Motivated for STEM: Developing an Understanding of Highly Motivated Students' Self-Concept in STEM Education

A. Dean Franks
University of Southern Mississippi
Mary Margaret Capraro
Texas A&M University & Aggie STEM

Abstract
Self-concept, self-efficacy, and interest are inextricably tied together. Researchers collected data from high school students' (n = 44) responses to 4 short answer questions taken from a National Institute of Education interest inventory survey. These students were Texas science and engineering fair winners awarded the opportunity to attend a week-long residential STEM camp on the campus of a research-intensive university. The researchers analyzed responses through descriptive coding to determine how these participants imagined themselves as scientists. Results revealed participants saw themselves first based on career options then in more generalized imaginings based on solving problems and helping humanity, being creative or curious about the world, perceiving science as an integral part of life inseparable from other experiences, and finally, perceiving science as a personal source of joy and excitement. Recommendations are included for educators in order to motivate all students who have an interest in STEM to make decisions that will inform their possible career choices within the STEM field.

Introduction

Mathematics and science education, along with related fields that are often included in discussions of STEM (Science, Technology, Engineering, and Mathematics) education are considered essential areas of study for students who wish to become qualified for the increasing number of STEM dependent careers in the United States. Students' ability to enter the workforce over the next several generations will be increasingly contingent on their mathematics and science literacy (National Science Board ([NSB], 2015). However, not all students are motivated to engage in mathematics or science related coursework or activities (McDonald, 2016). Why is this? It could be that students who lack motivation to engage in STEM education do not see, or imagine, themselves as scientists.

Researchers in the current study examined the responses to a survey from young people who were the first, second, and third place science and engineering fair winners from across the state of Texas. These top high school students competed first in their schools, then advanced to the district level, and, finally, competed at the state science and engineering fair. The first, second, and third place winners were awarded the opportunity to attend a week-long residential STEM camp on a university campus. These winners participated in the camp (*n*=44); participation was voluntary for invited individuals. Each camp participant felt motivated to continue studying and engaging in STEM fields as evidenced from one of the survey questions. Through analyzing the students' responses to camp surveys, researchers aimed to identify how these high achieving, highly motivated participants imagined themselves as scientists to better understand the experiences and factors that may have influenced their development of positive self-concepts related to STEM. Understanding this development of positive self-concepts in STEM may provide insight into strategies that may be used to motivate and engage students who lack positive self-concepts within STEM.

Literature Review/Theoretical Framework

Motivation & Self-Concept in STEM education

Three main factors seem to be closely connected to motivating students in STEM education: self-concept, self-efficacy, and interest (Beier & Rittmayer, 2009). Self-concept and self-efficacy (Bandura, 1997) are very closely related yet are different and distinct. Self-concept can be described as self-perceptions related to one's experiences and academic, social, and physical environment that impact performance (Shavelson, Hubner, & Stanton, 1976; Üstündağ & Özcan, 2018). Similar to interest, which has been defined as "the process by which the underlying needs or desires of learners are energized" (Alexander, Murphy,

Keywords: Science, High School, Motivation, Self-Concept, Science and Engineering Fair, Informal Science

Woods, Duhon, & Parker, 1997, p. 128), self-concept is a fundamental predictor of classes and programs that students choose and, ultimately, predicts their educational choices that lead to success in school (Guay, LaRose, & Boivin, 2004). Additionally, the self-concept of students in schools foretells their educational accomplishments beyond previous achievements (Bandura, 1997; Huang, 2011; Justicia-Galiano, Martin-Puga, Linares, & Pelegrina, 2017; Marsh et al., 2005; Marsh & Martin, 2011; Seaton, Parker, Marsh, Craven, & Yeung, 2014). Academic self-concept signifies a student's awareness and understanding about themselves, their achievements, and their abilities in an academic environment (e.g., I can easily complete this science lab) (Becker & Neumann, 2018). Self-concept conclusions frequently embrace an affective decision connected to the degree to which a student likes the subject area (e.g., I enjoy science classes) (Bong & Skaalvik, 2003).

In contrast, self-efficacy has been described as a student's capacity to categorize and accomplish the progressions essential to achieve a particular objective. It is connected to a belief that a person can accomplish what they need to do to reach their goal (e.g., I think I can successfully solve those chemistry equations) (Bandura, 1994, 1997). Self-efficacy beliefs can foster motivation in several ways; according to Bandura, "they determine the goals people set for themselves, how much effort they expend; how long they persevere in the face of difficulties, and their resilience to failures" (p. 71). Students who hold strong beliefs in their competences use more effort when they fail to accomplish tasks, and students who have greater perseverance tend to accomplish more (Dweck, 2010). Self-efficacy and self-concept are connected in that students possess higher self-efficacy for tasks they think are important for their self-concept and for activities that are connected to their successes and enjoyment (e.g., Robert will be more confident in his ability to balance chemical equations if he likes chemistry and believes himself to be someone who is good in chemistry [Bong & Skaalvik, 2003]).

Self-concept and interest seem to grow, develop, and evolve through a shared relationship with success. The process generally takes place in three parts. First, students' success in an area clearly affects their growth of self-concept in that area (e.g., I did well in algebra class, therefore, I am good at mathematics). Then, self-concept will naturally influence their interest in that area (e.g., I'm good at algebra so I want to register for more math courses). Students' increased interest will contribute to their desire to participate in additional activities related to that area in hopes of acquiring further successful experiences, and the sequence repeats (Marsh et al., 2005; Nagy, Trautwein, Baumert, Köller, & Garrett, 2006).

As previous research has indicated, the nuanced interplay of self-concept in relation to other factors such as self-efficacy and interest can influence students' motivation and long-term educational success. The influence of self-concept alone can be complex as the term refers to "the totality of a complex, organized, and dynamic system of learned beliefs, attitudes, and opinions that each person holds to be true about his or her personal experience" (Purkey, 1988, p. 2). Researchers have found that students with a poor self-concept or self-image of themselves in mathematical contexts may become less motivated to engage in mathematics and may struggle to put forth the extra effort needed to complete a task, and therefore be more inclined to actively avoid math (Justicia-Galiano et al., 2017). Because students' self-concept involves a mix of self-perceptions, learned beliefs, and opinions that can both impact their performance and influence their self-efficacy, interest, and overall motivation (Bong & Skaalvik, 2003; Justicia-Galiano et al., 2017; Marsh et al., 2005; Nagy et al., 2006; Purkey, 1988; Shavelson et al., 1976), it is critical to investigate how students develop self-concepts and to foster positive self-concepts in students. Therefore, in the present study, researchers examined the self-concepts held by students who were high achieving in STEM and highly motivated to engage in STEM activities. The following research questions framed this investigation:

1. How do high achieving, highly motivated STEM students view themselves as scientists?
2. How can understanding high achieving, highly motivated STEM students' views of themselves as scientists help inform educators about ways to foster positive self-concepts and improve motivation in students who have less positive self-concepts in and less motivation toward STEM subjects?

Methods

Participants

Science and engineering fair winners (n = 44) from across the state of Texas received the opportunity to attend a fully funded, one-week residential STEM camp on the campus of a research-intensive university during the summer of 2016 as one of the rewards for their performance in a science and engineering fair competition. A grant from the Texas Workforce Commission afforded this opportunity to them. Demographics included 27 males and 17 females. The majority of the participants (67%) came from middle-class families as was determined from addresses in Zillow. Socioeconomic status was determined by using the home value or rental price of participants' homes as an estimate. Home values between 70K-110K (range of median home values) were indicative of middle SES. Conversely, home values below 70K or rental values lower than $900 per month were considered low SES. High SES was considered above 110K home value or above $3,000 per month rental value. All values were determined using Zillow.com.

Twenty-six of the participants identified themselves as Asian American, 12 as White/European, and 6 as Hispanic. Sixteen of the campers primarily spoke a language in their home other than English including: 4 Chinese, 2 Urdu, 2 Tamil, and 1 of each - German, Polish, Korean, Mandarin, Hindu, Spanish, Telugu, and Guajarati. Grade levels included 9th, 10th, 11th, and 12th graders (n = 1, 10, 17, 16, respectively). The categories in the state science and engineering fair were senior life sciences and senior physical sciences.

Camp Milieu

Professors in the College of Education held a one-week (7 day) residential camp on the campus of a world-renowned, research-intensive university. The campers attended four mini-courses on campus in two industry clusters (Biotechnology and Life Science and Advanced Technologies and Manufacturing). Professors and senior doctoral students taught the project-based learning mini-courses, which involved rigorous and challenging hands-on and lab-based activities in STEM subject area content. More specifically, the mini-courses were in: a) Aerospace Engineering - campers explored the field of aerospace through designing a project in the area of rockets. Each participant constructed a rocket using the engineering design process and built small balsa wood gliders that were attached to the rocket, carried to apogee by the rocket at which time the glider separated from the rocket and glided back to the ground; b) Chemical Forensics - during this project-based learning activity, campers used a variety of qualitative and quantitative chemistry techniques and utilized them to perform inquiry-based experiments (see Table 1). Students analyzed data and observations collected during experiments to determine the identity of an unknown compound that was discovered in a clandestine drug laboratory. Students kept a detailed laboratory notebook continuously recoding their setups, observations, and analyses as evidence of their knowledge acquisition; c) Veterinary Science -campers interacted with veterinary students as they described gross anatomical specimens and the biological levels of organization creating such specimens while learning serology (the scientific study of blood serum) to analyze cells and tissues. Using mathematical skills, the campers ran statistics to determine if the differences found were significant; and d) Cybersecurity - campers learned about identification of security principles, threat, and attack techniques used to gain unauthorized access to computer systems. They also used synthesizing techniques to properly arm and countermeasure systems through toolsets aimed at mitigation of risk that foster resilient, assured information technology operation. Students defined ethical reasoning and differentiated between ethical, social, and legal issues, and recognized their importance in cyber security.

Students also received multiple opportunities and avenues to learn about STEM labs and university life outside of their classes. Students visited on-campus research laboratories after classes each day including a chemistry road show, a hands-on physics show, a reactor laboratory, the fire school disaster city, a coastal lab, and the Center for Autonomous Vehicles. Campers resided and ate at university off-campus housing, which exposed them to typical daily campus living. During the weekend and evenings, campers went to the local skating rink, an entertainment center (bowling, laser tag), Adamson Lagoon (swimming), and attended a science-based movie at the local theater. These additional camp experiences afforded supplementary opportunities for the campers to explore the various facets of university life and academics.

Table 1 Content Areas of the STEM PBL Mini-Courses

STEM Topic Area	Instructional Strategy	Instructional Activities
1. Aerospace Engineering	Project-based - engineering design	Rocket and glider construction using the engineering design process
2. Chemical Forensics	Project-based Inquiry-based experiments	Identify an unknown compound from a "clandestine drug laboratory" through experimentation and observation
3. Veterinary Science	Working with veterinary students Problem-solving	Work with anatomical specimens and using serology and statistics to solve problems
4. Cybersecurity	Synthesis and Application	Designed countermeasure systems to mitigate attack risk. Made conclusions around issues of ethical, social, and legal concerns around cybersecurity.

Data Collection

Instrument

As part of the camp data collection process, researchers administered a 15-item short answer survey to participants at the end of the camp to determine what motivated and engaged these high-achieving students in the field of science. The researchers adapted the survey from the National Institute of Education website that provides suggested questions for items to use in creating a student interest inventory (Shumow & Schmidt, 2013). The 15-item short-answer survey included items such as: List three main ways you spend your free time; List activities in your everyday life that are related to science. Four particular questions, most directly focused on understanding how these highly-motivated students' self-concept enabled them to see themselves as scientists, were used. Thus, for purposes of this study, the researchers examined how participants answered four specific survey questions, which enabled the researchers to gain the most insight into discovering how these students saw themselves as scientists: Q10 - What, if any, specific aspects of mathematics, science, engineering, and technology do you find interesting? Q 11- What can someone who is good at science do? Q 14 - If you see yourself as a scientist, please describe when and where. And, Q 18 - In what ways will science be important in your future education and career/profession?

The instrument was submitted to content validity (Sireci, 1998) to determine the degree to which the instrument measured the particular variables the researchers intended to investigate. To determine this degree of validity, a panel of 3 experts, 2 in science education and 1 in science, was formed. These content experts examined the instrument's items independently of each other answering the following questions: Do you believe these items adequately measure students' motivation to be a scientist?; Are there any items that you believe should be removed, or should any items be added? They determined if aspects of self-concept as a scientist were accounted for by the items. If the panel members felt that the instrument did not cover the content adequately, the researchers in the current study were asked to provide additional items or areas where items should be found. At the end of this process, the experts determined that the instrument likely held high content validity.

Data Analysis

Before any data were collected, this study was approved by the Institutional Research Board at the university level. Additionally, informed consent was received from each of the 44 participants before the camp began. Researchers in the present study examined participant (*n*=44) responses to a 15-question short answer survey. The survey was administered online using Qualtrics after participants took part in the STEM summer camp described above. Four questions addressing self-concept and motivation were analyzed in this study. The two authors inductively coded data from participant responses to Questions 10, 11, 14, and 18 of the survey.

Descriptive Coding. The first level of coding was utilized to code the "basic topic of a passage" (Saldana, 2009, p. 70) and allowed the researchers to explore broad themes. The researchers were examining the responses to the four questions in light of the research questions related to how they saw themselves as scientists. Examples of themes that emerged were: "Solve Problems", "Research", "Creating", "Medicine", "Enjoy/Fun", and "Personal Dreams". After coding, the researchers met to compare coding and discussed until agreement was reached. Finally, Pattern Coding (Saldana, 2009), a second-level coding procedure that allows for the collapsing of codes to formulate theoretical constructs and processes, was completed to code for the final six categories the researchers determined as the constructs that aided in participants' imagining themselves as scientists. The coding framework that emerged was that students saw the **importance of science** and **enjoyed science,** imagining themselves in **careers** as scientists who could **solve problems, help humanity,** and find **creative solutions** to scientific issues in the future while pursuing aspects of science that spark their **curiosity**. As with the first round of coding, the two researchers coded separately according to the process described above and met periodically to discuss coding. Both researchers finally came together to discuss any discrepancies until agreement was reached and achieved a level of 95% interrater reliability (Hallgren, 2012).

Of essential importance to the current study is the idea of situated meaning (Gee, 1990). Situated meaning requires the individual to make a judgement about meaning based on prior experiences and current understanding. In the case of participants in the current study, they had engaged in scientific discourse and were responding to a survey after a one-week STEM camp. This intense immersion into scientific discourse allows for the creating of a figured world, "a picture of a simplified world that captures what is taken to be typical or normal" (Gee, 1990, p. 114), where imagining oneself as scientists becomes salient. This is accomplished, in part, based on the ideas the individual holds about science and on their development of a self-concept in relation to science and STEM, which is influenced by their learned beliefs, attitudes, and opinions about themselves as related to STEM fields.

Results/Discussion

The results of the study indicate the emergence of several themes. Responses within these themes outline the following: (a) how high achieving, highly motivated STEM students view themselves as scientists and (b) how students' views of themselves as scientists may inform educators about ways to foster positive self-concepts and improve motivation in students who have less positive self-concepts in and less motivation toward STEM subjects. Participants viewed themselves as scientists primarily within the context of their future careers, meaning part of their science-related self-concept was career-oriented. However, most responses also suggested that these participants had found ways to personally connect science to their personal lives and interests. For instance, responses in which participants expressed that science was a critical aspect of life itself and a personal source of enjoyment suggest that educators should seek to improve student motivation and positive self-concept in science by helping students personally relate to the subject. These participants had identified how science related to their daily lives and interests in a very personal way and were therefore motivated to engage in science and could see themselves actively pursuing science in the future, which suggests that they had positive self-concepts within science. In the following sections, the researchers outline the emergent themes, first discussing how participants perceived science as an integral part of life, inseparable from other experiences, and as a source of personal joy and excitement. The researchers then outline how participants developed a self-concept that focused on imagining themselves as scientists within careers that would allow them to solve problems, help humanity, and creatively pursue aspects of science that intrigue them.

Science as an Integral Part of Life

Science, and the scientific method, is how we learn about our world. Science is the study of how nature works, and, as such, it is how we learn about ourselves, our planet, our solar system, our galaxy, and the universe. It helps us understand both the microscopic and the macroscopic; mathematics and science are as much a part of painting and creating music as they are a part of creating medicines and advancing technologies. There is no aspect of human life that is not enhanced by STEM fields.

Many of the participants' responses encapsulated this idea through their imaging of science as an integral part of life. For instance, one participant explained, "All the time everywhere. Everything is science" when asked when and where participants see themselves as scientists. Likewise, other participants said, "every day at school" and that science "will help make me a more well-rounded person". Additionally, one participant said, "science is my education and profession, and will continue to be that in the future. I do not see myself doing anything else, as science includes such a wide variety of topics that can be investigated". Finally, there were comments made like, "science is very broad and is thus the basis of everything" and "It is the foundation of most if not all the fields I wish to work in".

By placing emphasis on science as an integral part of life, these participants' images of themselves as scientists did not confine them to a laboratory or a classroom. In fact, they were not even confined by a subject matter. Science "is everywhere" and is a "part of everything they do every day", so they understood STEM education affects all aspects of their daily lives. Science, in this instance, was not confined to these participants' academic self-concept in a particular domain, instead, it was also part of their general self-concept as an individual. Understanding science helps bridge disciplines such as visual arts, history, mathematics, science, and music and is an inextricable aspect of life itself.

Science as Something that Elicits Happiness, Joy, and/or Excitement

Learning happens best when it is something we are intrinsically motivated to study. Feelings of excitement or happiness to learn about science are what educators want to encourage in every student. This can lead to a higher sense of self-efficacy (Bandura, 1997) and self-concept (Shavelson et al. 1976). As discussed in the literature review, self-efficacy and self-concept are predictors of success. Participant responses that focused on the happiness, joy, and excitement of science included comments such as, "I love programming and coding" and "I find artificial intelligence fascinating and physics intriguing". Some participants were less specific about what they found exciting. Comments like, "I find everything in science interesting, as long as I can understand it" and "I enjoy the curiosity that is evoked by the uncertainty of science". Additionally, another student said, "Anyone who loves science is capable of being good at it as long as they put in the effort. In science, anything is possible, so anyone who loves science has the ability to do what they want". These responses show that participants believed they could be successful in science and believed science is "enjoyable and interesting" because they had a high level of self-efficacy and self-concept in STEM fields. To these participants, science and mathematics did not feel like work or studying, instead, participants felt that science, technology, mathematics, and engineering were about learning and developing a deeper understanding of concepts and the world around them.

Career Options

Young people may focus on career choice rather than majors when thinking about their future and college plans (Bullock-Yowell, McConnell, & Schedin, 2014). This tendency can lead students to overlook some majors because such majors do not necessarily easily lead to one particular career path. For instance, what does a biologist, a physicist, or a mathematician do? Some may believe these majors are only for teachers, and others may realize majors like biology and chemistry are stepping-stones for medical school; however, there will be others who do not realize the potential that lies in wait for those who endeavor to further their education in STEM fields. Research has shown that a positive academic self-concept influences students' subsequent educational and occupational aspirations (Parker et al., 2012), and results from the present study align with this finding.

Many of the participants' responses situated their self-concept as a scientist within their future careers. This trend suggests that participants' self-concept as scientists was career-oriented. For instance, common responses included jobs or fields such as researcher, science teacher, entrepreneur in STEM field, and medicine. Other responses were more general. In all cases, the responses suggested that the participants possessed career goals specifically related to science, and that they imagined a career as part of their future identity as a scientist. Participants' ability to imagine themselves in future STEM careers is directly related to their motivation and self-concept (Parker et al., 2012). This is because their idea of who they are and what is important in their lives is linked to their motivation and identity in a STEM context.

Responses related to self-concept in which students viewed themselves as researchers in their future careers included phrases such as, working "in a lab" or "conducting research". By imagining themselves as researchers, participants identified the setting and type of work they expect scientists to conduct. These participants saw themselves as future scientists who will work in labs conducting research or who may work out in nature conducting research. The key to the image is that participants saw themselves actively pursuing answers to research questions; their image was active. Some responses related to future careers were, "I like the thought of being out in the wilderness studying plants and animals", "I would like to be an aerospace engineer or physics professor at a university", "In terms of professional science, I hope to achieve a master's in biomedical engineering at Rice University and work in correlation with a recognized hospital", and "I would like to become a bioengineer that works in a research facility". Because self-concept is a complex mix of an individual's self-perceptions related to his or her experiences and academic, social, and physical environment (Shavelson et al., 1976; Üstündağ & Özcan, 2018), it is possible that part of their self-concept as a scientist was influenced by their personal experiences with researchers they know. It is also possible that some were influenced by famous research scientists.

When prompted to imagine themselves as scientists, other participants wrote responses that indicated that their self-concept in STEM involved viewing themselves as teachers as part of their future careers. In many cases, responses in this category included phrases such as, "to teach" or "help educate". Scientists teach others about how the world works. Science is about sharing information and guiding others into understanding the world better. Again, because an individual's environment and personal experiences influence his or her self-perception (Shavelson et al., 1976; Üstündağ & Özcan, 2018), these participants could have been imagining based on their most likely source of what scientists do by looking to their teachers and mentors who had helped shape their understanding of science and STEM-related subjects. It is likely that enthusiastic and dedicated teachers shaped participants' views of what scientists look like, act like, and do in a very tangible way.

Meanwhile, others saw themselves as involved in STEM-related industry or entrepreneurship as part of their future careers. In many cases, responses in this category included phrases such as, "work in a tech company" or "tech services I plan to offer". Again, their self-concept aligned with a particular area in which a scientist might work. Scientists create new products and develop technologies. They work for companies or start their own businesses and are not confined to a lab or university setting and budget. While it is likely that some participants were imaging based on people they know personally, it is also possible that some were influenced by high profile individuals (Schellenberg, Krauss, Hättich, & Häfeli, 2016). Additionally, the experience of taking part in the Advanced Technologies and Manufacturing track offered during the camp experience may have aided in participants' ability to imagine themselves as entrepreneurs or working in industry.

In addition, some participants imagined themselves as medical professionals (e.g., doctor, surgeon, veterinarian) and used phrases such as, "be a vet" or "becoming a surgeon" in their responses. Their self-image in STEM aligned with the desire to work to help people and animals live healthier lives. Scientists work in hospitals and clinics providing medical care to patients in need of medical assistance. These participants could have developed this particular career aspiration related to their self-concept through personal experiences with people they know such as parents or doctors who have cared for them (Shavelson et al., 1976; Üstündağ & Özcan, 2018). However, they could have also been influenced by the cross-cultural fascination with medical professionals, specifically with doctors and surgeons.

Finally, some participants saw themselves as scientists in the future. This category includes a wide range of responses that ranged from being in a particular scientific field such as biology to more general imagined career ambitions that suggested science or STEM would be important in their future careers. Examples of responses in this category included, "want to be a biologist" and "career in the hard sciences". By imagining themselves as general scientists, participants were identifying the fields of study they saw as being *scientific*. Scientists are biologists, chemists, or work in other STEM-related fields. These participants may not have had specific career goals in mind, but they were certain that science would be a part of their future career choice. This could be evidence that some participants, those who fell closer in line with "career in the hard sciences", had not determined a clear trajectory for their future. It could also mean that these participants were more focused on studying science in the future rather than what particular future job they would be pursuing. This is in no way a suggestion that these participants were less enthusiastic or determined to succeed in STEM fields; the implications are nuanced. The participants could have been primarily influenced by subjects rather than people when imagining themselves as scientists. Likewise, they could have been imagining a future career that is not defined as of yet. These participants may have been exposed to possibilities they were unfamiliar with before participating in the camp and may, therefore, have been in a state of reimagining themselves as scientists at the conclusion of STEM camp. In this case, they may have begun with a self-image as a teacher but may have later realized they could better see themselves as a researcher or entrepreneur.

Scientific Careers that Solve Problems and Help Humanity

It is not generally a natural progression for students who enroll in a multitude of science classes, complete a variety of daily homework assignments of figuring chemical equations and calculating speed and velocity in physics, to automatically relate their class material to broader world perspectives. In fact, students attending STEM-related camps have even indicated that they initially did not understand why they had to learn science in school and felt it was disconnected from the real-world (Roberts et al., 2018). However, findings from prior research have also shown that students who expressed an interest in and motivation to pursue science were better able to associate the concepts and content covered in their science-related classes to broader, real-world applications (Lee, Capraro, & Viruru, 2018). Furthermore, many of the students felt motivated to engage in science because they perceived the use of science as a way to solve problems that would benefit humanity (Lee et al., 2018; Lent, Brown, & Hackett, 2000). These factors are important for educators to note as they attempt to motivate all students toward careers that will be meaningful and fulfilling in different ways for each of their students.

In the current study, the responses of the high achieving, highly motivated students aligned with prior findings: many of the participants situated their imagined future selves as scientists in ways that described actions that would lead toward improving humanity. These specific students saw their role as scientists in ways that would be used to find solutions to problems that would improve the lives of others. Common responses included "discussing medical research". Other responses were more general. In all cases, the responses suggested that campers imagined taking on key problems that would benefit humanity in a number of ways by utilizing STEM education. For instance, participants said, "I will be able to see both the macro and micro level problems that exist in the human body. Knowing the detailed sciences in this process with help me be more proficient at my skills and jobs, so I can successfully help diagnose and cure people", "science will always be inventing and discovering new things that will change how we look at the world", and "science can help to build problem-solving skills". Each category below examines the ways in which participants positioned themselves as scientists by imagining their future as it pertained to solving problems to help humanity.

Those who spoke of solving problems mentioned things like wanting to solve problems "related to life", "using real facts and logic", and "defining new ways of learning". They felt there are many "innovative ways they can use to solve problems", that their "opportunities are endless", and that there are "always problems that they can solve". They desired to "minimize large problems with ease", "build problem solving skills", "solve problems through experimentation", and "research to alleviate problems facing the world through discoveries".

By imagining themselves in a role that focuses on solving problems, these participants provided insight into how they view the importance of STEM education. For them, STEM education, and ultimately, STEM-related professions, are about problem solving. These participants were solution-based problem solvers. In other words, they saw problems as puzzles that can be solved with science, research, and logic.

Others who discussed helping people wanted to "impact the lives of others" by using STEM fields to make positive changes that would benefit the day-to-day lives of people, while solving "problems big and small". One participant wanted to "improve living standards and conditions of people all over the world". By imagining themselves in a role that focuses on impacting lives, these participants provided insight into how they viewed the importance of STEM education and related fields. For these participants, the importance of improving standards of living and benefiting people's daily lives was essential to how they processed the importance of work in STEM fields. It goes beyond a basic understanding of needing to pass courses or interest in making money. These participants wanted to use their STEM education to make a lasting, beneficial impact on the human experience.

Additionally, some participants were very focused in the area of medicine. One discussed "helping humanity to resolve its ailments", while another wanted to "cure deadly diseases". Another participant wanted to "construct prosthesis for handicapped people". Additionally, one participant focused on "diagnosing and curing specific diseases". Participants who included medical innovation in their responses provided insight into how they viewed the importance of STEM education. For them, STEM education leads to professions in medicine and medical research where the emphasis is on saving lives and curing diseases. These participants were interested in ensuring a healthier future for those impacted by diseases and other medically treatable ailments.

Finally, there were some participants who talked about very specific areas where they felt they could make a difference in the future. One wanted to "send a rocket to the moon", another "build a completely new platform for computers", while a third wanted to "find new and efficient ways to use nonrenewable resources and utilize clean technologies". By imagining themselves in a role that focuses on technological innovations, these participants provided insight into how they viewed the importance of STEM education. In these participants' minds, STEM meant advancing technology. Through avenues such as space exploration, computer programing, and striving to find more effective ways of utilizing renewable energy sources, these participants were looking to STEM education to help them develop the technologies needed in the future to insure a bright tomorrow for everyone.

Ultimately these participants focused on changing the world. Some things they said were, they wanted to "help improve the world", "save the world", "understand the world and therefore change it". While "changing the world", they wanted to "make an impact on the world", and "discover answers globally." To sum it up, one desired to "Invent and discover new things that will change how we look at the world". In this way, participants showed that STEM education, for them, was directly linked to the ability to positively impact the human experience through a variety of innovations in many aspects of life.

Careers focused on Scientific Creativity and Being Curious about the World

Creativity has been defined as *the production of something both novel and useful* (Martindale, 1999; Stein, 1953). Most people realize that even if creativity is innate, it must be cultivated. Unfortunately, schools are placing more emphasis on rote learning concepts to pass high-stakes tests causing Jung and his colleagues (2010) to be afraid that opportunities for allowing thoughts to flow creatively are less today than in years past. As Albert Einstein once expressed, the greatest scientists are artists as well. Society must cultivate creative scientists so that new processes and inventions can continue.

Many of the participants' responses situated themselves as persons who saw scientists as creative and curious individuals. Participants desired to "observe and make conclusions about unknown things" and "things in the future", this is what "makes me a scientist". They talked about wanting to enter jobs that would allow them to "enjoy the curiosity that is evoked by the uncertainty of science", "discover an uncertain solution", and "know why things are the way they are". Others wanted to "create new things", "take risks", and "think outside the box while remaining open minded yet seeking solutions to world problems". Another participant noted, I want to "study biology because it intrigues me the most because it is all around us and its complexity is unthinkable". Statements were made about "discovering uncertain solutions", "creating and thinking", "inventing and innovating new systems", and "possibly discovering and implementing creative new solutions".

In other words, these participants wanted to "use their skills to help further any research on topics in order to help explain or describe mysterious topics". Curiosity and creativity are the driving forces for change and advancement in most fields, and these participants clearly not only realized that at a young age, but internalized the importance of creativity and curiosity as part of the image of themselves as scientists.

Conclusions

Through the process of reviewing participant responses to a post-STEM camp survey, researchers in the present study gained a deeper understanding of what motivates high achieving students in STEM education. Participants' responses provided insight, through descriptive coding, that allowed the researchers to peek into how their motivation in STEM influences how they imagine themselves as scientists as outlined by previous theorists (Bandura, 1997; Beier & Rittmayer, 2009; Shavelson et al., 1976). For instance, Bandura (1997) explained how self-concept impacts self-efficacy and leads to greater motivation for our participants to take part in future STEM activities. This is also in line with Beier and Rittmayer (2009) who focused on the interconnections between self-concept, self-efficacy, and interest. In the current study, researchers found that self-concept related to STEM meant participants had more self-efficacy for completing STEM activities and being successful in STEM fields, and this played a part in their overall interest in STEM education. The images they created through their survey answers can help educators better understand how to help other students become motivated and engaged in STEM education and develop positive self-concepts as well. Educators must recognize "self-concept's importance as a driver of human potential" and work continuously to identify ways to help foster a positive self-concept in their students (Seaton et al., p. 66). Of key importance to the current study, is the idea that self-concept based in STEM must start with getting unmotivated students motivated. Partially, at least, this can be encouraged by helping students positively identify with and as scientists. Participants in the study were already highly motivated, high achieving, and showed evidence of having a self-concept focused on STEM. By examining their responses, we can develop ideas for how to motivate and foster the development of students' positive STEM self-concept.

Recommendations

Through this study, the researchers examined ways these motivated and high achieving students pictured themselves as scientists. Delving deeper into understanding what motivated these 44 participants, the researchers discovered some important aspects leading to recommendations for educators of students who have somewhat of an interest in STEM subjects. Teachers need to be aware of how self-concept, self-efficacy, and interest work together in a student. Educators must facilitate this interconnected relationship with the three elements. Teachers must bolster a student's self-concept by reinforcing students until they solidify their own solid self-concept. Students need to believe they are good at STEM subjects. This self-concept allows for self-efficacy, which is when a student can complete the steps necessary to accomplish a particular objective (A student feels he can efficiently solve algebraic equations) (Bandura, 1997). Students who possess high self-concepts are generally ones who possess higher self-efficacy for things that are important for their self-concept and for activities they enjoy. Thus, if Juan is more confident in his ability to balance algebraic equations, he likes mathematics (algebra) and believes in himself as someone who is good in mathematics (Bong & Skaalvik, 2003). Thus, it is important for teachers to encourage and motivate discouraged students. Schools and informal STEM activities can provide opportunities to solidify students' STEM self-concepts through summer camps, museums, zoos, botanical gardens, planetariums, robotics clubs, exposure to research laboratories, and additional activities that allow for positive exposure to science outside of STEM book learning.

As shown through this research, the participants were able to see themselves as scientists through a variety of lenses, whether they be researchers in laboratories, entrepreneurs of companies, teachers in schools, medical doctors in hospitals and offices, these participants were able to visualize themselves in these various career roles and paths. Educators are encouraged to allow all students to realize the endless possibilities for those who pursue STEM careers. Inviting guest speakers into classroom, hosting career fairs, and providing opportunities for students to shadow scientists in the field are just some of the avenues that educators can use to encourage this perspective for students so that they can envision their future careers in science.

As was demonstrated from the survey responses, most of these participants were able to go beyond book knowledge and saw themselves as scientists solving environmental problems and ultimately improving humanity. Perhaps their science and engineering fair and camp experiences allowed them to look outside their science textbooks and see how science can be used for the improvement of humanity as a lofty goal for themselves as scientists. During their participation in STEM fairs and informal STEM camp activities, which can be encouraged by educators, many of these budding scientists worked alongside researchers in the field to complete their projects and while in the camp on the university campus. Teachers should mentor and encourage their students to participate when STEM professionals conduct these types of activities so that students can see real scientists in real laboratories finding solutions to problems that will make the world a better place for all of humanity in the future.

Other participants focused on the curiosity that is evoked by the uncertainty of science. These participants' learning happened best when it was intrinsically motivated. Feelings of excitement or happiness to learn about science is what educators want to encourage in every student. It is critical that teachers encourage all students to believe they can be successful and enjoy a high level of self-efficacy and positive self-concept in STEM fields. All students need to develop a comprehensive understanding of science, technology, mathematics, and engineering because the world around us needs creative and knowledgeable scientists who can make the world a better place for all of humanity.

Future Research

Future research in this area should consider the responses of participants before and after the camp experience to determine what effect the STEM camp experience may play in participants' images of self as scientists. This would help us better understand what effect the camp held on a large research-intensive campus surrounded by experts in various fields of STEM disciplines may have. It would also provide a more in-depth understanding of how invested these high achieving science students are in their pursuit of STEM education and careers.

Additionally, future research should select several campers and follow up their survey responses with one-on-one interviews to produce a case study that will provide more details about how students imagine themselves as scientists. This added layer of detail will allow for a clearer understandings and may lead to the development of new survey questions based on participant responses during the interviews. Once the case study is complete, reevaluating the survey and conducting a survey with more participants who may or may not be high achieving science students and who may or may not have attended a STEM camp would lead to a quantifiable understanding of the imaging of self as a scientist.

Finally, additional research could focus on interventions that help motivate students who are not already highly motivated, high achieving STEM students. Beforehand, researchers could administer a survey to examine participants' self-efficacy and self-concept related to STEM fields. Then, they could provide participants a STEM camp experience or some other highly concentrated exposure to a STEM education opportunity. Afterwards, participants could be interviewed and/or given a survey to examine the impact of the experience on their image of self as scientists and their self-efficacy and self-concept.

Limitations

All studies have some limitations. In the case of the current study, there are two primary limitations to consider. First, all of the participants were already highly motivated and high achieving in STEM education. This means that the researchers did not find a wide range of responses in most cases, which resulted in a collection of responses that were generally positive and did not vary much within categories. However, the focus of the study was on determining what could be learned from the motivation and self-concept of high achieving, highly motivated STEM students, so it was unlikely that the researchers would have found negative responses concerning the topics discussed in this study.

Additionally, because all participants were high achieving, as evidenced through their invitation to attend this specific STEM camp, the researchers did not have the opportunity to include a wide range of individuals, some of which may have been motivated in STEM but may not have been as high achieving. Again, for the purposes of the current study, this was not a concern because the purpose was to develop understanding through the responses of high achieving students. Future research may find it helpful to include voices of a wide range of students who enjoy STEM fields at a variety of achievement levels.

References

Alexander, P. A., Murphy, P. K., Woods, B. S., Duhon, K. E., & Parker, D. (1997). College instruction and concomitant changes in students' knowledge, interest, and strategy use: A study of domain learning. *Contemporary Educational Psychology*, *22*(2), 125-146.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York, NY: Freeman.

Bandura, A. (1994). Self-efficacy. In V. S. Ramachaudran (Ed.), *Encyclopedia of human behavior* (Vol 4, pp. 71-81). New York, NY: Freeman.

Becker, M., & Neumann, M. (2018). Longitudinal big-fish-little-pond effects on academic self-concept development during the transition from elementary to secondary schooling. *Journal of Educational Psychology*, *110*(6), 882-897.

Beier, M. E., & Rittmayer, M. A. (2009). Motivational factors in STEM: Interest and self-concept. In B. Bogue & E. Cady (Eds.), *Applying research to practice (ARP) resources*. Retrieved from http://www.engr.psu.edu/AWE/ARPresources.aspx

Bong, M., & Skaalvik, E. M. (2003). Academic self-concept and self-efficacy: How different are they really?. *Educational Psychology Review, 15,* 1-40.

Bullock-Yowell, E., McConnell, A. E., & Schedin, E. A. (2014). Decided and undecided students: Career self-efficacy, negative thinking, and decision-making difficulties. *NACADA Journal*, *34*(1), 22-34

Capraro, M. M., Capraro, R. M., & De Miranda, M. (2017, March). *The hidden supports of high school engineering and technology science fair winners.* Paper presented at the seventy-ninth conference of the International Technology and Engineering Educators Association, Dallas, TX. Retrieved from https://www.iteea.org/39488.aspx

Dweck, C. S. (2010). Even geniuses work hard. *Educational Leadership*, *68*(1), 16-20.

Guay, F., LaRose, S., & Boivin, M. (2004). Academic self-concept and educational attainment level: A ten-year longitudinal study. *Self and Identity*, *3*, 53-68.

Hallgren, K. A. (2012). Computing inter-rater reliability for observational data: an overview and tutorial. *Tutorials in Quantitative Methods for Psychology*, *8*(1), 23.

Huang, C. (2011). Self-concept and academic achievement: A meta-analysis of longitudinal relations. *Journal of School Psychology*, *49*, 505-528.

Jung, R. E., Segall, J. M., Jeremy Bockholt, H., Flores, R. A., Smith, S. M., Chavez, R. S., et al. (2010). Neuroanatomy of creativity. *Human Brain Mapping*, *31*, 398-409.

Justicia-Galiano, M. J., Martin-Puga, M. E., Linares, R., & Pelegrina, S. (2017). Math anxiety and math performance in children: The mediating roles of working memory and math self-concept. *British Journal of Educational Psychology*, *87*, 573-589.

Lee, Y., Capraro, M. M., & Viruru, R. (2018). The factors motivating students' STEM career aspirations: Personal and societal contexts. *International Journal of Innovation in Science and Mathematics Education*, *26*(5), 74-86.

Lent, R. W., Brown, S. D., & Hackett, G. (2000). Contextual supports and barriers to career choice: A social cognitive analysis. *Journal of Counseling Psychology*, *47*(1), 36-49.

Marsh, H. W., & Martin, A. J. (2011). Academic self-concept and academic achievement: Relations and causal ordering. *British Journal of Educational Psychology*, *81*, 59-77.

Marsh, H. W., Trautwein, U., Ludtke, O., Koller, O., & Baumert, J. (2005). Academic self- concept, interest, grades and standardized test scores: Reciprocal effects models of causal ordering. *Child Development*, *76*(2), 397-416.

Martindale, C. (1999). Biological bases of creativity. In R. J. Sternberg (Ed.), *Handbook of creativity*, (pp. 137-152). Cambridge, UK: University Press.

McDonald, C. F. (2016). STEM Education: A review of the contribution of the disciplines of science, technology, engineering, and mathematics. *Science Education International*, *27*, 530-569.

Nagy, G., Garrett, J., Trautwein, U., Cortina, K. S., Baumert, J., & Eccles, J. S. (2008). Gendered high school course selection as a precursor of gendered careers: The mediating role of self-concept and intrinsic value. In M. G. H. Watt & J. S. Eccles (Eds.), *Gender and occupational outcomes: Longitudinal assessments of individual, social, and cultural influences* (pp. 115–143). Washington, DC: American Psychological Association.

National Science Board. (2015). *Revisiting the STEM workforce: A companion to science and engineering indicators 2014*. Arlington, VA: National Science Foundation.

Parker, P. D., Schoon, I., Tsai, Y.-M., Nagy, G., Trautwein, U., & Eccles, J. S. (2012). Achievement, agency, gender, and socioeconomic background as predictors of postschool choices: A multicontext study. *Developmental Psychology, 48*(6), 1629-1642.

Purkey, W. (1988). *An overview of self-concept theory for counselors*. ERIC Clearinghouse on Counseling and Personnel Services, Ann Arbor, MI (An ERIC/CAPS Digest: ED304630)

Roberts, T., Jackson, C., Mohr-Schroeder, M. J., Bush, S. B., Maiorca, C., Cavalcanti, M., Schroeder, D. C., Delaney, A., Putnam, L. & Cremeans, C. (2018). Students' perceptions of STEM learning after participating in a summer informal learning experience. *International Journal of STEM Education*, *5*(35), 1-14.

Saldana, J. (2009). *The coding manual for qualitative researchers*. Thousand Oaks, CA: SAGE.

Schellenberg, C., Krauss, A., Hättich, A, & Häfeli, K. (2016). Occupational career patterns over 30 years: predictors and outcomes. *Empirical Research in Vocational Education and Training, **8***, 15.

Seaton, M., Parker, P., Marsh, H. W., Craven, R. G., & Yeung, A. S. (2014). The reciprocal relations between self-concept, motivation and achievement: Juxtaposing academic self-concept and achievement goal orientations for mathematics success. *Educational Psychology*, *34*, 49–72.

Shavelson, R. J., Hubner, J. J., & Stanton, J. C. (1976). Self-concept: Validation of construct interpretations. *Review of Educational Research*, *46*, 407-441.

Shumow, L. B., & Schmidt, J. A. (2013). A companion website for *Enhancing adolescents' motivation for science.* Retrieved from http://www.niu.edu/eteams

Sireci, S. G. (1998). The construct of content validity. *Social Indicators Research*, *45*(1-3), 83-117.

Stein, M. I. (1953). Creativity and culture. *Journal of Psychology*, *36*, 311–322. doi: 10.1080/00223980.1953.9712897

Üstündağ, S., & Özcan, G. (2018). Effect of educational games on self-concept levels of inclusive students studying in secondary schools. *Journal of Education and Training Studies, 6*(10), 183-192.

Author Note: A. Dean Franks is a visiting professor of Elementary Education at the University of Southern Mississippi. She can be contacted The University of Southern Mississippi – Department of Curriculum and Instruction, **118 College Drive,** Hattiesburg, MS 39406 (601-266-1000) or franksad1@gmail.com. Mary Margaret Capraro is professor of Mathematics Education at Texas A&M University and Co-director of the Aggie STEM Center with interests in teacher and student beliefs and influences on STEM achievement. She can be contacted at TAMU, Department of Teaching, Learning and Culture, 4232 TAMU, College Station, TX 77843-4232 (979-845-3013) or mmcapraro@tamu.edu

Acknowledgements: Funding for this project was granted by the Texas Workforce Commission - Governor's Science and Technology Champions' Academy (RFP# 320-17-05). We would also like to thank Aggie STEM for access to the data and facilitating this camp.