Motivationally-informed interventions for at-risk STEM students

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Abstract

Researchers have confirmed that students' motivation is one of the most important factors educators can target to improve learning (Williams & Williams, 2011). This study explored the role which student's motivation played in the retention of first-time, full-time freshman (FTFTF) STEM majors at Middle Tennessee State University (MTSU). Student motivational assessment was used to inform interventions for improving their college success. The research included 36 participants in a program at MTSU, called FirstSTEP. FirstSTEP is designed to improve the mathematics success of FTFTF STEM majors with Math ACT sub-scores of 19-23, which are mostly below the ACT benchmark for college readiness in mathematics. ACT's data suggests that students must have a Math ACT of 22 or higher to have a 75% chance to earn an A, B or C in college algebra (ACT, 2015) The FirstSTEP program focuses on mathematics preparation as an initial step in helping STEM majors improve their success in college. Participants start the program before their freshman year by attending a two-week Mathematics Summer Bridge (MSB), which refreshes students' algebra skills needed for precalculus, demonstrates connections between science and mathematics, and introduces them to components of college life. During the MSB, the students' motivation for success in their STEM major was assessed using the Science Motivation Questionnaire II (SMQ-II) authored by Glynn et al. (2011). The SMQ-II measures students' motivation on five levels: intrinsic motivation, self-efficacy, self-determination, grade motivation, and career motivation. The students' motivation scores were compared by race and gender. The participants' SMQ-II scores were compared to the scores of students in the Glynn et al. (2011) study. The FirstSTEP participants scored higher than the science majors in Glynn's research in all levels of motivation except for self-determination. To further understand how our students' self-determination perceptions related to their success in their chosen STEM majors, an instrument known as the Digital Metaphor (Rowlett, 2013) was used. Additionally, the participants' progress in their STEM majors was monitored and compared to that of a matched control group. Based on their precalculus semester grades, FirstSTEP participants were successful at a higher rate than a matched control group (81% to 73%, respectively). The freshman to sophomore STEM retention rate of FirstSTEP students was 48% compared to 34% in the control group. FirstSTEP participants, who were provided with additional academic and motivational support, had higher grade point averages, better grades in precalculus, and higher freshman to sophomore retention rates in their STEM major.

Introduction

Science, technology, engineering, and mathematics (STEM) play a vital role in our everyday life and exert a significant impact on the economy and the health of society (e.g., Bybee, 2010; Wang, 2013). However, according to the President's Council of Advisors on Science and Technology (PCAST, 2010), the performance of U.S. students on science and mathematics tests is consistently below the international average. The Organization for Economic Co-operation and Development (OECD, 2012) reported that among 34 countries, U.S. students performed below average in mathematics. Similarly, results from the Program for International Student Assessment (PISA) indicated that for 15-year-old U.S. students, the mathematics performance rankings declined from 25th in 2009 to 27th in 2012. Hossain and Robinson (2012) indicate that high school students show an extremely low level of interest for participating in STEM-related academics, and in contrast, many students show higher interest in arts, businesses, literatures, and entertainment-related careers.

Despite students' lack of interest in STEM careers, there is a significant need for more workers in the STEM fields. The PCAST (2012) policy report indicated that if the U.S. is to maintain its competitiveness in science and technology, it will need to produce one million more STEM specialists over the next decade than the current projections. Furthermore, researchers have indicated that approximately 40 percent of college students majoring in STEM fields, especially underrepresented minorities and women, end up switching to other subjects or fail to acquire any degree (e.g., Chen & Soldner, 2013; Peterson et al., 2011). According to the National Academy of Engineering, the first year of college is a crucial year and can indicate whether or not students will be successful in college (NAE, 2005). Chen and Soldner (2013), in a report to the U.S. Department of Education, pointed out that the performance of students in their first year of college established the tone for the following years. Hence, for educators, the big challenge is how to keep STEM majors motivated and successful during the crucial early years of college.

At MTSU, STEM fields include all majors in biology, chemistry, computer science, engineering, geosciences, mathematics, and physics/astronomy. Recognizing the importance of mathematics for STEM majors, many of these majors require at least one semester of calculus. Our research, similar to other reports (Sadler et al, 2007; Tia et al, 2005; Wilson and Shrock, 2001), has found that mathematics is a main factor in predicting success in STEM. According to the ACT College and Career Readiness Standards, students with Math ACT subscores of less than 22 have only a 25% chance of passing college algebra with a grade of C or better (ACT, 2015). Students majoring in STEM at MTSU, frequently take precalculus as their first mathematics course. The historical passing rate, obtaining grade C or better, for precalculus course at MTSU is around 64% (personal communication from Mathematics Department Chair at MTSU, 2014). Concerned about low success rates among STEM majors who are underprepared in mathematics, a group of faculty at MTSU developed a program called "Mathematics as a FirstSTEP to success in STEM" (FirstSTEP), which receives support from the National Science Foundation as a STEM Talent Expansion Program (STEP) project. The project team, which was committed to excellence in promoting mathematics teaching and learning, included faculty at MTSU such as: the Dean of the College of Basic and Applied Sciences who has taught mathematics and computer science for almost 40 years and has been the recipient of two awards from different universities including one for outstanding teacher and the other for innovative excellence in teaching, learning and technology; the Chair of the Department of Mathematical Sciences, who has taught mathematics for over 30 years; the Interim Director of the Mathematics and Science Education PhD program, who has taught mathematics and statistics for 20 years; a mathematics educator and a mathematics researcher both of whom had taught precalculus and calculus for 30 years combined. FirstSTEP concentrates on a combination of interventions designed to help students overcome mathematical deficiencies which can place freshmen at risk of not graduating in STEM. This program begins with a two-week Mathematics Summer Bridge with intensive mathematics instruction in a supportive setting prior to the students' first fall semester at MTSU. Even with the two weeks of intense summer mathematics instruction, support is still needed for FirstSTEP participants during the academic year. This is not surprising since all FirstSTEP participants have Math ACT subscores of 19 -23 and they take precalculus during their first semester of college. During the academic year, the FirstSTEP program offers support including mathematics tutoring, intrusive academic advising, study-skills, and college-life skills. In the summer after their first year at MTSU, the FirstSTEP students participate in a rigorous three-week, team-based, pre-research experience. The FirstSTEP program strives to help students improve their mastery of mathematical abilities and maintain high STEM retention during their first two years of college education to provide these students with a strong foundation for continued success and retention in STEM.

Research Methodology

Participants

Participants were First Time Full Time Freshman (FTFTF) STEM majors with Math ACT subscores of 19-23, inclusive, who had completed the admissions process and planned to enroll at MTSU in the upcoming Fall semester (2013-2014). The average Math ACT score of this group was 21. This cohort was the fourth group participating in the FirstSTEP program and had the following demographics: 13 (36%) female, 23 (64%) male, 13 (36%) African-American, and 23 (64%) white students.

Recruitment

In April 2013, the students accepted to MTSU for the Fall 2013 semester as FTFTF STEM majors with a Math ACT score of 19 to 23, inclusively, received information about the FirstSTEP program through the U.S. mail. The information was intentionally addressed to both the students and their parents. Approximately 400 families received an invitation to apply and about half of these students eventually enrolled at MTSU. Additional recruitment occurred at MTSU's spring and early summer orientation sessions. In total, 10% (40) of the eligible participants applied and were accepted. Without targeted recruitment efforts, the project team consistently recruited African-American participants at a higher rate (39%, Fall 2013) than the African American enrollment of all STEM majors at the MTSU (22%, Fall 2013).

An important distinction of FirstSTEP students is that they self-selected to participate in this program. There are several reasons why students may or may not elect to participate in FirstSTEP. From phone interviews, the project team learned that the most common reasons for not applying for the program included summer jobs, family responsibilities, and students' decisions to enroll in a different college. Over the years of working with this project, many of the students have reported that they participated in FirstSTEP because of their awareness that they are underprepared in mathematics. Their self-selection to participate in FirstSTEP could indicate either the participants' potential motivation to be successful or that of their parents. We also believe that each year a few of the students are ultimately motivated to join the program because small student stipends are given out when a component of the program is successfully completed.

The control group included the 85 FTFTF STEM majors with Math ACT subscores of 19-23 who took precalculus in the Fall 2013 at MTSU but *did not* apply to FirstSTEP.

Process

The participants took part in four assessments associated with FirstSTEP during their freshman year in the Summer and Fall of 2013: precalculus readiness pre- and post-tests, a motivation assessment called Science Motivation Questionnaire II (SMQ-II), a digital metaphor assignment, and precalculus final grade. The students confirmed their voluntary participation to help the project team improve education by signing the informed consent forms according to MTSU's guidelines. A description of each of the assessments follows.

Pre and Post precalculus Readiness Tests

A two-week Mathematics Summer Bridge (MSB) is one of the major components of the FirstSTEP program. The MSB program focuses on improving the students' mathematical abilities, study habits, and problem solving skills as well as life and college skills. On the first day of the MSB, the project team administered a pre-test to measure the participants' readiness to take MTSU's precalculus course. This evaluation created by a FirstSTEP project team member in collaboration with the rest of the team members, was conducted using an online assessment system called Pearson's MyMath Test. The pre-test consisted of 27 multiple choice questions covering important algebra topics such as: operations with rational and radical expressions, factoring polynomials; solving linear, quadratic, rational, and radical equations. Furthermore, this assessment examined a combination of student's conceptual understanding, computational abilities, and problem solving skills.

Upon completing the pre-test, each participant received an electronic individualized study plan within the MyMath Test system which contained practice problems specifically selected for each student based on problems they missed on the pre-test. The individualized study plans also included written instructions for solving each math problem that the students were assigned. Besides using MyMath Test individualized electronic practice problems, the participants also received instruction from a college professor on selected algebra topics which had been identified as challenging for precalculus students. In order to prepare students for the college experience, the professor lectured in the same manner that he did for his college classes. The topics of these lectures included factoring polynomials, simplifying and completing operations with rational expressions, interpreting, solving and applying linear, quadratic, and rational equations.

On the last day of the two-week MSB, the participants took a corresponding post-test. The average difference between the pre-test and the post-test scores was one of the indicators that signified the impact of the MSB on FirstSTEP students.

Science Motivation Questionnaire II (SMQ-II)

Bandura's (1986, 2001, 2006) social cognitive theory explains that the most effective student learning occurs when it is self-regulated. In this theory, learning takes place when learners comprehend, monitor, and control their motivation and behaviors to achieve their learning goals. Moreover, in social cognitive theory, motivation is described as "an internal state that arouses, directs, and sustains goal-oriented behavior" (Glynn et al., 2011, p.1160). Researchers have found that motivated students become successful academically by exploring, posing questions, asking for advice, being active, and contributing in classes and labs (Glynn et al., 2011; Schunk, Pintrich, & Meece, 2008).

To gain a better understanding of the FirstSTEP participant's motivation, the Science Motivation Questionnaire II (SMQ-II) survey was administered on the first day of the Mathematics Summer Bridge (MSB). This survey, which is authored by Glynn et al. (2011), attempts to measure students' motivation to learn science by examining their answers to key questions involving why students make great efforts to learn science, their feelings during the learning experiences, and the intensity and duration of their perseverance. This questionnaire consists of the five following components, where each motivation component has been defined by Glynn et al. (2011) as it relates to learning science.

- *Intrinsic motivation* - the innate pleasure of learning science simply for the sake of learning science.
- *Self-efficacy* – an individual's confidence in his/her ability to learn science well.
- *Self-determination* - an individual's belief in his/her personal control over learning science.
- *Grade motivation* - an extrinsic motivation for learning science in order to achieve good grades.
- *Career motivation* - an extrinsic motivation for learning science in order to secure a good career.

The participants responded to the survey questions via computer, without knowing the category of the questions. This instrument contained 25 items, 5 items from each component, using a 5-point Likert scale (0- 4 points for each item). Therefore, the total points obtained from each component were 0-20 points.

Originally designed as a science motivation questionnaire, Glynn et al. (2011) also found evidence for using versions substituting the word biology, chemistry, or mathematics for the word *science* in the questionnaire without negatively influencing the validity of the instrument. For this research the SMQ-II was modified (with permission and approval from Glynn) so that for every participant, the word science in the instructions and in each item was replaced by his/her STEM major (i.e., biology, chemistry, computer science, engineering technology, mathematics, and physics/astronomy). This questionnaire is shown in Table 1. Our major objective was to use this evaluation to plan and implement effective interventions to enhance and improve the students' motivation toward their STEM majors and consequently increase their retention rate.

Digital Metaphor

To further understand the motivational feelings of our students, especially their self-determination in being successful in their STEM majors, another assessment, called *digital metaphor* (Rowlett, 2013), was used in this study. It is believed by many that a picture or an image can tell a story just as well as an eloquently written text. Furthermore, metaphors allow individuals to communicate things they see, hear, and feel as they imagine them (Lawley & Tompkins, 2000). Taylor (1984) emphasizes the use of metaphors as a research tool in offering exceptional awareness into individuals' self-perceptions.

The participants in this study were asked to use a picture, taken by cell phone or from online sources such as Google images, to represent a metaphor for their reaction to the following statement: *"When I think about my determination about being successful in my STEM major, I am reminded of . . . ."* They were also asked to write a paragraph describing how the photo was related to that statement, underlining all the words they thought were the most important.

Precalculus Final Grades

Data were collected for a matched comparison group of FTFTF STEM majors with Math ACT subscores of 19-23 who registered for precalculus in their first semester during Fall 2013 at MTSU and did not participate in the FirstSTEP Program. The FirstSTEP students benefited from participation in a two-week MSB, a one credit-hour precalculus/college life seminar in the fall, and required tutoring attendance to improve their mathematical abilities while the control group did not. At the end of the semester, final grades of the participants and the control group were compared.

Science Motivation Questionnaire II (SMQ-II)

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In order to better understand what you think and how you feel about your science courses, please respond to each of the following statements from the perspective of "When I am in a science course…"

Statements	Never 0	Rarely 1	Sometimes 2	Often 3	Always 4
01. The science I learn is relevant to my life.					
02. I like to do better than other students on science tests.					
03. Learning science is interesting.					
04. Getting a good science grade is important to me.					
05. I put enough effort into learning science.					
06. I use strategies to learn science well.					
07. Learning science will help me get a good job.					
08. It is important that I get an "A" in science.					
09. I am confident I will do well on science tests.					
10. Knowing science will give me a career advantage.					
11. I spend a lot of time learning science.					
12. Learning science makes my life more meaningful.					
13. Understanding science will benefit me in my career.					
14. I am confident I will do well on science labs and projects.					
15. I believe I can master science knowledge and skills.					
16. I prepare well for science tests and labs.					
17. I am curious about discoveries in science.					
18. I believe I can earn a grade of "A" in science.					
19. I enjoy learning science.					
20. I think about the grade I will get in science.					
21. I am sure I can understand science.					
22. I study hard to learn science.					
23. My career will involve science.					
24. Scoring high on science tests and labs matters to me.					
25. I will use science problem-solving skills in my career.					

Note. The SMQ-II is copyrighted and registered. Go to **http://www.coe.uga.edu/smq/** for permission and directions to use it and its discipline-specific versions such as the Biology Motivation Questionnaire II (BMQ-II), Chemistry Motivation Questionnaire II (CMQ-II), and Physics Motivation Questionnaire II (PMQ-II) in which the words *biology*, *chemistry*, and *physics* are respectively substituted for the word *science*. Versions in other languages are also available.

Table 1. Science Motivation Questionnaire II

Results and Discussion

Precalculus Readiness Pre and Post Tests

The *Statistical Program for the Social Sciences,* version 20 (SPSS, 2011) was used to analyze the data gathered in this study. The Precalculus Readiness Test given at the beginning and end of the MSB had a maximum possible score of 100 points. The average pre-test score for the 36 participants was 20.55 ± 9.07 compared with their average post-test score of 48.67 ± 14.39, with a difference of 28.12 ± 5.32. Examining the results revealed a mean difference (post minus-pre) for white female students (36.05 ± 7.22) was the highest increase across gender and race. This improvement was 30.20 ± 10.01 among African-American female students, 26.48 ± 13.09 among white male students, and 22.42 ± 11.21 among African-American male students. Overall, female students improved more than male students on the precalculus readiness post-test as compared to the pre-test.

Science Motivation Questionnaire II (SMQ-II)

Using the SMQ-II survey (Glynn et al., 2011) and SPSS, we examined the motivation attitudes of our FirstSTEP students towards their STEM majors, overall and across gender and race. The mean of the total motivation scores was 78.9 points out of 100 with a standard deviation of 9.1. The average scores for each motivation component for the 36 participants are shown in Figure 1. Motivation components were compared based on gender in Table 2 and based on race in Table 3.

The Shapiro-Wilk Test indicated that the assumption of normality was met for total motivation ($p=0.06$), instrinsic motivation ($p=0.16$), self-efficacy ($p=0.17$), and self-determination ($p=0.51$). Grade motivation ($p<0.001$) and career motivation ($p<0.001$) failed to meet the assumption of normality. These results were consistent across gender and race.

The results from *the independent samples t-test* indicated that African-American students scored significantly higher than white students on total motivation ($t(34) = 2.53$, $p = 0.016$). African-American students also scored

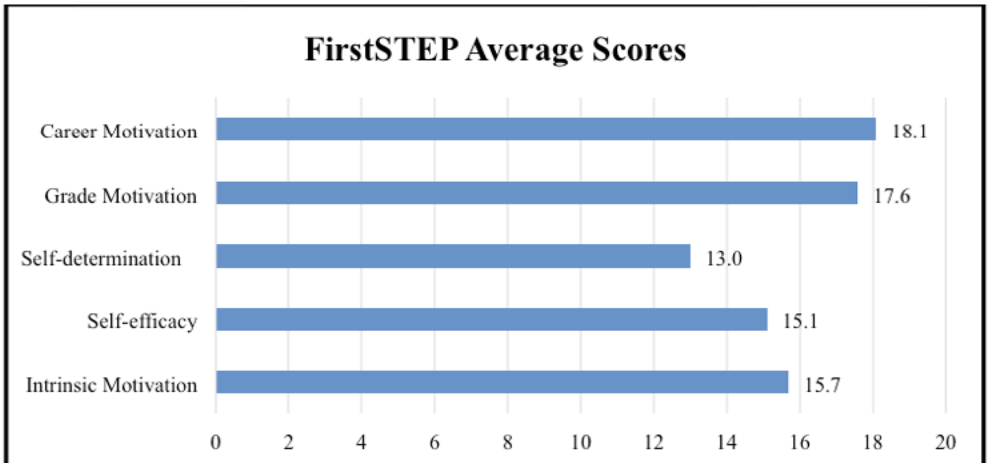

Figure 1. Average score of the motivation components for FirstSTEP participants

Note: The maximum possible point for each category is 20.

significantly higher than white students in self-efficacy (t (34) = 3.84, p = 0.001). Self-determination scores of African-American students were marginally higher than white students (t (34) = 1.96, p = 0.058.) To compare motivation components for male and female participants, the independent samples t-test was conducted and showed that there was no significant difference in mean scores across gender.

The scores on five motivation components of our FirstSTEP STEM major participants were also compared to the scores of science major students in the Glynn et al. (2011) study. The participants in Glynn study included 367 undergraduate science majors at a public university in the southern United States. The participants volunteered from two large-enrollment lecture classrooms, each class having up to 300 students. The incentive for participating in the study was earning extra credit. The percentages of the participants in Glynn's study, which were similar to those of their university population, were 65% women, 35% men, 7% African American, 3.1% Hispanic or Latino, 0.6% Multiracial, and 0.2% Native American. Many students did not volunteer to participate in the study for various reasons including lack of time, schedule conflict, or simply because they forgot.

	Gender			
	Female N = 13		Male N = 23	
Motivation Scores	Mean	SD	Mean	SD
Intrinsic motivation	15.46	3.26	15.87	2.49
Self-efficacy	15.54	3.91	14.78	2.43
Self-determination	13.77	2.65	12.52	2.27
Grade motivation	18.54	2.30	17.00	2.54
Career motivation	18.38	2.14	18.00	1.86
Total motivation	80.15	10.70	78.17	8.14

Table 2. A comparison of motivation components based on gender

	Race			
	African-American N = 13		White N = 23	
Motivation Scores	Mean	SD	Mean	SD
Intrinsic motivation	16.23	1.92	15.44	3.13
Self-efficacy	17.23	1.96	13.83	2.82
Self-determination	14.00	2.35	12.39	2.37
Grade motivation	18.85	1.14	16.83	2.82
Career motivation	18.85	1.46	17.74	2.09
Total motivation	83.62	6.93	76.22	9.13

Table 3. A comparison of motivation components based on race

When comparing the performance of Glynn science majors on motivation components with our participants, the FirstSTEP students scored higher in all motivation components except for the self-determination. Figure 2 represents the comparison between the FirstSTEP students' and the Glynn science majors' motivation scores for each component stratified by gender.

The results of the *two sample t-test* indicated "the population average score of FirstSTEP students was significantly higher than that science major students in the Glynn et al. (2011) study (p =.002). Compared to female science majors in the Glynn study, female FirstSTEP students scored significantly higher in self-efficacy (p = .014), grade motivation (p =.04), and career motivation (p =.002). When motivation scores from male FirstSTEP students were compared to male science majors in Glynn et al. (2011) study, FirstSTEP male students scored significantly higher in intrinsic motivation (p = .02). Contrary to the gender-related findings in the Glynn et al. (2011) study which concluded that men had higher self-efficacy than women and women had higher self-determination than men, our results were race-related (e.g., African-American participants appeared to have higher self-efficacy, career motivation and total motivation compared to white participants). Self-determination scores in our study were the lowest among the five motivation scores regardless of gender and race. To better understand the reason for this shortcoming, we analyzed the questions related to self-determination across gender and race. In Figure 3, the five questions that formed the self-determination component and the responses (0-4 points) were examined separately.

The participants, in the self-determination component, regardless of race and gender, earned the lowest scores when responding to the questions about spending time to learn and prepare for tests and labs in their STEM major courses. Therefore, to boost the students' control over their time and consequently their learning, a presentation about time management skills was provided for FirstSTEP students. Effective tools such as planning for short term and long term events using calendars and journaling were discussed. In that meeting, all the students who had participated in SMQ-II during MSB received a copy of their motivation scores along with

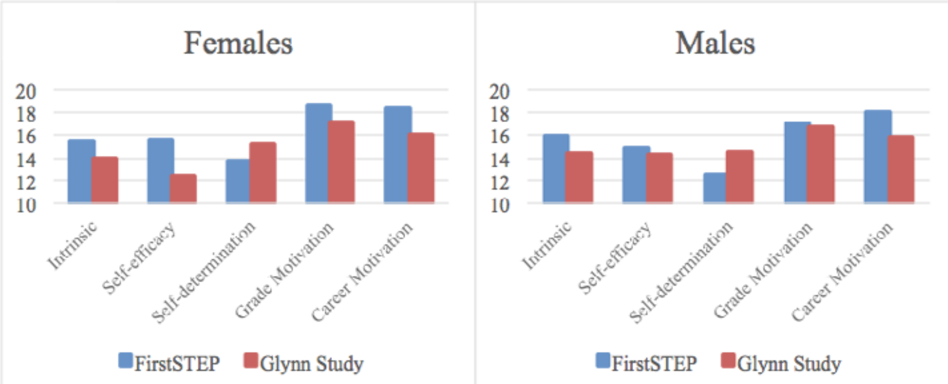

Figure 2. Average score for the motivation components comparing the FirstSTEP Participants with the Glynn Science Students Examined by Gender

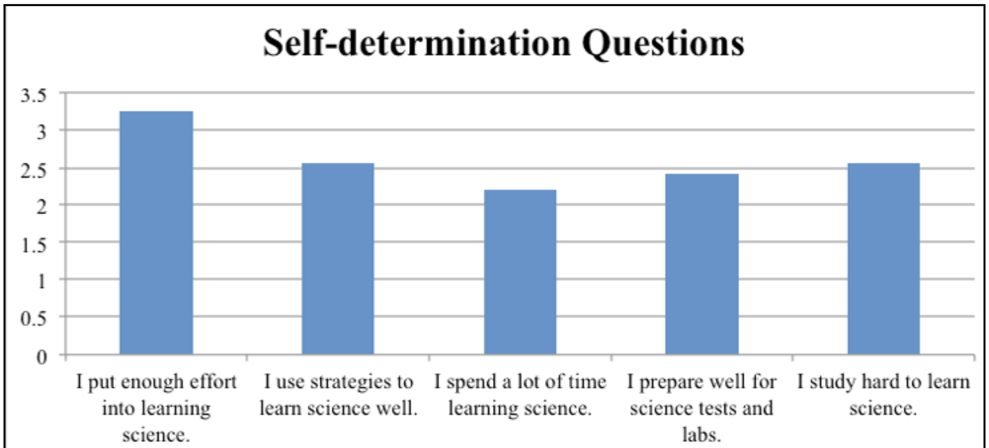

Figure 3. Comparison of self-determination questions

Note: The maximum possible point for each question is 4.

the class mean scores. In addition, the participants were provided with recommendations and suggestions to increase their motivation, especially their self-efficacy and self-determination, since these components have been found to be a strong predictor of mathematics achievement (e.g., Armstrong, 1980; Hakett & Betz, 1989; Pajeres & Graham, 1999; Pajeres & Schunk, 2001; Schunk, 1991; Zimmerman, 2000). All participants received a hard copy of three articles. 1. An article from the National Math + Science Initiative called: "Why STEM Education Matters." 2. An interesting article regarding self-efficacy by Albert Bandura (1977), which describes the role it plays in our lives and how it can be developed (Cherry, 2011). 3. "How to Build Your Self-determination" (Rao, 2009).

Overall, these participants who chose STEM as their majors possessed strong grade motivation as well as career motivation. However, their self-efficacy and self-determination scores were the lowest which indicated that many of them lacked the dedication necessary to study the sciences at a level which is essential to remain and graduate as STEM majors.

Digital Metaphor

George Lakoff and Mark Johnson (2003), in a book called: *Metaphors We Live By*, indicate that metaphors are widespread in our everyday life, not just in talking but also in thought and action. In this study we used digital metaphors (Rowlett, 2013) to gain awareness into our FirstSTEP individuals' self-perceptions regarding their STEM majors. At the first glance, our efforts may seem traditional and passive in addressing the lack of students' self-determination by holding a meeting, having a discussion, and teaching them how to use the calendar and journaling for short and long term events in their academic and social lives. Yet the novelty of this study lays on the rather significant coupling of the digital metaphor assignment to the above mentioned activities. Using the digital metaphor activity was intended to help the participants reinforce their commitment to their STEM majors by reflecting on their determination for being successful in their STEM majors. As Cohen & Sherman (2014) confirmed, writing about important values provides a moment to step back and regain perspective on what really matters, which can create the potential for change.

The participants chose an image and wrote a paragraph describing how that image was related to their determination for being successful in their STEM majors. One of the objectives for using the digital metaphor was to better understand our students' inner feelings about their self-determination for being successful in their STEM majors. Table 4 summarizes some of the 34 responses to *"When I think about my determination about being successful in my STEM major, I am reminded of . . ."* The rest of the responses are described below.

Three students chose a tree to be a metaphor for their self-determination and used terms like strong, planted, roots, foundation, and working constantly. Four students selected animals such as an orca whale, squirrel, monkey and duck as their metaphor, and phrases such as bravery, courage, never giving up, and determination were used. Three other students chose photos of mountains and described their self-determination as keeping their eyes on the prize and pushing themselves to their potential. Two students picked images of outer space to represent their self-determination, suggesting the future is unpredictable and the need for furthering space travel and technology. Finally, one student used an image of a weight lifter to represent his self-determination to signify that with hard work nothing is too difficult to accomplish.

While participation in the digital metaphor assignment was elective, almost all of the participants contributed (34 out of 36 students). Realizing the small number of participants, our objective to use digital metaphor was not to draw generalizable conclusions. Instead, our intention was two-fold: to help the *participants* reflect upon and articulate their motivation and determination toward being a STEM major and secondly, to provide the *researchers* and the project team with further understanding about the participants' motivation, determination and challenges toward being a STEM major.

Precalculus Final Grades

FirstSTEP participants and the corresponding matched control group began the semester taking precalculus in their first semester at MTSU. The participants benefited from one-on-one tutoring once a week to improve their mathematical skills. Each participant was assigned a specified number of required tutoring hours (1-3 hours/week), based initially on their Mathematics Summer Bridge post-test scores. Then these hours were modified depending on their midterm grades. Tutors were upper division mathematics major and graduate students. They were encouraged to use leading questions to guide students toward greater understanding of the assigned problems instead of simply solving the problems for the students.

Additional help in other STEM courses was also available at the students' request. Our FirstSTEP students were in different precalculus sections, but they all attended one of two seminar sections taught by the same faculty member. That extra hour of seminar provided the students with more real-life problems in precalculus, discussions, and reflections on topics related to academics as well as helpful strategies on how to overcome the challenges of making the transition from high school to college life. According to the U.S. Department of Education report (Chen

…reminded of…	Examples	Number of students	Important words emphasized in one or more examples
Family members	Whole family Mother Grandmother Grandfather	4	strength, dedication, love, loyalty, work ethics, believing in me, definitely motivates me
A particular person	Sanya Richards Ross A high school athlete Sylvester Stallone Phil Fish	4	completed and won a race, determined in finishing the race, very strong, determination, passion, he never gave up on his dream
Future	Graduation Finish line To improve the teaching of biology To improve the condition of humanity	4	walking across the stage, I am going to fight until the finish line! love biology and want to teach it, bettering the condition of humanity
A particular place	Roman Coliseum Local Children's Hospital	3	major world landmark, built very intelligently, so fascinating, a sense of happiness, dedication and motivation, focused, knowledge
Other objects	Computer keyboard Dam Tie Braces Hard work sign Computer	6	it has all I need to succeed, the tie is unfinished as I am, perfect teeth, nothing in life comes easy, giving up is not an option, technology, persevere when things get tough

Table 4. Responses from FirstSTEP students' digital metaphors

	FirstSTEP Students (N= 36)		Control STEM Students (N= 85)	
Grades	Frequency	%	Frequency	%
A	6	17	15	18
B	12	33	20	24
C	11	31	27	31
D, F and W	7	19	23	27

Table 5. Comparison of precalculus final grades of FirstSTEP students with the control group

	FirstSTEP Students (N= 36)		Control STEM Students (N= 85)	
GPA	Mean	SD	Mean	SD
High School	3.37	.45	3.47	.42
First Semester of College	2.56	.91	2.29	.94

Table 6. Comparison of Grade Point Average (GPA) for FirstSTEP students with the control group

Note: The maximum GPA at MTSU that could be attained was 4.00. Some high schools allowed for GPAs higher than 4.0.

& Soldner, 2013), some of the potential factors associated with STEM attrition are the institutional climate, support system, and resources for STEM learning. Factors which may damage a caring institutional climate include insufficient academic advising, inadequate career counseling, and lack of institutional support. Since college freshmen, especially first-generation students (i.e., students whose parents do not have a college degree), often identify faculty and administrators as quite unsympathetic and occasionally intimidating (Long-Grice, 2003), they need someone to explain the college culture and how to become a part of it (Richardson & Skinner, 1992). These students could benefit even more than their peers when they are active members involved in campus events (Pacarella et al., 2004). Therefore, the one hour allocated to seminar once a week was used to provide a friendly environment to help FirstSTEP students learn about and become familiar with services and resources offered at Middle Tennessee State University as well as to support and help them plan for a successful semester.

A comparison between the final precalculus course grades of FirstSTEP students and the control group is illustrated in Table 5. The matched control group consisted of 85 STEM majors with Math ACT 19-23 who registered for precalculus in Fall 2013.

The results from this comparison revealed that 81% of FirstSTEP students were successful in obtaining a final grade of C or better in precalculus. On the other hand, 73% of STEM students in the corresponding control group received a grade of C or better for the course.

Evidence has shown that first generation college students not only encounter the same pressures and struggles as their peers but also have a more difficult time making the transition from secondary school to college (e.g., Terenzini et al., 1996; Thayer, 2000). Incoming FTFTF, especially those who are first-generation college students, do not always realize the difference in high school and college life, including college grade point averages (GPA). Most of the participants in the study, especially males and African-American students, experienced a drop in their GPA (compared to high school) once they were in college. Table 6 shows both the FirstSTEP students' and the control group GPAs' in high school as compared to the first semester of college.

Conclusions

Educators in the STEM fields have a two-front battle: one is to attract students to STEM majors and the other is to keep them motivated to complete the major. Therefore, one of the objectives of the FirstSTEP program is to increase the retention of STEM majors, and thereby raise the number of STEM graduates at MTSU. The FirstSTEP program focuses on developing the students' mathematics abilities, exposing them to new and authentic experiences related to their STEM majors, providing assessment-based interventions to improve motivation, and assisting the students' transition into college life during the first two years of college.

According to ACT's College and Career Readiness Standards (ACT, 2015) the participants only had a 25% chance of being successful in college algebra, which is a lower level mathematics course than precalculus, due to their Math ACT subscores (19-23). On the other hand, the SMQ-II indicated that these students were overall more motivated to remain as STEM majors than the larger sample of science majors that Glynn studied. In particular, the motivation questionnaire results helped us realize that even though our students had high grade and career motivation, they might not have enough intrinsic motivation, self-efficacy and especially self-determination to ensure their success as a STEM major. This information enabled us to develop interventions to help improve the participants' self-determination. Serving both as a motivational tool for the students and an assessment tool for the project team, the digital metaphors provided additional insights into the internal motivations and commitments these students have for being a STEM major. As part of an effort to continuously promote the students' motivation toward learning college courses associated with their STEM majors, we provided guest speakers who could speak about careers in their STEM majors as well as opportunities for research and development projects while they are students at MTSU.

Using participants' motivation scores in developing interventions to improve their weakest motivation components and providing support to overcome their weak mathematics backgrounds enabled them to succeed at a substantially higher rate than their Math ACT alone would have predicted. Even though we are not able to separate out the effects of any single component of the project as the key factor in success, we are able to demonstrate that all of the components of the program combined resulted in higher success for the FirstSTEP students both in precalculus grades and STEM retention compared to the control group. In conclusion, the program was an illustration of the importance of improving retention rates in STEM by knowing our students, supporting them academically and emotionally, and motivating them to graduate with STEM majors. Furthermore, knowing more about our students' motivations and perceptions regarding their own success in STEM enabled us to design and include additional interventions for improving their success as college STEM majors.

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We would like to acknowledge the contributions of the MTSU FirstSTEP Team led by Thomas Cheatham. Team members include Donald Nelson, Chris Stephens, Elaine Bouldin Tenpenny, Jennifer Yantz, and Brittany Baum.