, Maltese and Tai (2010) conducted a study where they interviewed 116 scientists and graduate students regarding their early experiences with science. The researchers found that the majority of their participants mentioned a pre-middle school interest in science. Maltese and Tai also stated, "…nearly 40% of the responses from the participants indicated that school-based factors played a key role in sparking their initial interest in science, with the women in this study more likely than men to mention teachers as the source of their initial interest," (p. 681). Both of these major findings from this study prompted Maltese and Tai to emphasize the need to improve science education in an effort to maintain interest throughout a student's educational journey and to engage children at a young age in science.

Maltese et al. (2014) elaborated on the previous study (Maltese & Tai, 2010) and were

able to draw conclusions about the impact of early STEM interest for STEM students through an analysis of survey data. A survey was made available to students and employees at community colleges, colleges, and universities in 30 different U.S. states regarding their interest and experiences in STEM. After analyzing the data by group (STEM and non-STEM), Maltese et al. (2014) came up with several findings that are impactful for the future of STEM education. The authors of the study found that the majority of the participants indicated an initial interest in STEM before sixth grade. This aligns with the conclusion of Sadler et al. (2012), that early STEM interest and experience is important. Because the responses between the STEM and non-STEM groups were mostly the same in regard to the timing of their initial interest in STEM, Maltese et al. (2014) decided to look into who influences initial interest in STEM. They saw that the majority of respondents implied that their developed interest in STEM began as a result of the influence of a parent or teacher (Maltese et al., 2014), which was consistent with previous research (Gayles & Ampaw, 2011; Hall et al., 2009; Maltese & Tai, 2010; Shapiro & Sax, 2011; Whalen & Shelley, 2010; Museus et al., 2011).

In a study that was focused on learning about the role of parents and teachers in influencing students' decisions to pursue STEM, Sjaastad (2012) identified both parents and teachers as "definers" of STEM for young people. This study utilized a questionnaire that was given to over 5,000 college and university students in Norway. The questionnaire involved closed- and open-ended questions surrounding the topic of influential people on a young person's interest in STEM. After analyzing the data, Sjaastad (2012) came to the conclusion that parents and teachers have an influence on students' STEM- related educational choices in the fact that they are seen as models and can help students access STEM experiences that unveil STEM abilities. Sjaastad (2012) elaborated, "…interpersonal relationships are key factors in

order to inspire and motivate a choice of STEM education," (p. 1615). The results from this study indicate the need for students to have meaningful STEM-related interactions with people that they consider "important" in an effort to inspire them to pursue STEM-related education and careers.

Racial and Ethnic Minority Students in STEM

To learn about how certain subpopulations of students are influenced in STEM, Museus et al. (2011) gathered findings from multiple sources to provide reasoning behind racial and ethnic minority students' preparation, or lack thereof, and success in STEM. By looking at studies that investigate topics like enrollment of racial and ethnic minority students in STEM and predictors of further training in STEM after high school, a set of influences on the success of racial and ethnic minority students in STEM was extracted. The authors recognized school district funding disparities, tracking into remedial courses, underrepresentation in Advanced Placement courses, unqualified teachers, low teacher expectations, stereotype threat, oppositional culture, and premature departure from high school to be the main factors that hinder the success of racial and ethnic minority students in STEM (Museus et al., 2011). On the other hand, Museus et al. (2011) found that the following factors promote the success of racial and ethnic minority students in STEM: parental involvement and support, bilingual education, culturally relevant teaching, early exposure to STEM careers, interest in STEM subjects, and self-efficacy in STEM domains. The findings from this synthesis of literature imply the need for educators to be aware of the factors that influence racial and ethnic minority students, in the hopes that these students are more intentionally prepared for success in the STEM circuit (Museus et al., 2011).

In a small, in-depth study with college students, Palmer et al. (2011) explored the factors that promote success for students of color in STEM fields. By interviewing six students who

were enrolled in STEM majors ranging from Bioengineering to Computer Science, the authors of the study were able to identify three themes. Peer group support, involvement in STEM-related activities, and strong high school preparation were three areas that the participants identified as factors in facilitating their persistence and retention in STEM (Palmer et al., 2011). Palmer et al. (2011) stated, "…participants likely mastered course content when lessons were reinforced in peer groups…[that] fostered safe, engaging environments for asking questions that participants did not, or were reticent to, ask during class," (p. 500). This specific result indicates the importance of peer support, particularly within racial/ethnic minority groups, in order to facilitate persistence, retention, and success in STEM for students of color.

Gender Disparities in STEM

As aforementioned, there is a national gender gap in the STEM workforce (National Science Board, 2019). To address the underrepresentation of women in math-intensive STEM careers, Wang and Degol (2017) reviewed research surrounding the issue and came up with six underlying factors that contribute to the phenomenon. They are as follows: cognitive ability, relative cognitive strengths, occupational interests or preferences, lifestyle values or work-family balance preferences, field- specific ability beliefs, and gender-related stereotypes and biases (Wang & Degol, 2017). After defining these six explanations of women being underrepresented in the field, the authors go on to express practical strategies that can help deter the imbalance in STEM from recurring. Wang and Degol (2017) suggest to focus on ability and interest enhancement in STEM, intervene early to cultivate an interest in math and science, break down stereotypes about women in STEM, emphasize effort and hard work instead of talent, add more storytelling to STEM learning, communicate the relevance of a STEM degree to real-world applications, and provide more female role models for girls and women.

The gender gap in the STEM workforce traces back to students' educational experiences in and dispositions about STEM. Sadler et al. (2012) found that girls had vastly lower rates of STEM career interest than boys by the beginning of high school. More specifically, in their study that employed a survey of college students, males who intended to go to college at the end of high school had planned to pursue a STEM-related career at a rate that was three times higher than females. The researchers then clarify this finding, stating "This gender disparity is concentrated not in the 'science' but in the 'engineering' part of STEM" (Sadler et al., 2012, p. 424). It should be noted that for this study, health careers were held separate from engineering and science. The conclusion of Sadler et al. (2012) highlSights the need for females to engage in STEM intervention before high school.

To gain insight into how an environment can affect female performance in STEM, Shaffer et al. (2012) conducted a study in which they used "a group-based approach to reduce stereotype threat effects" (p. 454). The researchers in this study experimented with two groups of students, one group being exposed to "balanced" conditions in regard to gender in STEM, and the other group being exposed to "unbalanced" conditions. In both groups, participants read an article that highlighted the increase in the number of women in the STEM field. However, in the "balanced" group, the article proceeded to explain how the number of women in STEM is almost equal to that of men in STEM, while the "unbalanced" article elaborated on the underrepresentation that is still evident in regard to women in STEM. Participants then took a math test and answered follow-up questions regarding their experience. It was found that women in the "unbalanced" group performed worse than women in the "balanced" group, indicating the need to consider the framing of the message of underrepresentation to women in STEM. The authors went on to say, "messages of underrepresentation…may need to be tempered with

additional information showing that women are gaining ground and those women who are already in STEM fields are doing well," (Shaffer et al., 2014, p. 461).

In relation to interactions that females have in STEM, some studies have shown that it is not necessary for female students to be surrounded by only other females. Hughes et al. (2013) carried out a study in which two informal science camps were offered to middle school students in an effort to provide an authentic STEM research opportunity that would influence their identities in regard to STEM. The researchers associated STEM identity with interest in STEM and STEM careers, self-concepts as it relates to STEM domains, and the influence of role models on students' perception of STEM professionals. For this study, students chose to either enroll in a camp for females only or a coed camp. Each camp supported 100 total students, multiple grade levels, and a variety of racial/ethnic groups. Hughes et al. (2013) found that students enrolled in both camps for similar reasons (i.e. genuine interest in STEM), implying that the single sex aspect of the all-female camp was not a major influence on enrollment for the girls enrolled in that camp. In relation to both camps, Hughes et al. (2013) stated, "The girls in both camps were significantly influenced by their participation in terms of their interest, self-concept, and perception of scientists…[which] indicate a positive trajectory in their STEM identity" (p. 2000). The authors further argue that exposure to STEM opportunities and STEM professionals affected the participants more than the fact that one camp had all-female enrollees while the other was coed.

Not only did Hughes et al. (2013) discover important implications regarding STEM experiences for females, but Robnett and Leaper (2013) also drew conclusions about influential components of a female student's peers and their perception of STEM. Robnett and Leaper (2013) conducted a study where high school students were surveyed regarding their academic

backgrounds in STEM and English, friendship groups, and STEM career interest in order to investigate how the former two influence the latter. After analyzing student surveys, Robnett and Leaper (2013) concluded that motivational and friendship group concepts were predictors of STEM career interest. More specifically, the researchers mentioned:

> …when a friendship group does not support STEM and is primarily female, girls may find it more difficult to view STEM as compatible with their social gender identity. However, when the friendship group does support STEM, its gender composition may matter less. (Robnett & Leaper, 2013, p. 661).

Robnett and Leaper also found that gender differences in STEM career interest were lower when students recognized a high ability in science and there was a low proportion of same-gender friends within the friendship group. This may indicate the importance of girls being involved with mixed-gender friendship groups in regard to their perception of STEM as a gender-neutral field.

Methodology

Participants

In an attempt to gain insight regarding the main research question, six students from Crestmore High School, a southeastern high school in the United States, who were enrolled in the school's engineering pathway, participated in this study. The demographics of Crestmore High School, and the engineering pathway at Crestmore in regard to race/ethnicity at the time of the study are demonstrated in Tables 1.1 and 1.2 respectively.

Table 1.1. *Demographics of Crestmore High School*

Race/Ethnicity	Percentage	Number of Students
African American	8.5%	100
American Indian/Alaska Native	0.3%	4
Asian	0.8%	9
Hispanic/Latino	18.5%	218
White	68%	800
Two or More Races	3.8%	45
Total	–	1176

Table 1.2. *Demographics of Crestmore High School's Engineering Pathway*

Race/Ethnicity	Percentage	Number of Students
African American	5.2%	10
American Indian/Alaska Native	1%	2
Asian	1%	2
Hispanic/Latino	10.4%	20
White	77.6%	149
Two or More Races	4.7%	9
Total	–	192

Female students made up 49% of the overall student population, while male students made up the other 51%. Within the engineering pathway, the gender breakdown consisted of 12% females and 88% males. The participants in this study represented female and male genders; Asian, African American, Hispanic/Latino, and White races/ethnicities; and lower class, middle class, and upper class socioeconomic statuses. Five of the six participants were in the same graduating class, four of whom participated in the study at the end of his/her junior year, and one who participated at the beginning of his senior year. The one participant who was in a different graduating class participated in the study at the end of her sophomore year. Table 1.3 shows a more descriptive classification of participants.

Table 1.3. *Participant Breakdown*

Pseudonym	Gender	Race/Ethnicity	Socioeconomic Status	Time of Participation
Jamie	Female	Asian	Middle	End of Junior Year
Maria	Female	Hispanic/Latino	Middle	End of Sophomore Year
Chelsea	Female	White	Middle	End of Junior Year
Martin	Male	African American & White	Middle/Upper	End of Junior Year
Daniel	Male	Hispanic/Latino & White	Lower and Upper*	Beginning of Senior Year
Wyatt	Male	White	Middle	End of Junior Year

*Multiple SES statuses were identified as influential to one student's experience with STEM.

Engineering Pathway

The engineering pathway at Crestmore High School is part of an implementation of the nationally recognized Project Lead the Way (PLTW) program, which utilizes activity-, project-, and problem-based instruction to provide students with opportunities to apply their learning in the context of the real world ("Bringing Real-World Learning to PreK-12 Classrooms", 2019). This pathway has been available to Crestmore students since the school's opening about a decade ago. Students who attend Crestmore are required to choose a pathway when they register for their freshman year and must complete at least three courses in their chosen pathway as a graduation requirement. The career pathways offered at the school are designed to provide students with a sequence of career/technical courses that prepare them for postsecondary degrees and in some cases, allow them to acquire industry certifications before graduating high school. The feeder school for Crestmore has, in previous years, offered a course to eighth grade students dedicated to exploring career opportunities, including the career pathways in which they would enroll in the following year. While this course informs middle school students of the pathway options at the high school level, not every eighth grade student is required to take the course.

Therefore, students can choose whichever pathway they so desire at the time of registration for their freshman year of high school and are allowed to remain in the pathway until graduation, regardless of their credit status within the pathway.

All Crestmore students have the opportunity to enroll in the engineering pathway. The courses that are offered to engineering students at Crestmore are Introduction to Engineering Design, Principles of Engineering, Civil Engineering and Architecture, Aerospace Engineering, Digital Electronics, and Engineering Design and Development. These courses are set in a tiered structure, where students must have certain courses completed before taking others. For example, Introduction to Engineering Design is a prerequisite course for Principles of Engineering. The five participants in this study who were part of the same graduating class had all previously completed Introduction to Engineering Design and Principles of Engineering, and were taking either Civil Engineering and Architecture or Digital Electronics at the time of participation. The single participant who was part of another graduating class was currently taking Introduction to Engineering Design, as it was her first year enrolled in the pathway.

At the time of the study, there were two engineering teachers at Crestmore. One teacher taught Intro to Engineering Design, Digital Electronics, and AP Computer Science. The other teacher taught Principles of Engineering, Civil Engineering and Architecture, Aerospace Engineering, Digital Electronics, and Engineering Design and Development. Each teacher had class sizes averaging around 24 students.

Data Collection

Most of Crestmore High School's 192 engineering students were introduced to the study through a brief five-minute in-person presentation of the research. Some students in the engineering pathway were not aware of the study, as they were absent on the day that

engineering classes were visited and presented information about the study. All students were extended the opportunity to participate if interested and were handed informational letters and consent forms that provided further details about the study. Students were required to receive and return parental/guardian consent before participating in the study. Purposeful sampling was utilized with students who showed initial interest in the study in an effort to effectively answer the research questions and acquire a sample that included representations from a variety of genders and racial/ethnic groups. Of the seven students who showed initial interest in the study, six actually participated in the study, as one student did not submit the required consent forms.

In an attempt to gain insight into the research question, this study utilized a semi-structured interview protocol to interview students. The interview protocol consisted of three sections of questions regarding each student's interest in STEM: Background in STEM, Current Interest in STEM, and Future in STEM. The three different sections of questions were included to help ensure that students provided details about each phase of their STEM experience. Some students were asked probing questions that were not originally listed on the interview protocol, as there may have been a need for clarification or further elaboration. Interviews were audio-recorded and ranged from 10-20 minutes. They were then transcribed and coded using a spreadsheet. An individual worksheet was created within the overall spreadsheet for each student, with each interview question and corresponding answer entered accordingly. Student answers were analyzed for common themes and new findings.

In addition to student interviews, each student's grade-point average (GPA) and history of courses taken in high school were used as supporting data in this study. Parents/guardians of participants were required to give permission on the consent form to access these records before

students were able to participate in the study. Student GPAs and history of courses taken in high school helped to offer further information about students' academic backgrounds.

Data Analysis

For this study, a qualitative data analysis approach was utilized in order to learn more about the details of student interest/experiences in STEM. An interview protocol was created to include questions that explore components of student identities and draw connections to student interest in STEM. Qualitative data was needed to help answer the research questions at a deeper level than a questionnaire would, given the small sample size of participants in this study. The data collected through interviews was coded for common themes in terms of student identities and interest in STEM and was used to make implications about how stakeholders in education can potentially address some of the factors that influence minority students and their success in STEM.

Results

The analysis of the data from this study suggests that high school engineering students link their interest in STEM to five components of their identities: (1) early interest/skill in STEM, (2) familial involvement with STEM, (3) self-motivation, (4) gender, and (5) socioeconomic status. Race/ethnicity, peer influence, and teacher influence were all factors that were not consistently recognized as influential components of students' identities/experiences in regard to their interest in STEM.

Early Interest/Skill in STEM

When asked about the timing of their initial interest in STEM, participants in this study consistently mentioned an early interest. All six students said that their interest in STEM began during or before middle school, but the way that their interest began varied. Some students

mentioned a genuine interest or skill in a specific discipline of STEM, while others highlighted the influence of a teacher or the structure of a class/program as what sparked their initial interest in STEM.

More specifically, of all of the participants, Maria and Daniel were the only two who recognized the start of their initial interest in STEM beginning at a time during middle school. Jamie and Chelsea also originally credited middle school with their initial interest in STEM but later corrected this response and said that their interest actually began in elementary school. Similarly, Martin mentioned middle school as the time of initial interest in STEM and later stated, "Math's always been my favorite. Always…[even when I was] little." Wyatt, on the other hand, originally noted elementary school as the beginning of his interest in STEM.

Upon asking students how they recognized their initial interest in STEM, responses varied. All six students found a genuine interest in the subject matter, either because it personally intrigued them or because of the structure of a specific course. Some of the participants also found that they demonstrated strong skills in a discipline of STEM, which influenced their attraction toward the discipline of STEM that they initially found an interest in. The below excerpt reveals Daniel's recollection of his initial experience with and interest in mathematics:

> …every time I would learn how to do something it'd make me feel better once, you know, I got the questions right. Like, you'd work hard on a problem and you'd get the right answer. You know the formulas and, like, it's a good feeling when you know how to actually do the math part.

Still other students mentioned the influence of a teacher on their initial interest in STEM, either that a teacher was a role model for the student or they enjoyed the way that a teacher taught a specific class. This type of influence is represented in Jamie's description of the impact that a female engineering teacher had on her interest in STEM.

> Ms. Henry, she, she was the engineering teacher and she was a girl. So like, she, like, really worked with us.

There were no patterns found connecting the influence of initial interest beyond genuine interest in STEM in regard to student identities. These findings did not necessarily align with findings from the literature (Maltese et al., 2014).

Table 2.1. *Initial Interest in STEM*

Pseudonym	Time of Initial Interest in STEM	Influenced by Genuine Interest, Skill, or Teacher
Jamie	Elementary School	Genuine Interest & Teacher
Maria	Middle School	Genuine Interest
Chelsea	Elementary School	Genuine Interest & Skill
Martin	Elementary School	Genuine Interest
Daniel	Middle School	Genuine Interest & Skill
Wyatt	Elementary School	Genuine Interest & Teacher

Familial Involvement in STEM

In regard to familial involvement in STEM, majority of the participants acknowledged some extent of a connection between their family members and the STEM field. Some participants had family members who were formally involved with STEM, through careers or studies at the post-secondary level, while others had family members who showed an interest, but weren't formally involved with STEM. The female participants in this study expressed a different response to familial involvement in STEM relative to male participant responses.

Of the six participants in this study, five mentioned having at least one family member who was interested in or involved with STEM. The female participants all had at least a parent who had an interest in STEM, as evidenced through a formal career in STEM or through informal conversations with the student about STEM topics. For example, Maria recalled the impact that conversations with her father have on her interest in STEM:

> Well actually, now that I think about it, my dad is interested [in STEM]. But it's not, like, that strong. Now, I think I wouldn't say it's as strong as mines, where I read books [about STEM topics] and stuff. But he does like, like, he never got to finish school…So like, he, we, we like to talk about it as far as he learned, like, oh this is how we did it in Mexico and, like, he just likes to conversate about math.

Maria also mentioned that she had cousins who were engineers in Mexico, but clarified that their formal interest in STEM did not have an influence on her interest in STEM.

Ironically, Chelsea had a similar story to Maria in regard to family involvement with STEM and its influence on her interest in STEM. Chelsea's father also did not finish school, but shows his interest in STEM through the conversations that he has with Chelsea. Specifically, she stated:

> My dad actually never graduated high school and his dream was to become an architect. And that's kinda what led me now to like, I wanna do civil engineering, and like, on a lot of projects this year I've come home and been like, hey dad, I need draft paper, like I need all these tools and he still has all of his stuff from high school when he took architecture classes and so like he's been able to help me a lot. Even though he's not an engineer or an architect, he ha—he knows a little bit about everything, it seems like.

Chelsea further elaborated on this influence of familial involvement with STEM, mentioning that some of the previous conversations she had with her dad helped her decide to pursue civil engineering as opposed to mechanical, which was originally what she planned on pursuing when she started the engineering pathway at Crestmore.

In addition to the other female participants in the study, Jamie also revealed that some of her family members were involved with or interested in STEM and expressed how it influenced her interest in STEM. Jamie's father and sister were both formally involved with STEM, as her dad had been an engineer and her sister had taken courses at a post-secondary college engineering program with a major in engineering. She also mentioned that she had a cousin who

worked in computer software development. Of all of these family members, Jamie indicated that her interest in STEM was influenced by her sister. She noted:

> Well, actually I just remembered, in fifth grade, my sister put me in [a girls STEM] program…So she signed me up for it, she was like Jamie you're gonna love it… I was really interested in it and my sister was the one who was talking to me, cause she was in the engineering program at the time.

In regard to the male participants, two of them recognized a familial involvement or interest in STEM. However, none of the males suggested an influence of this involvement/interest, or lack thereof for one student, on their own interest in STEM. For example, Wyatt said that he has conversations about STEM interest with his brother, who is going to school to pursue an engineering degree. But in his response to the question *"How have your family members' involvement or interest in STEM, or lack thereof, influenced your continued interest in STEM?"*, he made no mention of the interest in STEM that his brother has as an influential factor in his own continued interest in STEM. He explained:

> Well they, um, they support me on, like, my choices and they thought engineering was a cool, like, career to do and that if I get, like, where I need to be in it, and like, succeed, I'll be, like, really successful.

The other two male participants said that the interest in STEM, or lack thereof, of their family members actually had no influence on their own interest in STEM.

Self-Motivation

All students were prompted with probing questions that asked about whether self-motivation, teachers, family members, or peers were influential in the student's continuation of the engineering pathway. Upon hearing these options, all six participants immediately highlighted their self-motivation as the driving factor of influence on their interest in STEM. In most cases, there was no elaboration on the answer of self-motivation to continue the pathway.

However, some students linked their self-motivation back to their initial interest and experience in STEM.

Gender

While there were no specific interview questions intended to target gender and its implications in the participants' experiences with STEM, gender was a topic that naturally came up in four of the six students' interviews in at least one instance. The female participants all recognized gender as having a role on their interest and experiences with STEM. On the other hand, only one of the male participants mentioned his gender having an effect on his interest and experiences in STEM.

All of the female students in this study expressed an obvious connection between their continuation of pursuing STEM-related opportunities and their gender. They all acknowledged the discrepancy in involvement and interest with STEM in reference to gender at some point throughout their interviews, specifically in the context of the engineering pathway at Crestmore. When asked *"How did your identity influence your initial interest and experience in STEM?"*, the female participants actually answered from their current perspective and interest in STEM, as opposed to considering their initial interest and experiences with STEM. Maria mentioned:

> Um, well, maybe, just, like, being a female and just, like, being, like, a minority in, like, math and just, like, engineering in general interests me, like, oh, I kinda feel, like, proud of being able to really be interested in stuff.

On a related note, Jamie stated:

> Okay, well, cause, like, there's not that many girls, so I like that it's, like, different, like, okay, they need more girls in it…so this would, like, I can get a career in this, and I know, like, engineers, people in STEM make more money…so I'm like, okay I can do that.

It is obvious that these students see their gender as something that addresses a need in STEM and that they can be proud of. However, to gain insight into the aforementioned question, it seemed

more sensible to review these student responses in regard to how they became interested in STEM, which in two out of three cases was not influenced by any component of the student's identity. Maria and Chelsea recalled that their initial interest in STEM was sparked by a genuine interest in the structure and nature of mathematics, with no mention of gender, race, or socioeconomic status playing a role in that interest. In Jamie's case, she first became interested in STEM because of an experience that she had with an all-female STEM program, that was coordinated by a female engineering teacher. In reference to how this experience influenced her interest in STEM, she said:

> …[the teacher], like, told us, like, not many girls are in the engineering field and, like, we should introduce it to more girls. So that was, and there was a good amount of people in there too…It was just girls.

Jamie indicates through her response that seeing an all-female group come together to engage in STEM-related activities, led by a female teacher who emphasized the need for more girls in STEM impacted her interest in STEM, further than just her initial encounter with it.

In relation to the female participants' current and continued interest in STEM, each of them recognized the lack of representation in the field. During this portion of the interview, a couple of students mentioned the need to be aware of this representational inconsistency in order to be successful in the field, while also describing the motivation that this inconsistency stirs up in them to continue pursuing STEM-related opportunities. Maria explained her thoughts in the following way:

> Yeah, just like, um, I wouldn't say, like, just proving myself, but like, I don't know, representing I guess you could say, like, just being proud that I can [pursue engineering] and that I'm, I'm counted as a minority.

Chelsea had a similar disposition about being a female in STEM, based around conversations that she had with other female students who are currently pursuing careers in engineering. She said:

> I know some people who have, that are older now and take, like are in [a post-secondary engineering program] and stuff that are female, and like they, they tell you straight up, like there's not a lot of [females] there. And I'm like, well that's, that's something that I wanna do…like that's not something that's very common, so, like, I wanna be able to say, yeah I'm an engineer and people be like wow, dang, that's pretty impressive…so, like, that's the part that drives me. Like, if I can be able to say, yeah I'm an engineer with all these guys, like, that's an accomplishment to myself.

Maria and Chelsea also both saw the need to be aware of the lack of female representation in STEM, so as to not be surprised by what they will likely encounter in their post-secondary educational and career experiences in the field. Jamie made mention of the fact that there are not many Asian women in the field, but did not directly link this to a drive to stay in the field. She cited other components of her identity as driving factors to remain involved with STEM.

With regard to the male participants in this study, Daniel was the only student who indicated an effect on his experience in STEM based on his gender. He was also the only male participant to bring up the gender representation gap in the engineering pathway during his interview. Daniel described his STEM experience as follows:

> …yeah I feel like, cause a lot of my male friends tend to, you know, slack on education, and you know, not really pay attention in class. I feel like, I feel like if anything, my gender has, like almost held me back. In like, in some cases, like engineering, I feel like, there's, there's a, there's more males than females in engineering classes, and I tend to have a lot of friends.

In the above quote, Daniel referenced a connection that he noticed between the lack of balance in relation to gender enrollment in the engineering pathway and negative peer influence on his academic performance. Upon being prompted to elaborate on his thoughts about the gender gap, he stated:

> …a lot of girls just don't like, they're not interested in engineering. It's just an opinion. And the ones that are in our engineering classes are, like, one of the smartest, like, one of the best engineering students in our class…Oh yeah, I definitely recognize that there's more males than females.

Socioeconomic Status

Socioeconomic status (SES) was mentioned in half of the students' interviews as playing a role in their involvement or interest in continuing to pursue a STEM-related pathway and/or planning to engage in STEM-related opportunities at the post-secondary level. For all three students who recognized SES as an important part of their decision to pursue engineering, they each had a specific financial standard set for their future selves that prompted this decision. Two students even referenced a time in their lives where they considered themselves in a lower socioeconomic class as a reminder of why they plan to pursue STEM-related opportunities after high school. For example, Daniel, who explained that he had experience as a person of low *and* high SES, more specifically described:

> I think [that] experiencing the lower, like low, low class, like experiencing that, like, has definitely influenced me to like, you know, continue to, like, continue to, like, learn about engineering, and continue to, like…because I've had, like, I've been tooken care of by people that didn't take care of themselves and they never really applied theirselves in school. Like, you know, I've, like, I know people that probably if they woulda tried to apply theirselves in, you know, STEM courses, then they probably would have, like, found something, they would eventually found something that made them happy and made them a lot of money and they could take care of themselves. So, I think that engineering just keeps me going because I know that's what I wanna do, that's what makes me happy, and I know that I never wanna stoop down to that lower class level again. I'd rather stay up… when I was living in the lower class, I felt like around that time I would have, I wouldn't have found, I wouldn't have tried, you know, as hard in engineering as I do now.

Daniel, at multiple times throughout his interview, referenced his time as a "lower class" citizen as a motivator to stick with engineering, even when he foresees that it can become difficult.

Jamie also demonstrated this sort of reference back to a time of different SES in her life when she stated:

> …my dad [was] always like, be a doctor, you know, you can [make] the most money and I think it's cause, like, I knew, like, um, in, like, middle school my family kind of struggled with money, so I always thought, okay if I get a job that…pays a lot of money, I can, like, help out and stuff.

Martin, the other student who mentioned SES as an influential factor in pursuing STEM, did not indicate any sort of financial struggle as a motivator, but rather said that maintaining the upper class SES was important and attainable by becoming an engineer.

Race/Ethnicity

While the six participants in this study revealed common influential factors on their interest and experiences in STEM, they were also mostly consistent in indicating the components of their identity that did not have an influence on their interest in STEM. Those who represented racial/ethnic minorities in the study did not recognize race as having any sort of influence on their interest in STEM, but more on their future experiences in STEM. The participants who represented minorities did not express any major previous obstacles or concerns when answering questions about the influence of their identity on their interest in STEM. Upon asking students how their identities (gender, race/ethnicity, SES) influenced their interest in STEM, the students of racial/ethnic minorities did not mention race. The only time that race actually came up, if it did at all, for each of the racial/ethnic minority students was when they were considering obstacles that they might face in the future in the STEM field. As such, Maria briefly stated:

> …I mean I hope it doesn't happen, but I don't wanna be discouraged for like my race, cause, like, I really don't see many Hispanics in that [field].

In a more detailed account, Daniel described his concerns in the following way:

> I don't know what, like, race dominates engineering, but I know that in this world and this country, that racism is a real problem, like is a real bad problem, and I

> don't know if, I, I hope not, but there could, I could eventually one day, like, you know be denied a job because you know, I know a white person looks better than, you know, a Mexican person, but I, I'm not sure. Like, I, I have no idea how the real world is, so I don't know what I'm getting into yet, so, I pray for the best…if you're consistent with your work and you're good, and, like, you actually listen and you learned engineering up and down, I don't think that people will really judge me by my race if I, like, perform as expected.

Even so, none of these students articulated any major anticipated obstacles that they would not be able to overcome in the STEM field in regard to race.

Peer Influence

Additionally, peer influence was a factor of participants' interest and experiences in STEM that was inconsistent across interviews. None of the participants made mention of negative peer interactions that were potentially discouraging to the process of pursuing STEM opportunities. In fact, Martin actually mentioned his peers as the reason why he decided to pursue the engineering pathway. In response to a question regarding how his peers influenced this decision, Martin stated:

> Yeah, because they were like, it's fun to take and it's challenging and it looks good on your college resume, so…

In other cases, like Daniel's, there was a mention of having a difficult time focusing in the engineering pathway, because of friends being in the same classes and causing potential distractions. With both of these examples, the "peers" being discussed were friends of the students. In contrast, all of the female students' interviews, had no mention of "friends" in engineering classes. The only time peers were brought up in Maria's interview was when she explained their reactions to her involvement in STEM, saying "Oh I know you can make it far."

Teacher Influence

Teacher influence, similar to peer influence, was not a guaranteed influential factor on students' interest and experiences in STEM. The interactions with teachers in STEM varied,

which was evident in student responses. For example, Jamie had an experience with a teacher that heavily influenced her initial STEM interest, as she saw her teacher as a sort of role model to follow. In Maria's experience, she shared that seeing her teachers' interest in STEM reassures her in her pursuit of STEM opportunities:

> But there have been, like, some teachers who like, just, I guess share the interest, a, interest and see, like, I don't know just like knowing other people are out there like that.

Daniel, on the other hand, mentioned that he had a negative experience with a teacher, where he was once told that he would not amount to becoming an engineer. All three of these mentions of teacher influence, negative and positive, drove students to continue pursuing the engineering pathway.

Discussion and Implications

Conducting this study helped provide understanding into how the identities of high school engineering students influence their interest and experiences in STEM. The participants in this study consistently highlighted connections between their interest in STEM and the following five components of their identities: (1) early interest/skill in STEM, (2) familial involvement with STEM, (3) self-motivation, (4) gender, and (5) socioeconomic status. Some of the factors that students recognized as influential in their pursuit of a STEM-related pathway were consistent with previous studies, while others were not as supportive of the literature.

Consistent with previous literature, the findings from this study suggest that an early initial interest in STEM is important for students who pursue STEM-related opportunities (Sadler et al., 2012; Maltese & Tai, 2010; Maltese et al., 2014). The participants in this study all associated their initial interest in STEM with a time during or before middle school. An initial sense of self-efficacy or genuine interest in relation to a discipline of STEM at an early age

seemed to be imperative in fostering the foundation necessary for these students to continue pursuing STEM throughout their educational journeys. This finding implies the need for students to be exposed to engaging and meaningful STEM opportunities at a young age.

In reference to familial involvement in STEM, this study suggests that female students in STEM respond differently than males. While most of the participants had a family member who was involved with or interested in STEM, only the female participants actually recognized an influence of a family member's interest in STEM on their own interest. All three female students had engaged in conversations outside of the school building with some of their family members about their interest in a discipline of STEM. Based on this study, a family member's support is more likely to impact a female student's decision to continue pursuing STEM-related opportunities, particularly at the high school level and potentially extending into the post-secondary level, more than a male's decision to do so. This result also indicates that it may not be as important for male students in STEM to have family members who are interested in STEM, in order to pursue a STEM-related pathway and career, contrary to recent literature that emphasizes the importance of family member interest/involvement with STEM (Museus et al., 2011; Gayles & Ampaw, 2011; Sjaastad, 2012).

In addition to female students in STEM needing support from family members, it also was important for them to be aware of the underrepresentation in the field. Each female participant in the study, and one male, recognizing the gender gap in the context of the engineering pathway at Crestmore speaks to the awareness that the students at this school have about women in STEM, prior to entering their post-secondary experiences. While the female participants in this study did not all express the need to be proud of being a female in STEM, they did all acknowledge that they would be representing underrepresented groups in STEM.

This finding further supports the idea that females do not need to be surrounded by other females in order to be successful in STEM, but rather need to recognize and rely on their genuine interest in STEM (Hughes et al., 2013; Robnett & Leaper, 2013). Being exposed to this type of underrepresentation early helped foster a sense of pride, accomplishment, and motivation amongst some of the female participants that may serve as a foundational support for them to lean on if/when they face obstacles because of their gender in STEM, which is in conjunction with the results of Shaffer et al. (2014) that females perform better knowing that they are "gaining ground" in the STEM field.

Reasonably, self-motivation was a determining factor in a student's continuation of the engineering pathway and plans to pursue STEM-related opportunities at the post-secondary level. It is apparent that students must acquire a genuine interest in a discipline of STEM in order to want to follow through with a STEM-related course load. This idea of self-motivation is imperative in considering minorities in STEM, especially as they will likely face obstacles because of their identity at some point in their STEM experiences. If those involved with and planning to pursue STEM careers are not self-motivated to do so, they may flounder in the field, as they will not have the foundational interest in STEM as a support system when difficulties arise.

Surprisingly, socioeconomic status is a motivator for students' involvement in and continuation of STEM-related opportunities. Participants in this study who mentioned SES as an influential factor on their interest in STEM did so out of seeing the value in the financial benefits attached to pursuing a career in STEM, particularly in engineering. This response to SES at the high school level indicates that high school students in STEM tend to think about their future, in

terms of post-secondary and career opportunities, earlier than even the start of high school. This highlights the need for students in STEM to interact with STEM professionals at an early age.

The factors of student identities/experiences that were not consistently influential on interest in STEM in this study were race/ethnicity, peer influence, and teacher influence. Overall, students of racial/ethnic minorities did not seem to pay attention to this type of underrepresentation in the engineering pathway. This result seemed to be a product of a school culture that encourages students to pursue what they are passionate about and interested in, as evidenced by the fact that none of the participants mentioned any negative peer influence or interactions regarding their interest in STEM. While there was not strong evidence of race/ethnicity and peer influence playing major roles in the students' decisions to pursue STEM-related pathways or plan to pursue careers in STEM, based on previous literature (Museus et al., 2011; Robnett & Leaper, 2013; Palmer et al., 2011), it may be important for minority students, in particular, to be made aware of research-based positive influences and strategies that can combat obstacles that they may encounter at the post-secondary level.

Limitations

The main limitation on this study was the small sample size, only allowing for speculative results about the general population. Having more participants would help in providing more supported findings and implications in regard to STEM education in general. Also, one of the participants, the school year after participating in the study, removed himself from the engineering pathway because of athletic responsibilities. Because he knew this change was going to happen, some of his interview answers were not as authentic as they could be, particularly the questions regarding his future in STEM.

Conclusion and Future Research

In summary, early interest in STEM, familial involvement with STEM, self-motivation, gender, and socioeconomic status are all components of a student's identity that can influence their interest and experiences in STEM. The findings from this study can inform educators, parents/guardians, siblings, and even students in STEM on how to intervene, interact with, and engage certain parties in the STEM circuit in an effort to improve STEM education and move toward a more accurately represented STEM workforce.

The limitations of this study and the lack of research surrounding engineering students at the secondary level of education highlight the importance of future research within this specific topic. As the study of engineering naturally employs multiple disciplines of STEM, continuing to learn about students who are involved with K-12 engineering programs is essential in revealing more about why and how these students, particularly minority students, are motivated to continue pursuing STEM. Future research should study larger groups of K-12 engineering students, so as to acquire more generalizable results in regard to individual minorities that can provide implications for all parties involved in the STEM circuit. To gather more well-rounded information, future studies should consider involving the people who influence the students' interest and experience in STEM (i.e. engineering teachers, parents, siblings). Longitudinal studies with K-12 engineering students, as they continue pursuing STEM post-secondary education and eventually find careers in STEM, would also be helpful in addressing any shifts in mindsets or obstacles that minority students in STEM may need to anticipate in order to successfully reach their goal of obtaining a career in STEM.

Appendix

Interview Protocol

Background in STEM

1. When did your interest in science, technology, engineering, and/or mathematics begin?

2. What discipline(s) of STEM did you initially recognize an interest in?

3. How did your interest in STEM begin?
    a. Was your interest initiated by your educational experience? Maybe a teacher/role model?
    b. Was your interest initiated by extracurricular opportunities?
    c. Was your interest initiated by peer involvement or interest in STEM?

4. Do you have any family members who have an interest in science, technology, engineering, and/or mathematics? How do you know that this interest exists? What discipline(s) of STEM do they have an interest in?

5. Do you have any family members who are formally involved with STEM? What does that involvement look like?
    a. Does anyone in your family have a STEM-related career, facilitate STEM opportunities for others, participate in extracurricular STEM opportunities, etc?

6. How have your family members' involvement/interest in STEM, or lack thereof, influenced your continued interest in STEM?

7. How would you identify yourself in regard to gender, race/ethnicity, and class/socioeconomic status?

8. How did your identity influence your initial interest and experiences in STEM?

9. What most heavily influenced your decision to pursue the engineering pathway that you are currently enrolled in?

Current Interest in STEM

10. What encourages you to continue pursuing a STEM-related course load (prompted by enrollment in the engineering pathway)?
    a. How have your teachers or family members been an influence?
    b. Are you self-motivated to continue with this pathway?

11. How have your peers influenced your continuation of the engineering pathway?
    a. Have these influences been positive or negative? How so?

12. What discipline(s) of STEM do you feel that you are the strongest in?

13. What discipline(s) of STEM do you have the most interest in?

14. How has your identity that you described earlier influenced your continued interest in pursuing the engineering pathway?

15. How does your current interest in STEM influence your involvement with the engineering program at your school?
    a. What extracurricular STEM opportunities do you participate in?
    b. Do you strictly participate in required courses associated with the engineering pathway?

16. Has your identity ever influenced you to reconsider pursuing a STEM-related pathway? Why or why not?

Future in STEM

17. How do you plan to pursue STEM-related opportunities after you graduate high school?
    a. Will you continue with a STEM-related course load in your post-secondary education?
    b. Do you plan to have a career involved in STEM?

18. How are your future plans regarding STEM-related fields influenced by your identity?
    a. Does your identity have a role in encouraging or discouraging your continued involvement with STEM?

19. Do you anticipate obstacles in pursuing STEM-related opportunities because of your identity? How do you think your interest in STEM will affect your ability to overcome these anticipated obstacles?

References

Bringing Real-World Learning to PreK-12 Classrooms. (2019). Retrieved from https://www.pltw.org/about-us/our-approach

Gayles, J. G., & Ampaw, F. D. (2011). Gender matters: An examination of differential effects of the college experience on degree attainment in STEM. *New Directions for Institutional Research*, *152*, 19 – 25.

Hall, C., Sullivan, S., Kauffman, P., Batts, P., & Long, J. (2009). Are there gender differences in factors influencing career considerations? *American Journal of Educational Studies*, *2*(1), 23 – 38.

Hughes, R., Nzekwe, M., & Molyneaux, B. (2013). The Single Sex Debate for Girls in Science: A Comparison Between Two Informal Science Programs on Middle School Students' STEM Identity Formation. *Research in Science Education, 43*(5), 1979-2007.

Maltese, A. V., & Tai, R. H. (2010). Eyeballs in the fridge: Sources of early interest in science. *International Journal of Science Education*, *32*(5), 669 – 685.

Maltese, A. V., Melki, C.S., & Wiebke, H.L. (2014). The Nature of Experiences Responsible for the Generation and Maintenance of Interest in STEM. *Science Education*, *98*(6), 937 – 962.

Museus, S., Palmer, R., Davis, R., & Maramba, D. (2011). Special Issue: Racial and Ethnic Minority Students' Success in STEM Education. *ASHE Higher Education Report, 36*(6), 1-140.

National Science Board. (2019). Science and Engineering Indicators 2020: Science and Engineering Labor Force. *Science and Engineering Indicators 2020*. Alexandria, VA.

Palmer, R. T., Maramba, D.C., & Dancy, T.E. (2011). A qualitative investigation of factors

promoting the retention and persistence of students of color in STEM. The Journal of *Negro Education*, *80*(4), 491-504.

Robnett, R., & Leaper, C. (2013). Friendship Groups, Personal Motivation, and Gender in Relation to High School Students' STEM Career Interest. *Journal of Research on Adolescence, 23*(4), 652-664.

Sadler, P. M., Sonnert, G., Hazari, Z., & Tai, R. (2012). Stability and volatility of STEM career interest in high school: A gender study. *Science Education*, *96*(3), 411 – 427.

Shapiro, C. A., & Sax, L. J. (2011). Major selection and persistence for women in STEM. *New Direction for Institutional Research*, *152*, 5 – 18.

Shaffer, E., Marx, S., & Prislin, D. (2013). Mind the Gap: Framing of Women's Success and Representation in STEM Affects Women's Math Performance under Threat. *Sex Roles, 68*(7-8), 454-463.

Sjaastad, J. (2012). Sources of inspiration: The role of significant persons in young people's choices of science in higher education. *International Journal of Science Education*, *34*(1), 1615 – 1636.

Wang, M., & Degol, J. L. (2017). Gender gap in science, technology, engineering, and mathematics (STEM): Current knowledge, implications for practice, policy, and future directions. *Educational Psychology Review, 29*(1), 119-140.

Whalen, D. F., & Shelley, M. C. (2010). Academic success for STEM and non-STEM. *Journal of STEM Education*, *11*(1/2), 45 – 60.

Vita

Morgan Lane

Education

May 2016	University of Kentucky, Lexington, KY, B.S. STEM Education

Professional Positions

2016 – present	Shelby County Public Schools, Mathematics Teacher Shelbyville, KY

_____Morgan Lane_____