STEM UP: A STEM UNDERGRADUATE PROGRAM TO HELP MIDDLE SCHOOL YOUTH SELECT STEM MAJORS AND CAREERS THROUGH COGNITIVE APPRENTICESHIP

by

Kyla A. Rischard

A Thesis Submitted to the Faculty of the
DEPARTMENT OF EDUCATIONAL PSYCHOLOGY

In Partial Fulfillment of the Requirements
For the Degree of
MASTER OF ARTS

In the Graduate College
THE UNIVERSITY OF ARIZONA

2015
STATEMENT BY AUTHOR

The thesis titled STEM UP: A STEM Undergraduate Program to Help Middle School Youth Select STEM Majors and Careers through Cognitive Apprenticeship prepared by Kyla A. Rischard been submitted in partial fulfillment of requirements for a master’s degree at the University of Arizona and is deposited in the University Library to be made available to borrowers under rules of the Library.

Brief quotations from this thesis are allowable without special permission, provided that an accurate acknowledgement of the source is made. Requests for permission for extended quotation from or reproduction of this manuscript in whole or in part may be granted by the head of the major department or the Dean of the Graduate College when in his or her judgment the proposed use of the material is in the interests of scholarship. In all other instances, however, permission must be obtained from the author.

SIGNED: Kyla A. Rischard

APPROVAL BY THESIS DIRECTOR

This thesis has been approved on the date shown below:

______________________________
Dr. Heidi Legg Burross
Professor of Educational Psychology

November 24, 2015
Date
Acknowledgements

I would like to acknowledge my academic advisor Dr. Heidi Legg Burross, department head Dr. Mary McCaslin, and minor advisor/program director Dr. Mary Irwin for reviewing this study, as well as my husband/peer Mattius Rischard for proofreading and supporting me throughout the research process. I would also like to thank the principals, administrators, teachers, and my STEM undergraduates for their continuous collaboration and feedback. I would especially like to extend my sincerest gratitude to the middle school students who participated in the STEM UP study. I very much look forward to working with future middle school scholars to gain a deeper insight into not only how they plan for their STEM future, but the reasons why they select STEM possible selves.
# TABLE OF CONTENTS

- ABSTRACT .......................................................................................................................... 7
- INTRODUCTION .................................................................................................................. 8
- LITERATURE REVIEW ....................................................................................................... 10
  - BALANCED POSSIBLE SELF ......................................................................................... 11
  - MENTOR INSTRUCTIONAL MODEL ............................................................................. 12
  - MENTEE INSTRUCTIONAL MODEL .............................................................................. 13
  - CURRICULUM PURPOSE ............................................................................................... 14
  - CURRICULUM COMPONENTS ...................................................................................... 14
  - POSSIBLE SELVES DESIGN PRINCIPLES ................................................................... 16
  - PURPOSE ......................................................................................................................... 17
  - THEORETICAL LENS ...................................................................................................... 18
  - QUESTIONS .................................................................................................................... 18
  - DEPENDENT VARIABLES ............................................................................................. 19
  - HYPOTHESES .................................................................................................................. 20
- METHOD ............................................................................................................................ 21
  - PARTICIPANTS ............................................................................................................... 21
    - PILOT STUDY ............................................................................................................... 21
    - FULL IMPLEMENTATION .............................................................................................. 22
  - INSTRUMENTS ................................................................................................................. 23
    - PILOT STUDY ............................................................................................................... 23
    - FULL IMPLEMENTATION .............................................................................................. 23
  - PROCEDURE ..................................................................................................................... 24
A STEM UNDERGRADUATE PROGRAM

PILOT STUDY ................................................................. 24
FULL IMPLEMENTATION ................................................. 25
DESIGN ............................................................................ 26
LIMITATIONS ................................................................. 26
ANALYSIS ....................................................................... 27
PILOT STUDY ................................................................. 27
FULL IMPLEMENTATION ................................................. 28
RESULTS ......................................................................... 30
PILOT STUDY ................................................................. 30
FULL IMPLEMENTATION ................................................. 30
DISCUSSION ................................................................. 40
PILOT STUDY ................................................................. 40
FULL IMPLEMENTATION ................................................. 41
FUTURE RESEARCH ....................................................... 49
REFERENCES ................................................................. 52
APPENDICES .................................................................. 54
APPENDIX A: SURVEY .................................................. 54
APPENDIX B: PLAN OF ACTION ....................................... 55
APPENDIX C: EXAMPLE OF PLAN OF ACTION WITH CODING ........................................... 56

List of Figures

FIGURE 1: MENTEES’ COMPETENCE AND MOTIVATION ............................................. 33
List of Tables

TABLE 1: CORRELATIONAL DATA.................................................................32
TABLE 2: POSSIBLE SELVES IDENTIFICATION.............................................35
TABLE 3: BECOMING HOPED-FOR/AVOIDING FEARED..................................36
TABLE 4: REQUIREMENTS IN MIDDLE SCHOOL..........................................37
TABLE 5: STRATEGIES IN MIDDLE SCHOOL...............................................38
TABLE 6: REQUIREMENTS IN COLLEGE.....................................................39
TABLE 7: STRATEGIES IN COLLEGE..........................................................40
Abstract

This study examined how middle school students planned to obtain future STEM college majors and careers through a possible selves curriculum in a 13-week, in-school cognitive apprenticeship model. STEM undergraduates mentored STEM-interested middle school mentees ($N=21$) from six under-served middle schools. Through possible selves activities, mentees worked on strategies to avoid becoming their feared possible self and become their hoped-for possible self. In the middle of the semester, mentee self-reported competency in STEM fields, motivation, administrator-reported STEM course grades, and STEM attendance were collected. On average, mentees felt 10.67% more motivated to pursue STEM than they felt competent in STEM. Mentees who reported higher competency tended to have higher course grades, and mentees who reported higher motivation tended to have higher attendance, although attendance was high overall, indicating insufficient sample size or variance to demonstrate significance. Mentees who attended class more tended to have a higher course grade but the same statistical issue occurred in that there may not have been a significant correlation due to sampling and self-selection biases. The majority of mentees identified unrelated possible selves, defined concrete self-improvement and abstract self-maintenance strategies, identified self-discipline as a requirement in middle school, described intellectual independence and teacher harmony strategies to solve everyday problems in middle school, identified instructivist college requirements, described responsibility as a transferable strategy, and dependence on an expert as a nontransferable strategy to solve long-term problems in college to obtain their STEM possible self.

Keywords: possible selves, STEM, cognitive apprenticeship, under-served communities
STEM UP: A STEM Undergraduate Program to Help Middle School Youth Select STEM Majors and Careers through Cognitive Apprenticeship

No one assessment represents the totality of an individual’s knowledge, but one assessment can highlight important factors that call for critical reflection, both on an individual and societal level. On Arizona’s Instrument to Measure Standards (AIMS) 2011 Science Exam, “approximately three quarters of Asian Pacific American (76.2%) and White (73.9%) students passed…[but] less than half of Black (45.8%), Hispanic (45%), and American Indian (33.1%) students passed” (Milem, Bryan, Sesate, & Montaño, 2013, p. 24). Although Whites make up the majority of the United State’s population (64%), Arizona is home to “nearly twice the proportion of Hispanic and four times the proportion of American Indians” in comparison to the rest of the nation (p. 12). Arizona education should build upon these populations’ respected histories and cultures to enhance their learning, specifically in STEM (science, technology, engineering, and mathematics) domains.

Despite efforts to close the achievement gap the Science and Engineering Readiness Index (SERI) ranks Arizona 45th out of 50 states (Zhao, 2011). The nation’s recent push for STEM college majors and careers is demonstrated in President Obama’s 2009 “Educate to Innovate”, which prioritizes “broadening participation to inspire a more diverse STEM talent pool…[that focuses] on underrepresented groups…[by] setting the standard with exceptional role models (“Educate to Innovate”, 2009). Mentoring programs, among other initiatives, are addressing educational inequalities and assisting individuals in developing their aspirations for their immediate and long-term future.

Project SOAR (Student Outreach for Access and Resiliency) is a mentoring program at a Southwest university in the United States (2013). The program’s mission is to pair undergraduate
students with middle school youth from under-served communities. As the graduate assistant for the STEM section of Project SOAR, I developed the STEM UP research to analyze middle school students’ perceptions of their possible selves (what one hopes to become, what one expects to become, and what one is afraid to become) in college STEM majors and careers (Markus & Nurius, 1986). This intervention was accomplished by pairing selected STEM-interested middle school students (mentees) with an undergraduate STEM major student (mentor) via motivational activities and curriculum meant to access cognitive drive to succeed in STEM academic areas (1986).

Project SOAR provided middle school students with access to mentors from real-world disciplines, and activities that were designed to influence their perceptions of possible selves. These activities were intended to positively affect their science competency and further reflect on their motivation to select STEM college majors and careers. The mentoring model employed principles of cognitive apprenticeship (Collins, 2006), so that when the mentoring semester was completed, the mentees would be knowledgeable in additional support systems and continue building their plan of actions to achieve their possible selves, independent of their mentor.

This is a novel STEM intervention to the Southwest secondary educational system that has demonstrated successful outcomes in other, similar veins of research. The purpose of this research is to better understand how middle school students from under-served communities plan to obtain a future in STEM college majors and careers. In this STEM UP research, I used an educational psychology and critical pedagogy lens to guide my analysis. The approach I took in conducting this research is described in Mia Birdman’s statement in “The story we tell about poverty isn’t true” (2015): “The quarter-truths and limited plot lines have us convinced that poor people are a problem that needs fixing. What if we recognized that what's working is the people
and what's broken is our approach? What if we realized that the experts we are looking for, the experts we need to follow, are poor people themselves? What if, instead of imposing solutions, we just added fire to the already-burning flame that they have? Not directing—not even empowering—but just fueling their initiative” (p. 1).

**Literature Review**

Possible selves is a representation of “individuals' ideas of what they might become…would like to become, and what they are afraid of becoming, and thus provide a conceptual link between cognition and motivation” (Markus & Nurius, 1986, p. 1). This theory has been presented in data that is meaningful and generalizable, albeit largely correlational. Even recent studies, such as Buday, Stake, and Peterson’s “Gender and the choice of a science career: the impact of social support and possible selves” draws upon correlational inferences to determine the ways in which possible selves and social support motivate genders to enter STEM fields with variable levels of success (2012). Granted, their results showed that ten years after participating in a high school STEM summer camp, a selection of high achieving science professionals in a Midwestern sample of 66 men and 48 women demonstrated an association between “social support and a vision of oneself in a science career [STEM possible selves]” and “having a career in a science-related field and with having positive perceptions of a science career” (p. 207). These results are indicative of some of the factors that impact one’s creation of a positively oriented possible self.

Specifically among middle school students, possible selves has been validated as a viable curriculum through several empirical studies, as well. According to Oyserman, Terry, and Bybee, who authored a possible selves curriculum *(School to Jobs)*, middle school students are in a key age group where they are exploring interests in future careers (2002). Curriculum like the
authors’ *School to Jobs* activities, which engaged middle school students in authentic practice with a STEM mentor, aimed to help them believe that what they hoped to become is closely related to what they expected to become in regards to a STEM major and career (2002). By increasing the plausibility of achieving a balanced STEM possible self, students’ motivation to assert their academic efforts in specific, productive ways becomes linked to increasing their STEM competency. This was demonstrated in their results, which showed significant difference between intervention and control treatment groups in post-tests in the following measurements: behavior, involvement, connection, concern about school, and the development of balanced possible selves (2002).

**Balanced possible self.**

The obtainment of a balanced possible self comes from the individual’s belief that they can become their perceived hoped-for possible self—i.e. the nature of one’s self-efficacy (Bandura, 1977). Psychologist Albert Bandura coined self-efficacy to explain behavior as affected by one’s perception of their abilities. Bandura would argue that one’s self-efficacy should be aligned with one’s external performance to be considered balanced in one domain.

When an individual analyzes their three perceptions of their future possible selves (hoped-for, expected, and feared), the goal is that they obtain a balanced possible self that is self-regulated. Oysserman and Fryberg defined a balanced possible self as “the construal of both positive expectations and fears in the same domain…Youths with balanced possible selves have both a positive self-identifying goal to strive for and are aware of the personally relevant consequences of not meeting that goal” (2006, p. 4). Simply put, balanced possible selves promote strategies for responsible choices to move away from a feared possible self and move towards a hoped-for possible self.
Balanced possible selves is defined in this *STEM UP* study as the projection of oneself in one central occupation/situation that one is both competent and motivated to obtain. However, there are two crucial factors to consider: environment and developmental stage. I built on Oysserman and Fryberg’s (2006) operationalization of balanced possible selves using Bandura’s (1977) theory of self-efficacy.

Bandura theorized that individuals value what they are good at (similar levels of competency and motivation). However, individuals living in under-served communities may have a higher level of motivation—potentially from a greater amount of resistance capital (Yosso, 2005) than their competency level. In this respect, the mentees themselves would appear to be out of balance, when it is really the world in which they live in that is out of balance.

Additional factors to consider are the mentees developmental stages. Adolescents are in an age group where they are exploring who they are and who they would like to become. Instead of identifying and analyzing their possible selves in one central domain, as Oysserman and Fryberg assert (2006), mentees may explore various futures. Therefore, the balance of one’s possible selves should not be attributed solely to the individual’s experience. Mentees’ hoped-for, expected, and feared possible selves can be in different domains. This is not because the mentees are out of balance, but because they are exploring multiple futures simultaneously. However, mentees who define a balanced possible self demonstrate working towards one central future.

**Mentor instructional model.**

The instructional model of the STEM undergraduate course follows the traditional course model commonly used in higher education: lecture paired with discussion. The program director teaches Monday lecture where the four sections (STEM, Greek, and two traditional) of Project
SOAR meet in one large lecture hall. The four teaching assistants meet with their respective section for Wednesday discussion in smaller classrooms. In addition to the traditional course model, the course features a unique service-learning component called Project SOAR. Through this 100% engagement opportunity, undergraduate mentors work with a small group of middle school mentees on the campus of an under-served middle school. The purpose of this instructional model is to enhance formal academic learning through authentic practice and interaction with middle school mentees.

**Mentee instructional model.**

The mentee instructional model is a cognitive apprenticeship model. Collins defines cognitive apprenticeship as “teaching processes that experts use to handle complex tasks…[and focuses] on cognitive skills and processes, rather than physical ones” (Collins, 2006, p. 48). This model is used because the STEM mentors are expected to act as “experts” in apprenticing the mentees, who act as “novices”. The mentors are “experts” in the sense that they have higher-level STEM content knowledge as well as access to and success in higher education knowledge. The mentees are “novices” in the sense that they are interested in STEM college majors and careers, but have middle school-level STEM content knowledge and access to and success in higher education knowledge. Although the cognitive apprenticeship model focuses on the mentor helping the mentee gain a refined understanding of STEM content knowledge and higher education knowledge, the mentor-mentee relationship becomes bidirectional over the course of a semester, for the mentors and mentees teach and learn from each other.

In relation to STEM, a cognitive apprenticeship model can help STEM-interested mentees refine their knowledge in three ways. First, the mentees’ STEM content knowledge grows through STEM curriculum (STEM mentoring activities). Second, in the possible selves
curriculum (seven possible selves activities) the mentees work with their mentor to learn how to construct and reconstruct their possible selves in relation to STEM majors and careers as needed. Thirdly, the possible selves curriculum provides mentees with an opportunity to explore their current and future interests in STEM. During the possible selves curriculum, the mentees may realize that STEM is not a field they wish to elect into. Therefore, the possible selves curriculum also helps mentees explore their interests outside of STEM majors and careers.

**Curriculum purpose.**

The purpose of the curriculum is to help middle school mentees analyze their future possible selves in STEM college majors and careers. However, this does not mean that the success of this program relies solely on whether mentees express interest in STEM major and career pursuit. On the contrary, the program aims to provide opportunities for mentees to analyze early in their lives if STEM is truly a desirable future. If mentees realize that STEM is not where their passions lie, the mentees can discuss career interests outside of STEM via the possible selves curriculum.

**Curriculum components.**

The curriculum includes three types of mentoring activities: STEM, possible selves, and traditional. The Project SOAR mentoring program does not assume that its STEM mentors have experience in creating lesson plans. Therefore, the Project SOAR program provides a set of STEM activities and their materials for the mentors to use with their mentees. These STEM activities are provided to support the STEM mentors, not to dictate which STEM activities they can select and engage in with their mentees. In fact, mentors are encouraged to implement STEM activities that they participated in and first became excited about the sciences as a middle school student. Many of the current STEM activities are redesigned by former mentors.
Secondly, mentors learn and administer the possible selves activities. There are seven possible selves activities that each mentor is responsible for administering with their mentees. These seven possible selves activities are modified from Oyserman, Terry and Bybee’s *School to Jobs* possible selves curriculum (2002). The goals of the seven possible selves activities include: (1) creating a group to construct a positive sense of STEM membership, and set the stage for school involvement and adult possible selves, (2) examining adult images to create a concrete experience of imagining STEM adulthood, (3) constructing timelines to build the connection between STEM present and future, and to normalize failures and setbacks as part of progress to the future, (4) building possible selves and strategies boards to bridge the connection between current STEM behavior, next year, and adult attainments, (5) solving everyday problems to provide experience breaking down everyday STEM school problems into more manageable parts, (6) solving everyday problems to reinforce mentees’ ability to make STEM-related plans for the future, and the need to reach out to adults to accomplish this, and (7) wrapping up and moving forward to organize experiences so far, and look forward to their future. The mentors have successfully engaged in three of the seven possible selves activities at this point in the semester. They will complete the remaining four possible selves activities in the second half of the semester.

Lastly, mentors engage in traditional mentoring activities. STEM activities can help mentees refine their STEM content knowledge, and possible selves can help mentees draft plans of action to obtain a balanced possible self. However, mentees may benefit from other forms of support. Mentors are provided with a set of traditional mentoring activities that encompass a variety of developmental topics. Traditional mentoring activity topics include: getting to know your mentee, goal setting, academic strengths and learning styles, self-esteem building, skills for
life, career exploration, and closures. Mentors have the freedom to select any traditional activity they want to employ with their mentee. Mentors are responsible for deciding when they implement each of the seven possible selves activities. They are also responsible for determining which STEM and traditional activities they believe their mentees will benefit from.

**Possible selves design principles.**

Although there are three types of mentoring activities, the core of the intervention curriculum is the possible selves activities. Therefore, it is essential to describe the design principles. Possible selves curriculum employs a cognitive apprenticeship model in the mentoring sessions (Collins, 2006). The possible selves curriculum uses traditional apprentice design principles. This method addresses cognitively challenging disciplines in the possible selves mentoring sessions. The design principles of the possible selves curriculum are:

1. Modeling
2. Coaching
3. Scaffolding
4. Articulation
5. Reflection
6. Exploration

When mentors engage in the possible selves activities with their mentees, the mentors first demonstrate a task so that the mentees can observe (modeling). The mentors observe and facilitate their mentees when they attempt to perform a task on their own (coaching). As the mentors progressively provide smaller amounts of support for their mentees to perform a task (scaffolding), the mentors encourage their mentees to verbalize their knowledge and thinking aloud (articulation). Then, the mentors enable their mentees to compare their performance to
others (reflection) and invite them to pose and solve their own problems (exploration).

The possible selves curriculum is designed based on these six principles. The STEM and traditional mentoring activities were not explicitly designed based on these principles. However, the STEM and traditional mentoring activities complement the possible selves curriculum by adding focus in STEM domains and access to and success in higher education.

Collin’s (2006) six traditional apprenticeship design principles are used in the overall curriculum (STEM, possible selves, and traditional mentoring activities) but are not explicitly stated. However, the traditional apprenticeship design principles used in the curriculum resembles design principles from related research, as in the possible selves curriculum in School to Jobs (Oyserman, Terry & Bybee, 2002). The School to Jobs possible selves curriculum’s design principles include: (1) the use of small learning groups with intentionally vague initial prompts encourages constructivist learning, (2) demonstration of STEM undergraduate role models in possible future career fields helps students to visualize positive possible selves, (3) activation of funds of knowledge in activities increases engagement, (4) problem-based instruction later in curriculum (identifying what you want to become, iterating that idea through several sessions) creates opportunities for students to practice the application of in-class techniques to the community, (5) application of knowledge gained in class to a possible selves draft determines the plausibility of obtaining a balanced possible self, and (6) integration of a new possible self into daily environment increases practice and self-efficacy.

**Purpose.**

In today’s Millennial generation, students are often faced with the same question we were asked growing up: what do you want to be? However, modern youth are now expected to provide an answer that describes their future aspirations within the context of higher education.
According to the Council of Economic Adviser’s October 2014 report, “About 61% of adult Millennials have attended college, whereas only 46% of the Baby Boomers did so” (p.3). In regards to STEM college major selection, “the absolute number of majors in these fields has increased over time as college enrollment has expanded” (p.14). While this demonstrates an increase in STEM major college students, it does not explain how students plan to obtain STEM majors and careers. The purpose of this research is to better understand how middle school students from under-served communities plan to obtain a future in STEM college majors and careers.

**Theoretical lens.**

The theoretical lens I used to analyze the measurements of possible selves was an educational psychology (Bruner, 2009) and critical pedagogy lens (Freire, 2000). The possible selves curriculum was in nature psychological—analyzing perceptions of three possible selves. However, I do not believe one can learn effectively without their cultural heritages being embraced and acknowledged as valuable contributions to their learning and engagement within the classroom. Therefore, I used this critical pedagogy lens to analyze the mentees’ possible selves in specific regards to embracing their unique heritages.

**Questions.**

This study poses the research question: How do middle school students plan to obtain future STEM college majors and careers through a possible selves curriculum in a cognitive apprenticeship model? This question was answered through four specific questions. Is there a similarity between self-reported competency and motivation in STEM? Is there a relationship between administrator-reported course grade and administrator-reported attendance? Is there a relationship between each self-reported measure (competency and motivation) and each
administrator-reported measure (course grade and attendance), respectively? What current and future strategies do middle school students demonstrate when planning to obtain a future in STEM?

The purpose of this study was not to assume significant, quantitative improvement in the assessed measurements. On the contrary, the study aimed to investigate how middle school students planned for their futures, regardless of whether or not they elected into a STEM college major and career. Granted, site coordinators selected mentees to be a part of the STEM mentoring program based on the mentees’ self-professed interest in STEM domains. However, through the course of the possible selves curriculum and reflection of their possible selves, the mentees may realize that their future interests may lie within or outside the fields of STEM. Simply put, STEM is provided as a field of interest, but not enforced as the single path to success. Additionally, college is not enforced, but provided as a potential option to plan for a future self that is meaningful for each mentee.

**Dependent variables.**

Measures of motivational constructs like self-efficacy are not all directly measureable. Therefore, it is appropriate to measure individuals’ motivation linked to their competence through self-assessed instruments designed to determine the plausibility of obtaining one’s hoped-for possible self. The self-assessed instruments in this STEM UP study are a survey and plan of action essay that the students write during the treatment.

The survey measured the following self-reported dependent variables: (1) motivation to obtain a STEM college major and career, and (2) competency in current STEM content domains. The plan of action essay measured the following self-reported dependent variables: (1) identification of three types of possible selves, (2) strategies to become one’s hoped-for possible
self and avoid becoming one’s feared possible self (balancing one’s possible selves), (3) requirements to do well in middle school, (4) strategies to solve everyday problems in middle school, (5) requirements to do well in college, and (6) strategies to solve long-term problems in college in order to obtain a STEM career.

In order to assess the validity of the mentees’ self-reported current performance in STEM, there were two administrator-reported dependent variables: (1) STEM course grade, and (2) STEM attendance. Site coordinators reported attendance and course grade in the mentee’s favorite STEM (science or math) class at six site schools.

**Hypotheses.**

There are four hypotheses in this *STEM UP* research. First, I hypothesized that the mentee’s self-reported competency and motivation mean would be approximately equal. I hypothesized this because Bandura believed that “self-motivation…serves as an effective mechanism for cultivating competencies” (Bandura, 1981, p. 1). Therefore, I hypothesized that the mentees’ self-reported competency mean would reflect their motivation mean.

Secondly, I hypothesized that there would be a positive relationship between administrator-reported STEM course grade and attendance means, where the mentees’ course grade would correlate with their increasing attendance means. I hypothesized this because Bandura posited that individuals value what they are good at.

Thirdly, I hypothesized that the mentees’ self-reported competency and motivation means would positively correlate with the administrator-reported STEM course grade and attendance means, respectively. I hypothesized this because previously research has demonstrated that self-reported measurements are closely related to administrator-reported measurements (Cassady, 2001).
Fourthly, I hypothesized that the mentees’ plans of action would demonstrate current and future strategies to overcome obstacles in order to obtain a future in STEM majors and careers. I hypothesized this because I believed the mentees already possessed knowledge of overcoming obstacles based on their lived experiences and that they would build on these strategies to define concrete strategies to obtain a STEM college major and career via discussions with the STEM mentor.

Method

Participants

Pilot study.

In the pilot study semester, I trained 16 STEM mentors. All of the mentors elected a STEM major. These mentors’ STEM majors included biochemistry, biology, chemistry, management information systems, microbiology, molecular and cellular biology, neuroscience and cognitive science, pre-physiology, physiology, psychology, public health, speech, language, and hearing science, and veterinary science.

On average, each mentor worked with two mentees, yielding 45 mentees. This amount of mentees did not achieve sufficient statistical power. Sixty-four mentees were needed to reach sufficient power, which was based on previous experimental studies using possible selves (Oyserman, Terry & Bybee, 2002). Due to the Institutional Review Board, school district, and middle school principal approval process, no data was collected on mentees or their diverse interests, i.e., gender, ethnicity, hobbies, possible selves orientations, etc.

The mentors worked with their mentees at five under-served middle schools. Each of these site schools was previously identified as participant schools in the Project SOAR mentoring program. One of the site schools was Title I public STEM Magnet middle school, one
was a Title I public International Baccalaureate middle school, one was a Title I public middle school, one was a non-profit after school program that housed neighboring Title I middle schools, and one was a charter school that paid for its students’ tuition. At the Project SOAR site schools, “an average of 68% of students qualify for free/reduced lunch, and 90% are non-Anglo, of which the majority (74.7%) are Latina/o” (2013). The students selected from these schools to participate as mentees in Project SOAR had previously voiced interest in the college process and STEM careers to teachers, advisors, or site coordinators. This self-identified interest was reflected in their generally high level of academic achievement and attendance, which was consistent in most mentoring sessions and later confirmed in the full study.

**Full implementation.**

In full implementation semester, I trained 24 STEM mentors. Twenty-one out of the 24 mentors elected into a STEM major. These mentors’ STEM majors included biochemistry, biomedical engineering, industrial engineering, molecular and cellular biology, neuroscience, pharmacy, physiology, psychology, public health, speech, language, and hearing sciences, sports management, and veterinary science. One elected into an education major, and two were undeclared majors who expressed interest in science domains.

On average, each mentor worked with three middle school mentees, yielding 67 mentees. Of the 67 mentees, 65 assented to participate in the *STEM UP* research. However, 21 of the 65 mentees turned in their parent consent forms. Thus, up to 21 mentees were analyzed for each measurement. This amount did not achieve sufficient statistical power based on previous experimental studies using possible selves (Oyserman, Terry & Bybee, 2002).

The mentors worked with their mentees at six middle schools. Two of the site schools were Title I public STEM Magnet middle schools, one was a Title I public bilingual middle
school, two were Title I public middle schools, and one was a charter school that paid for its students’ tuition. Each of these schools had dedicated site coordinators who organized the Project SOAR mentoring program at their school, collaborated with me throughout the semester, and reported the STEM mentees’ attendance and course grade. The site coordinators and the mentors were the backbone of ensuring the success of this study.

**Instruments**

**Pilot study.**

Due to the approval process, no measurements were taken to assess how middle school mentees planned to obtain STEM majors and careers in the pilot study semester. However, the mentors did engage in all seven possible selves activities with their mentees throughout the semester and information on the ease and effectiveness of these activities was used to refine them.

**Full implementation.**

I used four instruments in the full implementation semester. The four instruments were: (1) survey, (2) course grade in mentee’s favorite STEM (science or math) class, (3) attendance in mentee’s favorite STEM (science or math) class, and (4) plan of action essay. The survey and plan of action essay were mentee self-reported measurements. The course grade and attendance were administrator-reported measurements.

The survey measured two mentee self-reported dependent variables (see Appendix A for survey). The first measurement was self-reported competency in STEM. The second measurement was the self-reported motivation in STEM. Each measurement was assessed through three Likert-scale questions (1 being strongly disagree to 5 being strongly agree).

In order to assess the validity of the mentees’ self-reported current performance in
STEM, there were two administrator-reported dependent variables. The first administrator-reported measurement was the mentees’ STEM course grade. Site coordinators reported the course grade in the mentees’ favorite STEM (science or math) class as a letter grade or as a numeric grade. The second administrator-reported measurement was the mentees’ STEM attendance. Site coordinators reported the attendance in the mentees’ favorite STEM (science or math) class as a percentage of days present out of the total school days.

The plan of action essay measured the following self-reported dependent variables: (1) identification of three types of possible selves, (2) strategies to become one’s hoped-for possible self and avoid becoming one’s feared possible self (balancing one’s possible selves), (3) requirements to do well in middle school, (4) strategies to solve everyday problems in middle school, (5) requirements to do well in college, and (6) strategies to solve long-term problems in college in order to obtain a STEM career (see Appendix B for plan of action).

Procedure

Pilot study.

The program director and I began recruitment one semester prior to the pilot study semester. We created a flyer that I posted around campus. Also, we created an email to send to STEM department heads and faculty members, who were asked to forward the email to their STEM undergraduates.

In the pilot study semester, I taught 16 mentors in the weekly discussion section. The mentors first participated in each of the seven possible selves activities with their classmates before implementing the possible selves activities in their mentoring sessions.

Mentors first had to identify their own possible selves and discuss how they planned to balance their possible selves with their classmates. Through collaboration with their peers,
mentors discussed how to help each other’s mentees plan for their futures. This was most effective through role-play. The mentors would engage in each possible selves activity in small groups. One mentor acted as they would in a typical mentoring session (facilitating the activity), and the other mentors assumed the role of the mentees (demonstrating potential challenges in the activity). For example, in the third possible selves activity, mentors discussed helping their mentees identify their three possible selves by building upon their mentees’ values and interests. In the fifth possible selves activity, mentors identified effective mentoring strategies to help their mentees overcome obstacles by discussing the importance of time management or financial aid support offered in college. To help their mentees balance their possible selves, mentors gave each other examples of what they could say to their mentees such as, “provide your mentee with positive reinforcement when they share an experience”, and “work with your mentee to identify external resources for support they can use when the mentoring semester is over”. After the mentors participated in the possible selves activities, they administrated the curriculum to each of their mentees. However, no data was collected in the pilot study due to the approval process.

**Full implementation.**

The recruitment process for the full implementation semester began one semester prior to the study. The flyer was posted around campus and a STEM department head and faculty email was sent out and forwarded to STEM undergraduates. Additionally, the pilot study mentors spoke with their STEM peers, friends, and roommates about the STEM section of Project SOAR as well as their experiences mentoring STEM-interested middle school youth. This boosted the STEM section’s size. Lastly, STEM major undergraduates who were originally enrolled in one of the three other sections (one Greek, two traditional) were asked if they would like to join the STEM section. This was not mandatory, but provided as an option to engage in discussion with
peers who were STEM-focused. The recruitment process was successful and yielded 24 STEM mentors.

In the full implementation semester, I used the same method described above to train 24 mentors in the possible selves curriculum during weekly discussion section: building a community of learners. In addition to learning the possible selves activities and how to effectively implement each one in mentoring sessions, mentors administered and collected the survey and the plan of action essay directly from their mentees in their mentoring sessions. The survey and plan of action essay were administered at the end of two possible selves activities, as outlined in the possible selves curriculum. The site coordinators reported course grades and attendance in each STEM mentee’s favorite STEM (science or math) class directly to me.

**Design**

The design of this study is correlational and qualitative. The two measurements assessed in the survey (self-reported competency and motivation) were quantitatively compared to the administrator-reported course grade and attendance, respectively. This was to determine if self-reported and administrator-reported measurements correlated, and thus determine if the mentees’ perceptions of the measurements were reflected in their performance. To examine how the mentees planned to obtain futures in STEM, I qualitatively analyzed their plan of action essays. This was to identify emerging themes that the mentees presented in their plans to obtain a STEM future.

**Limitations**

Limitations include the necessary nonrandom grouping of the mentees with their STEM mentor, as to capitalize upon mentees’ interest in particular STEM fields. For example, a site coordinator paired a mentee interested in animals with a veterinary science major mentor.
The usage of self-reporting techniques could also threaten internal validity of the data gathered on competency and motivation in STEM. However, I compensated for this limitation by asking site coordinators to report course grade and attendance to compare with the self-reported measures.

There is an existing assumption that influencing mentees can indeed affect STEM competency in a “positive” manner, as opposed to a “negative” manner—i.e., withdrawal from STEM pursuits. As the mentees engage in possible selves and STEM activities, they may realize that their current and future passions do not lie within STEM majors and careers. If I analyzed the plan of action quantitatively, results may appear to produce “negative” future majors and careers simply because mentees’ interests lie outside of STEM domains. Therefore, I chose to analyze the plan of action qualitatively, as to better understand how mentees plan for a future that is meaningful to them, regardless of whether their ambitions lie within or outside of STEM fields.

An additional limitation was highlighted in one of my findings from the pilot study: mentors may falsify their implementation of all seven possible selves activities as well as supplemental STEM activities. There is a threat to the validity of the results when there is a threat to the fidelity of implementation of the curriculum. To address this limitation, I asked mentors in the full implementation semester to create and submit possible selves portfolios that provided documentation of each of their mentees’ possible selves activities.

Analysis

Pilot study.

No data was collected in the pilot study semester. Therefore, no data was available to analyze until the full implementation semester.
Full implementation.

I analyzed the following four instruments: (1) survey, (2) STEM course grade, (3) attendance, and (4) plan of action. In the survey, mentees’ self-reported measurements of competency and motivation were analyzed quantitatively. The administrator-reported STEM course grade and attendance were each analyzed quantitatively through a correlation test. Mentee self-reported competency and motivation from the survey were correlated with the administrator-reported STEM course grade and attendance, respectively. The plan of action was analyzed qualitatively and assessed independent of the three quantitative measurements to determine current and future strategies that mentees reported to plan for their futures in STEM domains.

In the survey, mentees answered six Likert-scale questions (1 being strongly disagree to 5 being strongly agree). Three questions measured mentees’ perceptions about their competency in STEM, and three questions measured mentees’ perceptions about their motivation in STEM. I analyzed 21 mentee surveys. First, I calculated the self-reported competence mean. Next, I calculated the self-reported motivation mean. Then, I converted the self-reported competency mean and self-reported motivation mean into percentages, respectively. Lastly, I compared the two percentages by calculating their difference to determine if they were similar (hypothesis 1).

STEM course grade was analyzed quantitatively. I analyzed 16 of the 21 mentees’ administrator-reported course grades because I was unable to obtain the other five mentees’ administrator-reported course grades. Course grades were reported in one of two forms: a letter grade or a numeric grade. I first converted all of the course grades (letter grade and numeric grade) using a dummy variable (1 being an F to 5 being an A). Then, I calculated the average of the 16 mentees’ administrator-reported course grade on the five-point scale. Lastly, I converted this average to a percentage.
Attendance in the mentees’ STEM class was analyzed quantitatively. I analyzed the same 16 of the 21 mentees’ administrator-reported attendance because I was unable to obtain the other five mentees’ administrator-reported attendance. STEM course grade and attendance were taken from the same 16 mentees. The administrator-reported attendance was reported as a percentage. I calculated the 16 mentees’ mean attendance directly from the percentages.

To determine if there was a positive relationship between administrator-reported STEM course grade and attendance means (hypothesis 2), I used Spearman and Pearson correlations to treat grades as ranks as well as simple quantities, respectively. Correlation coefficients were the same for both forms of analysis.

I ran two separate Pearson correlations to determine if the mentees’ self-reported competency and motivation means positively correlated with the administrator-reported STEM course grade and attendance means, respectively (hypothesis 3). These tests were meant to verify if mentees could accurately report their competency and motivation in STEM in relation to their actual performance.

The plan of action was analyzed qualitatively to analyze themes in how mentees planned for a future in STEM (see Appendix C for example of plan of action with coding). I believed that analyzing the plan of action essay a priori would disservice the middle school students, as if I could know better than the middle school mentees themselves how they should plan for their futures. Therefore, I analyzed the plan of action post hoc for emerging themes that the mentees demonstrated in their writing.

A former Project SOAR mentor taking a one-unit independent study course helped me identify emerging themes in the plan of action that demonstrated knowledge of current and future strategies to obtain a future in STEM (hypothesis 4). We began our identification process by
separately determining emerging themes from the same four plan of action essays (25% of total). The agreeableness subscale consisted of four plans of action essays ($\alpha = .76$). We repeated this analysis process for the next four plans of action essays. The second agreeableness subscale consisted of eight plans of action essays ($\alpha = .82$). Because we reached 82% agreement on the first eight plans of action essays (50% of total), we analyzed emerging themes separately for the remaining 50% of the plan of action essays.

**Results**

**Pilot study.**

Due to the research approval process, I was not able to collect data from middle school mentees in the pilot study semester. During the pilot study, I trained 16 undergraduate STEM mentors in the seven possible selves activities as well as STEM activities. Mentors administered the seven possible selves activities in their mentoring sessions and provided verbal feedback in regards to how their mentees responded to these activities. The majority of the mentors shared that their mentees enjoyed analyzing their possible selves. However, no other evidence was collected.

**Full implementation.**

In the survey, 21 mentees reported their competency and motivation in STEM domains. They had a mean competency in STEM domains of 71.65% ($SD = 14.60\%$). The most frequent competency reported was 72.00% and ranged from 52.00% to 100.00%. The same 21 mentees had a mean motivation in STEM domains of 82.32% ($SD = 9.40\%$). The most frequent motivation reported was 82.32% with a range of 66.00% to 100.00%. On average, the mentees reported a 10.67% greater level of motivation than competency in STEM (hypothesis 1).
Mentees’ actual and self-reported measures were taken from the same pool of $N = 21$ participants to compare as separate, dependent variables. Due to the descriptive nature of this study, all types of measures were collected from a single group, i.e., there is not an independent variable under analysis. Administrators reported 16 of the 21 mentees course grades in their STEM (science or math) class. The mentees had a mean course grade in their STEM class of 67.50% ($SD = 28.00\%$). However, it is important to note that the most frequent course grades were an A and a D, reflecting a bimodal distribution. The course grades ranged from an F to an A. These measurements were not all reported in percentages, requiring the transformation of letter grades into dummy-coded variables for quantitative analysis. Administrators reported the same 16 mentees’ attendance in their STEM (science or math) class. The mentees’ average attendance in their STEM class of 95.69% ($SD = 5.30\%$), but the most frequent attendance was a 100.00%. Attendance ranged from 81.00% to 100.00%.

There was a positive relationship between administrator-reported STEM course grade and attendance means, although it failed to reach significance ($r(14) = 0.33, p = .22$). The sample reflected consistently high attendance and demonstrates a certain level of sample bias when compared to the highly variant course grades, though the correlation indicates that those with higher attendance tended to have higher grades at the trend level (hypothesis 2). The insufficient statistical power of the sample size and the fact that most of the attendance lacked variance (the mode was 100.00%), could have influenced the significance level (see Table 1). This result demonstrates that attending school every day might be associated with better grades, but only to a certain extent. Competency and high performance in STEM is not purely related to attendance.

Both self-reported measures were positively correlated with both administrator-reported measures, respectively (hypothesis 3). First, the mentees’ self-reported competency in STEM
domains ($M = 71.65\%$) was positively correlated with their actual course grade in their STEM (science or math) class ($M = 67.50\%$). The Spearman correlation demonstrated that there was a relationship between self-reported competency and administrator-reported course grade ($r(14) = .51, p = .04$). Additionally, the mentees’ self-reported motivation in STEM domains ($M = 82.32\%$) was also positively correlated with their actual attendance in their STEM class ($M = 95.69\%$), although not at a significant level ($r(14) = .20, p = .46$). Similar issues arise with sample size and the limitations of the relationship with attendance, which was skewed toward 100.00\%.

Table 1

<table>
<thead>
<tr>
<th>Measure 1</th>
<th>Measure 2</th>
<th>$r$</th>
<th>$b$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administrator-reported grade</td>
<td>Administrator-reported attendance</td>
<td>.33</td>
<td>1.24</td>
<td>.22</td>
</tr>
<tr>
<td>Self-reported competency</td>
<td>Administrator-reported grade</td>
<td>.51</td>
<td>1.00</td>
<td>.04*</td>
</tr>
<tr>
<td>Self-reported motivation</td>
<td>Administrator-reported attendance</td>
<td>.20</td>
<td>2.01</td>
<td>.46</td>
</tr>
<tr>
<td>Self-reported competency</td>
<td>Self-reported motivation</td>
<td>.62</td>
<td>0.41</td>
<td>.001*</td>
</tr>
</tbody>
</table>

*These correlations were significant at an $\alpha = .05$ level.

On average mentees reported a higher percentage of motivation to do STEM than competency in STEM. This trend was also demonstrated in the mentees’ actual course grade and attendance, where on average administrators reported a higher percentage of attendance in their STEM class than course grade in their STEM class (see Figure 1). Means on self-reported measures were converted from Likert-scale averages to percentages. Mentees’ administrator-reported course grade in their STEM class was converted from letter grade averages into percentages using dummy variable coding (1 being an F to 5 being an A). Mentees’
administrator-reported attendance in their STEM class is displayed as an average percentage. Error bars represent an average unit of SD.

![Graph showing percentages across different measurements: Self-reported competency, Administrator-reported course grade, Self-reported motivation, Administrator-reported attendance.]

*Figure 1.* Mentees’ self-reported competency and motivation in STEM domains.

In the plan of action essay, the same 16 mentees wrote about planning for their futures in STEM fields (see Table 2) where they were asked to identify their three possible selves. A possible self was determined if a mentee defined a feared possible self. Twelve of the 16 mentees defined a feared possible self. The mentees’ possible selves were then determined if they were related or unrelated. A related possible self was either the same hoped-for and expected possible self or a different hoped-for self and expected possible self. Of the 12 mentees who defined their possible selves, four mentees defined the same hoped-for and expected possible selves, and three
mentees defined different hoped-for and expected possible selves. Unrelated possible selves were defined as unrelated hoped-for and expected possible selves. Five of the 12 mentees who defined possible selves described an unrelated hoped-for and expected possible self. The most reported possible selves were defined as unrelated possible selves, where a feared possible self was defined but their hoped-for and expected possible selves were unrelated ($n = 5$). This demonstrated that mentees imagined an undesirable future, but had difficulty balancing their possible selves around one central future.

Futures were determined if a mentee did not define a feared possible self. Four of the 16 mentees did not define a feared possible self. If a mentee did not define a feared possible self, the mentees’ futures were categorized as integrated or singular. Integrated futures are three desirable futures that are all potentially obtainable. Of the four mentees who defined futures, one defined integrated futures. Integrated futures can be mutually attainable, i.e. acquiring a high-paying job, a car, and a family. Singular futures are three desirable futures, but only one is potentially obtainable, i.e., becoming a doctor, engineer, or salesman. The most frequent future was defined as a singular future, where a feared possible self was not defined and they defined three desirable futures with only one future potentially obtainable. This demonstrated that mentees imagined a variety of futures, but had difficulty imagining types of futures around one central career. The most popular possible selves/futures included a doctor ($n = 5$), engineer ($n = 4$), professional athlete ($n = 3$), and McDonald’s employee ($n = 3$).
When mentees were asked to write about how they would balance their possible selves, mentees described self-improvement or self-maintenance strategies (see Table 3). Mentees typically depicted both self-improvement and self-maintenance strategies. Self-improvement was determined if the mentee described improvement strategies to work towards a desired possible self/future. If a mentee defined self-improvement strategies, mentees’ self-improvement strategies were then determined as abstract or concrete. An abstract self-improvement strategy was a general statement that aimed to improve the mentee’s current situation. Thirteen abstract self-improvement strategies were found in the 16 mentees’ plans of action. A concrete self-improvement strategy was a specific statement that aimed to improve the mentee’s current situation. The most reported self-improvement strategies were concrete ($n = 14$), which demonstrated that the majority of mentees who defined self-improvement strategies described concrete examples of improving themselves to work towards a desired possible self/future.

Self-maintenance was determined if the mentee described strategies to avoid negative life outcomes to work towards a desired possible self/future. If a mentee defined self-maintenance strategies, mentees’ self-maintenance strategies were coded as abstract or concrete. An abstract self-maintenance strategy was a general statement that aimed to avoid a negative life outcome ($n$...
A concrete self-maintenance strategy was a specific statement that aimed to avoid a negative life outcome. The most reported self-maintenance strategies were abstract \((n = 11)\). This demonstrated that the majority of mentees who defined self-maintenance strategies described abstract examples of avoiding negative situations to work towards a desired possible self/future.

<table>
<thead>
<tr>
<th>Major theme</th>
<th>Minor theme</th>
<th>Student</th>
<th>Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-improvement</td>
<td>Abstract</td>
<td>3B</td>
<td>“I will work hard.”</td>
</tr>
<tr>
<td>Self-improvement</td>
<td>Concrete</td>
<td>14A</td>
<td>“Getting good grades.”</td>
</tr>
<tr>
<td>Self-maintenance</td>
<td>Abstract</td>
<td>17B</td>
<td>“Stay focused on what you want to be in life.”</td>
</tr>
<tr>
<td>Self-maintenance</td>
<td>Concrete</td>
<td>1A</td>
<td>“I will not go to juvie/jail.”</td>
</tr>
</tbody>
</table>

When mentees were asked to write about what three requirements were to do well in middle school, they generally described self-discipline requirements (see Table 4). Three self-discipline themes were demonstrated: earn good grades, silence in class, and avoid friends who talk in class. Mentees most often described that a requirement in middle school was earning good grades \((n = 18)\). Mentees elaborated by explaining that earning good grades is typically equated with being silent in class, especially when the teacher is talking \((n = 10)\). Lastly, mentees believed that avoiding their friends who would talk to them during class time would help them earn good grades \((n = 4)\). Mentees perceived middle school success as avoiding classroom collaboration, being silent, and doing well on course assignments to earn good grades.
Table 4

**Self-Discipline in 3 Requirements to Do Well in Middle School**

<table>
<thead>
<tr>
<th>Minor theme</th>
<th>Student</th>
<th>Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earn good grades</td>
<td>18C</td>
<td>“Get good grades.”</td>
</tr>
<tr>
<td>Silence in class</td>
<td>3B</td>
<td>“Listen to the teachers by following the directions and not talking…”</td>
</tr>
<tr>
<td>Avoid friends who talk in class</td>
<td>17C</td>
<td>“Three requirements are not having bad friends, don’t talk in class, having people that don’t talk in class.”</td>
</tr>
</tbody>
</table>

When mentees were asked to write about three strategies to solve everyday problems in middle school, they generally described two strategic domains: individual and social (see Table 5). An individual strategy is determined when a mentee described working towards independence to solve everyday problems in middle school. Three types of individualism were found: intellectual independence, emotional independence, and antisocial commentary. Intellectual independence was determined when a mentee described working towards cognitive independence. Sixteen instances of intellectual independence strategies were found in the 16 mentees’ plans of action. Emotional independence was determined when a mentee described working towards affective independence and wellbeing \( (n = 8) \). Antisocial commentary was determined when a mentee described others as distractions \( (n = 4) \). The most frequent individualism was intellectual independence \( (n = 16) \). This demonstrated that mentees believed independently working on their own cognition was a beneficial strategy to solve everyday problems in middle school.

Social strategies were determined when a mentee described solving everyday problems by working with either their teacher or their peers. Mentees only described working with their teacher in harmony. The most common response, found in nine of 16 plans of action, was teacher harmony strategies indicating that mentees believed that working with their teacher was a
beneficial strategy to overcome everyday problems in middle school. When mentees wrote about working with their peers, they either described peer harmony or peer avoidance. Peer harmony was identified when mentees discussed collaborating with peers to overcome problems like miscommunication in classroom debates in middle school \((n = 7)\). Three peer avoidance strategies were determined when mentees discussed staying away from their peers in order to overcome problems like bullying or distractions in class.

Table 5

*Example Statements of Coding 3 Strategies to Solve Everyday Problems in MS*

<table>
<thead>
<tr>
<th>Major theme</th>
<th>Minor theme</th>
<th>Student</th>
<th>Student Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individualism</td>
<td>Intellectual independence</td>
<td>14A</td>
<td>“Figure out and memorize what I am learning.”</td>
</tr>
<tr>
<td>Individualism</td>
<td>Emotional independence</td>
<td>3C</td>
<td>“Get lots of sleep, take my time cause if I rush them I’m most likely to get everything wrong.”</td>
</tr>
<tr>
<td>Individualism</td>
<td>Antisocial commentary</td>
<td>17C</td>
<td>“Don’t talk to my friends.”</td>
</tr>
<tr>
<td>Social</td>
<td>Teacher harmony</td>
<td>16C</td>
<td>“Tell a teacher if there is a fight, or I will ask questions, try to stay fokest [sic].”</td>
</tr>
<tr>
<td>Social</td>
<td>Peer harmony</td>
<td>6A</td>
<td>“At least once a day there is a problem, like when one student say one thing and the other person misunderstood...I could avoid that happening to me by trying to make myself clear.”</td>
</tr>
<tr>
<td>Social</td>
<td>Peer avoidance</td>
<td>1A</td>
<td>“Ignore bullies and stay out of everyone’s ways.”</td>
</tr>
</tbody>
</table>

When mentees were asked to write about three requirements to do well in college, they generally described instrucitivism requirements (see Table 6). Five themes were demonstrated: individual studying, silence in class, note taking, importance of grades, and punctuality. Mentees most often described studying alone as a central college requirement \((n = 7)\). Mentees believed that they would need to be quiet in college classrooms and elaborated on this by explaining that note taking was a core requirement in college \((n = 5)\). Earning good grades was another requirement described \((n = 4)\). Lastly, mentees said that being on time to class was expected of them in college.
Table 6

*Instructivism in 3 Requirements to Do Well in College*

<table>
<thead>
<tr>
<th>Minor Theme</th>
<th>Student</th>
<th>Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual studying</td>
<td>18B</td>
<td>“Scholarships, study, participate in college.”</td>
</tr>
<tr>
<td>Silence in class</td>
<td>3B</td>
<td>“Don’t talk while learning or using my phone.”</td>
</tr>
<tr>
<td>Note taking</td>
<td>3B</td>
<td>“Write down notes and study for test.”</td>
</tr>
<tr>
<td>Importance of grades</td>
<td>16C</td>
<td>“I will get good grades, stay fokest [sic], do homework.”</td>
</tr>
<tr>
<td>Punctuality</td>
<td>17A</td>
<td>“Not go to class late.”</td>
</tr>
</tbody>
</table>

When mentees were asked to write about strategies to solve long-term problems in college to obtain their STEM career, mentees generally described transferable and nontransferable strategies (see Table 7). A transferable strategy could be transferred from mentees’ formal education to their STEM careers in the long-term. Four transferable strategies were demonstrated in the 16 mentees’ plans of action: responsibility, problem-solving, collaboration, and research skills. Responsibility, described by nine respondents, was found when a mentee described taking responsibility for their own actions or their own consequences. Five problem-solving strategies were found in descriptions of ways to solve issues, while collaboration was determined when mentees described working with others to solve long-term problems \( (n = 5) \). Research skills were determined when mentees described searching for the answer. Two research skills were also found.

Nontransferable strategies were determined when a mentee described strategies that could not be transferred from their formal education to their STEM careers in the long-term. Three nontransferable strategies were demonstrated: dependence on expert, note taking, and silent work. Dependence on an expert was used when a mentee described reliance on the teacher \( (n = 4) \). Note taking was identified when a mentee described solving long-term problems in college.
by taking notes in class \((n = 3)\). Silent work was determined when mentees described completing their work (most often in class) in silence \((n = 2)\). The most frequent nontransferable strategy to solve long-term problems in college to obtain a STEM career was depending on an expert \((n = 4)\).

Table 7

<table>
<thead>
<tr>
<th>Major theme</th>
<th>Minor theme</th>
<th>Student</th>
<th>Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transferable</td>
<td>Responsibility</td>
<td>18C</td>
<td>“Being prepared, learning how to manage money, having my priorities straight.”</td>
</tr>
<tr>
<td>Transferable</td>
<td>Problem solving</td>
<td>17B</td>
<td>“Think of ways to solve your problems in class before you ask.”</td>
</tr>
<tr>
<td>Transferable</td>
<td>Collaboration</td>
<td>6A</td>
<td>“I have to work well with other people.”</td>
</tr>
<tr>
<td>Transferable</td>
<td>Research skills</td>
<td>20A</td>
<td>“Talking to the text to make sense of the problems.”</td>
</tr>
<tr>
<td>Nontransferable</td>
<td>Dependence on an expert</td>
<td>19E</td>
<td>“Show my work, get help, and process of elimination.”</td>
</tr>
<tr>
<td>Nontransferable</td>
<td>Note taking</td>
<td>14A</td>
<td>“Take notes, study, and do not stay up late.”</td>
</tr>
<tr>
<td>Nontransferable</td>
<td>Silent work</td>
<td>17C</td>
<td>“Pay attention, and don’t talk.”</td>
</tr>
</tbody>
</table>

**Discussion**

**Pilot study.**

STEM activities were revised based on mentor feedback provided in their final reflection paper for their experimental education course. I found that STEM lessons which provided clear instructional implementation (step-by-step progressive picture models) and additional resources (video links, mentee handouts, etc.) for mentors from non-education major backgrounds were most popular among mentors and thus were the STEM activities that the mentors implemented the most often with the mentees. Furthermore, I omitted the less effective STEM activities (with open-ended lesson plans) and replaced them with STEM lessons that provided more assistance
for non-education major undergraduates to ensure academically stimulating STEM activities for the mentees.

Observing undergraduates during mentoring sessions was not a part of the Project SOAR program. However, as I grew concerned with the performance of one of my mentors in discussion, I observed the mentors in their mentoring sessions. Although the vast majority of the mentors were successfully implementing the possible selves and STEM activities they reported on their weekly mentoring session timecard log, there was one mentor who falsified their implementation of the curriculum. Therefore, I continued to observe my STEM mentors informally once a month in their mentoring sessions to ensure successful implementation of possible selves and STEM activities. To further ensure successful implementation of possible selves activities, I asked my STEM mentors to create basic possible selves portfolio, which includes evidence of the completion of all seven possible selves activities for each of their mentees.

In the pilot study, I met with each of my mentors at the mid-point of the semester for a 15-minute meeting. I noticed this informal meeting provided mentors with the opportunity to discuss how they were doing in the course, how mentoring sessions were going thus far, potential concerns, how to identify mentor strengths, and areas mentors wished to improve upon in the final half of the semester. This also allowed mentors to continuously reflect on their growth in the second half of the semester. Therefore, I continued to hold mid-semester meetings with the mentors in full implementation semester.

**Full implementation.**

“No matter what, I know I will select a STEM major in college.”
The purpose of the survey was to gain a better insight into how mentees perceived their competency and motivation in STEM domains. My first hypothesis stated that the mentee’s self-reported competency and motivation mean would be approximately equal. The results of the survey showed that this hypothesis was incorrect. The mentees’ self-reported motivation was 10.67% greater than their competency in STEM.

My second hypothesis stated that there would be a positive relationship between administrator-reported STEM course grade and attendance means, where the mentees’ course grade would correlate with their increasing attendance means. The results of the administrator-reported course grade and attendance in the mentees’ STEM class showed that this hypothesis was correct. This correlation was not statistically significant. However, it demonstrated that attendance was maximal and yet their course grades were not increasing at a similar rate.

In comparing the mentees’ self-reported competency and motivation to the administrator-reported course grade and attendance, respectively, my third hypothesis stated that the mentees’ self-reported competency and motivation means would positively correlate with administrator-reported STEM grade and attendance means, respectively. The results of the survey and administrator-reported course grade and attendance showed that this hypothesis was somewhat accurate. Self-reported competency was correlated with their course grades at a significant level, indicating that mentees could accurately report self-assessments of performance. Self-reported motivation and attendance did share a positive relationship, but the correlation was not significant due to the skewedness of the attendance measures. This relationship indicates that motivation can only be correlated with attendance to the extent that all mentees are attending school at high percentages.
The survey demonstrated that mentees typically felt that they were doing better in STEM domains than they actually were in their STEM (science or math) class (4.17% greater). Also, the survey showed that mentees typically felt that they were less motivated in STEM domains than they actually were in attending their STEM class (13.37% less). This revealed that mentees were typically motivated to participate in STEM despite the fact that they were not doing as well in STEM. One of the statements in the survey, “No matter what, I know I will select a STEM major in college”, demonstrates the mentees’ motivation to pursue STEM careers no matter their current performance.

Psychologist Albert Bandura (1993) would argue that individuals value what they are good at. However, with all respect, Bandura was not referring to individuals living in under-served communities. The reason why the mentees were motivated to do something that they were not performing well in is unknown. There are a couple general rationales why this may be. The mentees may frequently attend school because they see school as a source of social mobility, where food is given, education is a means of empowerment, and friendships are formed. Another reason may be because the mentees perceive STEM as an instrument: STEM brings money. Mentees may want to select a STEM future because it seems like a pragmatic choice to obtain economic security. However, these are general speculations that are not proven in this research. I encourage researchers to further explore why mentees elect into STEM college majors and careers.

“Scientist, paleontologist, and I dunno.”

The purpose of the plan of action was to gain a better insight into how middle school youth in under-served communities planned to obtain a future in STEM college majors and careers. The majority of the mentees defined possible selves. However, the mentees typically did
not define a balanced possible self (three possible selves related to one central future). This does not mean that the mentees were “out of balance.” On the contrary, the mentees are in an age group where they are exploring who they are and who they want to become. Narrowing down their possible career into a single domain is not a priority at this point in life. Possible selves helps the mentees explore and plan for various futures that are meaningful. Simply put, the possible selves framework is a planning process.

When mentees identified their possible selves, the majority of the mentees defined a feared possible self. This demonstrated that mentees were aware of the possible negative consequences to their actions. However, the majority of the mentees struggled with identifying a hoped-for and expected possible self that was related in one central domain. The current data is unable to support hypotheses on the causes for these unrelated possible selves. However, based on the age group, I speculate that they are exploring various futures, even though they identified a feared possible self.

Twenty-five percent of the mentees did not define a feared possible self. Instead, the mentees identified a series of singular futures. These singular futures were all desired, but only one future was obtainable. Similar to the mentees who identified a feared possible self, these mentees had difficulty focusing on a single career path.

The most popular possible selves/futures identified included a doctor (5), engineer (4), professional athlete (3), and McDonald’s employee (3). Mentees who hoped to become a doctor described this selection as a means to help people. Selecting an engineering career path was described as a means to earn money. Becoming a professional athlete merged money with intrinsic interest. Mentees were afraid of becoming specifically a McDonald’s employee, and frequently associated working at McDonald’s as a symbol of failure.
One mentee provided an especially interesting response to identifying her possible selves. She defined her possible selves as, “scientist, paleontologist, and I dunno [sic].” Originally, I thought that this mentee defined two futures. However, after reading her supplemental response to the plan of action, the mentee described a desire for someone to help guide her in searching for a meaningful and “practical” career. The mentee explained why she “did not know” her feared possible self:

I would really like some help figuring out what I want to be. It’s a shame that my passions dont [sic] apply to a college life. I dont [sic] think art or music will support my future life. I’d like something that I could do well in and support myself. The consequences if I dont [sic] go would be absolutely disastrous [sic]. It would be quite the conundrum. I just want to figure out my life. Im [sic] confused and I want to be able to say I know what Im [sic] going to do. I’d like to go into the science field. Im [sic] scared for the future but I think it will be a lot easier with some guidance [sic]. I would like to talk about a few of the fields [sic] I could go into. I think SOAR would be a good opportunity to talk about that. I really do appreciate SOAR and Im [sic] glad to get some people with exirience [sic] talking to me abut my future.

Taking an Anti-Deficit Achievement lens (Harper, 2012), this mentee’s explanation showed that the feared possible self that she initially identified (“I dunno”) was really a fear of not being able to select an art or music career for financial reasons. She perceived that they would need to sacrifice their intrinsic interests (art and music) to obtain careers that society attaches prestige to (scientist/paleontologist). What is important to discuss here is that the mentee
also believed that their mentor was an experienced form of support to help guide the mentee in navigating their possible selves.

“I will get good grades…I will not go down the wrong path.”

The mentees did not typically describe how to balance their possible selves. However, mentees did define self-improvement and self-maintenance strategies using concrete and abstract examples. The majority of mentees described concrete self-improvement strategies, such as “I will get good grades” in their STEM classes. However, self-maintenance strategies were described primarily as abstract, such as “I will not going down the wrong path.” These common responses demonstrate how the mentees specifically plan to improve themselves and prepare for their academic futures, but they struggled to describe concrete ways to avoid becoming their feared possible self. While it is beneficial that mentees understand the steps they need to take to succeed academically, they may benefit from additional support in discussing the factors that can negatively influence their educational attainment.

“Listen to the teacher…do all my work…avoid playing around with my friends.”

When mentees were asked what the three requirements were to do well in middle school, mentees frequently defined self-discipline requirements. The three most frequent self-discipline requirements were: earn good grades, silence in class, and avoid friends who talk in class. Mentees most often reported earning good grades was a requirement. The major prerequisite that the mentees perceived to obtain good grades was to be silent during class. They described being able to be silent during class and listen to their teacher by avoiding their friends. While earning good grades is important at any level of education, the mentees’ perception of silence and avoiding collaboration is problematic. In college and real-world professional settings, especially in STEM domains, verbal discourse and collaboration is key to the learning process.
Additionally, quantitative assessments become less of the main focus. For example, when a doctor operates on a patient in the emergency room, they do not work in silence or in absence of a medical team. The patient is not a “multiple-choice test”. Educators should design learning environments that emphasize the importance of collaboration and enhance problem-solving abilities that are transferable to the real world.

“Focus on the lesson and not other people.”

My fourth hypothesis stated that the mentees’ plans of action would demonstrate current and future strategies to overcome obstacles in order to obtain a future in STEM majors and careers. When mentees were asked about strategies to solve everyday problems in middle school, they frequently defined six strategies within two domains: individual and social. The two most frequently defined strategies were intellectual independence and teacher harmony. Mentees often described independent study and memorization as a method to solve everyday problems. However, only one mentee defined a common problem in middle school. The mentee wrote, “At least once a day there is one problem, like when one student say [sic] one thing and the other person misunderstood, and now they’re having a huge argument.”

The majority (n = 9) of the mentees focused on strategies to improve through academics by working in harmony with their teacher. While focusing “on the lesson and not other people [peers/friends]” is perceived to be beneficial to improve the mentees’ grades, teacher dependence can be problematic in the real world. In specific regards to STEM occupations, STEM employees are expected to create new knowledge. This is typically accomplished through collaboration of experts, but not dependence. The mentees, and STEM employees, certainly benefit from expert guidance. However, self-regulated learning is an important skill in the process of building new knowledge.
“Be a better note taker; write down notes; take good notes.”

Mentees generally described instructivist requirements when asked what three requirements were to do well in college. The most frequent college requirement defined was studying independently. The main way mentees described preparing to study was by taking good notes in class. This was a prominent theme in nearly every plan of action. This demonstrated that mentees believed that college would expect them to study alone—in absence of collaborating with their peers—using their notes. Taking notes and quietly listening to a lecture is the typical model seen in higher education. It is no surprise that this is the image of university learning that these mentees are preparing for. This conception reflects a long-standing need for researchers and policy makers to recast the university learning environment with teaching methods that prepare scholars for the 21st century.

“I have to always be prepared for everything.”

When mentees were asked to write about strategies to solve long-term problems in college to obtain their STEM career, mentees generally described transferable and nontransferable strategies. The most frequent transferable strategy to solve long-term problems in college to obtain their STEM career was responsibility. Mentees typically described responsibility with general examples, such as, “I have to be prepared for everything.” While mentees believed holding themselves accountable for their own choices and actions was a beneficial strategy to obtain their STEM career, unfortunately long-term problems are not always within one’s control. Therefore, adapting skills from the educational setting to real life problems is important to consider and reflect upon.

Certain skills that are learned in formal education settings are not always transferable to the real world. The most frequent nontransferable strategy to solve long-term problems in college
to obtain a STEM career was depending on an expert. This demonstrated that mentees believed that their teacher was a beneficial source to overcome long-term problems. Unfortunately, the teacher cannot be relied upon post-graduation as a source of immediate guidance in STEM domains. Asking co-workers and bosses questions can help a new professional, but striving to become an expert in a STEM field requires that one develop more transferable forms of knowledge schema. Developing new knowledge and innovations requires one becoming an expert themselves. Scaffolding guidance to help the mentees become self-sufficient is another important skill in the 21st century.

There was one interesting response to solving long-term problems in college. One mentee stated, “Go to the library before that day we start long-term problems and find a bunch of math books and read them all.” This may demonstrate the mentees’ mental associations between textbook knowledge and real world problem solving.

**Future research.**

Both the everyday and long-term strategies in the plans of action helped to support my fourth hypothesis: the mentees’ plans of action would demonstrate current and future strategies to overcome obstacles in order to obtain a future in STEM majors and careers. Although these four hypotheses were investigated in this study, certain questions emerged from my analysis.

Some of these questions were due to the limitations that arose during the course of the study. Out of the 67 mentees who assented to participate in this study, 21 mentees turned in their parent permission form. Sample size could be improved in future research by allotting a greater amount of time for the mentees to turn in their parent permission forms. Another limitation was the timing of data collection. The course grades and attendance were reported at differing times throughout the semester. Future researchers should consider controlling for time when collecting
data. Identifying which STEM class (science or math) the grades and attendance were reported from was another limitation. Due to the workload of the administrators, I was unable to determine which STEM class the data was based on. All course grades were converted to letter grades for consistency during quantitative analysis. In order to calculate more precise measurements, researchers should do their best to calculate means from raw percentages opposed to letter coding. Lastly, course attendance was reported as a numerical value. However, it is unknown if the attendance percentage came from the mentees’ STEM course or from the entire school day. To minimize error, researchers should collaborate closely with the site schools.

Lastly, because it took one full semester to obtain consent from the University of Arizona Institutional Review Board, district approval, and middle school principal permission, I intend to plan for the approval process in the Spring 2016 semester for a mixed methods design of *STEM UP* in the Fall 2016 semester. The mixed methods design will build upon the quantitative design of *STEM UP* by incorporating mentee mapping (drawn responses) for interview discussions. This specific employment of drawn responses in regards to the mentees’ possible selves is due to my upbringing in the same under-served communities as the mentees. The intent of this design is to make the familiar demographic strange to myself to avoid potential assumptions of growing up in under-served communities (Mannay, 2010). I hope to further analyze not only how mentees plan for a future in STEM, but why they select a STEM possible self.

As stated earlier, researchers studying education in under-served communities should work towards adding “fire to the already-burning flame that they have” (Birdman, 2015, p. 1). This *STEM UP* study demonstrated that middle school youth already possess the capability and the skills to plan for their possible futures. The next step in this field of research is critical, as
scholars seek to establish the mechanisms underlying middle school students’ career selection, and the role that STEM plays as a factor in that selection.

How do the industries influence students from under-served communities to see STEM domains as methods to make money, rather than contribute to society? What are the primary factors contributing to decisions about career selection when balancing one’s possible selves?

This study found that there is a qualitative link between financial gain and STEM careers in the participants’ perceptions, which are reflective of the aims of governmental, educational, and private institutions that seek to encourage STEM pursuits in low-income communities as a method of social mobility. The current research cannot prove the existence of a correlational or causal relationship between socioeconomic status and perceptions of the utility of a STEM profession. However, addressing this connection and the questions raised above in my future research involves the deeper use of interviews and document analysis to establish the perspectives of the middle school students, and larger sample populations for the use of inferential statistics. These multiple methods of analysis in future studies have the potential to bring under-served communities further into critical discourse on their possible futures, giving their students an additional voice in determining the careers that they wish to pursue. In the end, researchers should continue to refine their methods of support for middle school scholars to plan for their possible selves. They should “Just enjoy it!”
References


Appendix A

Survey

Directions: The purpose of this survey is to collect information about why middle school students are interested in science, technology, engineering, and mathematics fields (STEM). There are three sections of this survey. Please respond to each question completely and honestly in the spaces provided. You have the right to stop at any time and not answer a question. The information you provide will be used for graduate research at the University of Arizona. If you have further concerns or questions, please contact Kyla Kemp at kylak@email.arizona.edu.

Section I:

Directions: Please circle one number that best describes the way you feel in the following questions, where 1 is to strongly disagree, 2 is to agree, 3 is to be neutral, 4 is to agree, and 5 is to strongly agree:

**STEM: Your Science, Technology, Engineering, or Mathematics Class**

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Earning good grades is important to me.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>2.</td>
<td>I feel confident when I take a STEM test.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>3.</td>
<td>My classmates often ask me for help in STEM classes.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4.</td>
<td>I look forward to going to my STEM classes.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5.</td>
<td>No matter what, I know I will select a STEM major in college.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>6.</td>
<td>I rarely need help with STEM homework.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>
Appendix B

Plan of Action

Directions: How do you plan to obtain your STEM Possible Self? Please write in complete sentences to describe each of the six questions listed below to describe your STEM plan of action.

STEM: Your Science, Technology, Engineering, or Mathematics Middle School Class, College Major, and Future Career

1. What are your three Possible Selves?
2. How will you become what you want to become and avoid becoming what you are afraid of becoming?
3. What are three requirements of you to do well in middle school?
4. What are three strategies you will do to solve everyday problems in middle school?
5. What are three requirements of you to do well in college?
6. What are three strategies you will do to solve long-term problems in college to obtain your STEM career?
Appendix C

Example of Plan of Action with Coding

One mentee’s plan of action is provided below. For each question, coded major themes are in **bold** and minor themes are *italicized*.

What are my three possible selves? I am thinking about becoming a doctor. I want to be a doctor because I love helping people. I am also thinking about becoming a vet. I really want to be a vet because I love animals, and because I enjoy helping animals feel better. My third possible self is an engineer. I am not sure about what type of engineer I want to be yet. One of the reasons I want to become an engineer is because they earn a lot of money, and because engineers apply the principals [sic] of science and mathematics to develop economical solutions to technical problem (**futures, three singular futures of which three are STEM-related**).

How will I become what I want to become and avoid of what you are afraid of becoming? I am afraid of becoming a failure. I am afraid of failing everyone’s expectations. Those are the two things that I am afraid of becoming, so I will do everything I can so that I don’t become a failure. Some things I can do to prevent that are go to the university, get a job, and don’t mess around (**self-improvement, three abstract ways to approach one of their desired futures**).

What are the three requirements of you to do well in middle school? In middle school I have a lot of requirements if I want to do well. I have to listen to the teacher (**self-discipline, be quiet when teacher is talking**). I have to do all of my classwork and all my homework (**self-discipline, earn good grade**), and I have to avoid playing around with my friends when I should be listening to the teacher (**self-discipline, avoid having friends who talk in class**).
What are three strategies I will do to solve everyday problems in middle school? Well for starters I have to say what the everyday problems are in middle school. At least once a day there is one problem, like when one student say [sic] one thing and the other person misunderstood, and now they’re having a huge argument. Some things I can do to avoid that happening to me are by trying to make myself clear (social, peer harmony), and if it’s to [sic] loud to say anything I can always wait until after class to tell them (social, peer harmony). The third strategy I use is when someone says something mean to me I just ignore them and move on (individual, emotional independence).

What are three requirements I have to do to do well in college? If I want to do well in college [sic] I have to pay attention in all my classes (instructivism, be silent in class). I have to take good notes (instructivism, take good notes), and I have to come prepared everyday. If I don’t follow these requirements then I won’t do well in the university. If I want to get a job and be stable enough to raise a family I have to do well in the university.

What are three strategies I will do to solve long-term problems in college [sic] to obtain your STEM career. If I want to obtain my STEM career, I am going to have to solve a lot of long-term problems (transferable, problem solving). I have to always be prepared for everything (transferable, responsibility). I have to work well with other people (transferable, collaboration), and I have to always be open minded [sic].