THE RELATIONSHIP BETWEEN MATHEMATICS IDENTITY AND PERSONALITY ATTRIBUTES WITH STUDENTS' CAREER GOALS

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In this study, we surveyed 570 Calculus I and Calculus II students at two large public universities in the Northeastern region of the United States. We explored the relationship between these students' career goals in mathematics and other STEM fields, with their mathematics identity and self-identified personality attributes. Our findings suggest that mathematics identity can be used as a way of explaining persistence in mathematics and other STEM fields. We also found certain personality attributes to be correlated with persistence in these fields and these personality attributes varied based on gender. We conclude with a detailed analysis of our findings and some implications.

Keywords: Affect and Beliefs; Gender; Post-Secondary Education

Introduction

There is a shortage of individuals entering STEM (Science, Technology, Engineering, and Mathematics) careers in the United States (Langdon, McKittrick, Beede, Khan & Doms, 2011; National Academy of Sciences, 2010). For the past 50 years, there has been a notable decline in the number of college students choosing STEM majors, and college students are more likely to switch from a STEM major to a non-STEM major than the other way around (Seymour & Hewitt, 1997). Furthermore, data suggest that there has not been notable increases in the percentage of students receiving STEM degrees in recent years, with only a 1% increase of bachelor's degrees awarded in STEM fields between 2002 and 2012 (NSF, 2015). Given that the growth of STEM jobs was three times that of non-STEM jobs during the past decade or so, this shortage of citizens interested and educated in the STEM fields is of national concern (Langdon, McKittrick, Beede, Khan, & Doms, 2011).

In addition, there is evidence of a continued underrepresentation of women choosing a career in STEM fields. For instance, based on data reported by the National Science Foundation, in 2013 although women made up 46.1% of the entire U.S. workforce, they were only 14.8% of those employed as engineers, 11.8% of those employed as physicists and astronomers, and only 25.4% of those employed as mathematical or computer scientists (NSF, 2015). Furthermore, the percentage of women earning degrees in STEM fields has been declining. For example, the percentage of women earning bachelor's degrees in the mathematical sciences fell from 48% in 2001 to 43% in 2009. Other fields, such as engineering and computer science, have seen similar declines in women earning such degrees during the same timeframe (NSF, 2015). Though these results inform us of the underrepresentation of women in these fields, they do not provide insight as to why these trends are occurring. It is important to explore reasons why this underrepresentation is still persisting and why gender gaps in participation are increasing in some cases.

Prior research has shown a connection between individuals' mathematics identity and students' persistence and commitment to mathematics and other STEM fields (Boaler & Greeno, 2000; Cass, Hazari, Cribbs, Sadler, & Sonnert, 2011). Furthermore, in previous work, Piatek-Jimenez (2015) noted specific self-identified personality attributes common amongst women mathematics majors.

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For this study we are combining these two constructs to determine what relationships exist between students' mathematics identities and self-identified personality attributes with their intended choice of career.

The following research questions were used to guide this study: 1) What is the relationship between students' career goals in a STEM field with their mathematics identity and self-identified personality attributes?; 2) What is the relationship between students' career goals in a mathematics field (mathematician and mathematics teachers) with their mathematics identity and self-identified personality attributes?; and 3) How do these models vary between females and males?

Theoretical Framework

Identity is a construct that is becoming increasingly utilized in mathematics education research when exploring students' persistence and attrition in mathematics (Boaler & Greeno, 2000; Martin, 2000; Piatek-Jimenez, 2008; Piatek-Jimenez, 2015). Though different authors have conceptualized the construct in slightly different ways, we view "mathematics identity" as how individuals see themselves in relation to mathematics based on their perceptions and navigation of everyday experiences with mathematics (Enyedy, Goldberg & Welsh, 2006). We view this as being a part of an individual's "core identity", which is a more enduring sense of who an individual is and who he or she wants to become (Cobb & Hodge, 2011).

Our framework for mathematics identity draws from prior work in the field of mathematics and science (Cribbs, Hazari, Sadler, Sonnert, 2012; Carlone & Johnson, 2007; Hazari, Sonnert, Sadler & Shanahan, 2010). In our framework, mathematics identity is comprised of the sub-constructs interest, recognition, and competence/performance. Interest refers to an individual's desire or curiosity to think and learn about mathematics. Recognition refers to how an individual perceives others view him or her in relation to mathematics. Competence/performance refers to an individual's beliefs about his or her ability to understand and perform in mathematics. It is the inclusion of these three factors that provide a better picture of an individual's mathematics identity.

While mathematics identity is a strong predictor for students' career goals in certain STEM fields, such as engineering (Cass et al., 2011) and mathematics (Cribbs et al., 2012), other factors influence an individual's choice whether or not to pursue a STEM career. Furthermore, Gee's (2001) work related to identity indicates that an individual may have many different identities. For example, a woman mathematics major may identify as both a woman and a mathematics major. Potentially conflicting expectations about what it means to be a woman and what it means be a mathematics major may inform her decision whether or not to enter a career in mathematics.

In particular, our study is concerned with the role that gender plays in the expectations and choices an individual makes. For example, gender stereotyping could play a role in how individuals view themselves and subsequently the choices they make. Research notes that parents (Furnham, Reeves & Budhani, 2002; Frome & Eccles, 1998) and teachers (Helwig, Anderson & Tindal, 2001; Li, 1999) hold different beliefs about males' and females' abilities in mathematics. In addition, many scholars have noted connections between individuals' personality attributes and career choice (Ackerman & Beier, 2003; Buddeberg-Fischer, Klaghofer, Abel & Buddeberg, 2006; Schaub & Tokar, 2004). Furthermore, Luyckx, Soenens, and Goossens (2006) found correlations between an individual's identity and personality traits. By exploring mathematics identity and students' self-identified personality attributes, we might develop a better understanding of how expectations and other identities interact to influence students' career goals.

Methods

This study collected data from two different universities in the northeast region of the United States by administering surveys in the fall of 2014 with students enrolled in Calculus I and Calculus

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II courses, yielding 570 completed surveys. The survey was developed to collect student demographic information, career goals, perceptions related to mathematics identity, and self-identified personality attributes. Content validity was insured through: 1) pulling from literature related to personality attributes, gender, and mathematics identity (Cribbs et al., 2012; Piatek-Jimenez, 2015; Ely, 1995; Jones & Myhill, 2002; Luhtanen & Crocker, 1992), 2) conducting a pilot test with survey items related to personality attributes and gender stereotyping in the spring of 2014, and 3) conducting a pilot test with the completed survey in the summer of 2014. The initial pilot test also included a series of focus group sessions with participants to further refine the survey items. Both pilot tests were done with college students enrolled in mathematics and mathematics education courses at the universities where the study was conducted.

Logistic regression was used to address each research question because the outcome variable (career goals) was dichotomous. One regression model was created to examine students' career goals in a STEM field and another was created to explore students' career goals specifically in a mathematics field (mathematician or mathematics teacher). Table 1 details the possible choices available on the survey and corresponding number of responses. We can see from the table that of the 53 participants with career goals in a mathematics field, just under 60% of them were interested in becoming K-12 mathematics teachers.

Table 1: Number of Students Selecting each Career Goal

Career Goal	Number	Percent of Sample
Non-STEM (e.g. lawyer, business person)	197	35
STEM		
Mathematician	22	4
Math teacher	31	6
Life/earth/environmental scientist	52	9
Physical scientist	26	5
Engineer	176	31
Computer scientist, IT	53	9
Science teacher	8	1
STEM Total	368	65

Because we were looking at mathematics identity in particular (and not STEM identity), we were also interested in how the results might differ when comparing students who have chosen a mathematics field to those choosing a non-STEM field. Therefore, in conducting the regression analysis for research question 2, all other STEM participants were excluded in order create a model that compared how participants selecting mathematician or mathematics teacher related to those who selected a non-STEM field. A proxy for mathematics identity was used based on results from a previous analysis (Cribbs et al., 2012). In addition, the following control variables were considered for the model: gender, age, class standing in college, and mathematics course enrollment.

Results

Table 2 details the results for research question 1: What is the relationship between students' career goals in a STEM field with their mathematics identity and self-identified personality attributes? Only significant control variables, with a significance level of $p < 0.05$, were included in the final models shown in this section.

Table 2 shows that the only control variable remaining in the model was "current math class." The results indicate that mathematics identity significantly predicts students' career goals in a STEM field with an odds ratio of 1.5. In other words, a one unit increase in the mathematics identity proxy

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increases the odds of a student selecting a STEM career field by one and a half times. The results also indicate that several self-identified personality attributes are correlated with students' career goals STEM. The positively correlated items are "I am able to be 'one of the guys'" with an odds

Table 2: How do mathematics identity and personality attributes predict STEM career goals

(N=570)	Estimate	SE	Odds Ratio	Sig.
Intercept	1.258	0.837		
Controls				
Current math class	0.280	0.081	1.323	***
Mathematics Identity	0.406	0.087	1.501	***
Self-Identified Characteristics				
I am feminine	-0.143	0.051	0.867	**
I am forceful with my opinions	-0.226	0.072	0.798	**
I earn good grades	-0.543	0.121	0.581	***
I am able to be "one of the guys"	0.185	0.076	1.204	*
I am academically motivated	-0.250	0.113	0.779	*
I show concern for people's well-being	-0.308	0.106	0.735	**
I am inquisitive	0.268	0.098	1.307	**
I am passionate about my major	0.315	0.087	1.371	***

*p<0.05 **p<0.01 ***p<0.001

ratio of 1.2, "I am inquisitive" with an odds ratio of 1.3, and "I am passionate about my major" with an odds ratio of 1.4. The negatively correlated items include "I am feminine" with an odds ratio of 0.9, "I am forceful with my opinions" with an odds ratio of 0.8, "I earn good grades" with an odds ratio of 0.6, "I am academically motivated" with an odds ratio of 0.8, and "I show concern for people's well-being" with an odds ratio of 0.7.

Table 3 details the results for research question 2: What is the relationship between students' career goals in a mathematics field and their mathematics identity and self-identified personality attributes?

Table 3: How do mathematics identity and personality attributes predict career goals in a mathematics field (mathematician or mathematics teacher)

(N=250)	Estimate	SE	Odds Ratio	Sig.
Intercept	-2.684	1.355		*
Mathematics Identity	1.340	0.248	3.819	***
Self-Identified Characteristics				
I am self-sufficient	-0.375	0.176	0.687	*
I am concerned about future career obligations	-0.385	0.139	0.681	**
I cry easily when I am angry/upset	0.217	0.103	1.242	***
I have high career aspirations	-0.931	0.240	0.397	*
I am concerned about future family obligations	0.343	0.141	1.409	**
I do not mind sacrificing my personal time for my studies	-0.441	0.153	0.643	*
I have a strong work ethic	0.217	0.103	1.763	*

*p<0.05 **p<0.01 ***p<0.001

Table 3 shows that mathematics identity significantly predicts students' career goals as a mathematician or mathematics teacher with an odds ratio of 3.8. The results also indicate that several

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self-identified personality attributes are correlated with students' career choice as a mathematician or mathematics teacher. The positively correlated items are "I cry easily when I am angry/upset" with an odds ratio of 1.2, "I am concerned about future family obligations" with an odds ratio of 1.4, and "I have a strong work ethic" with an odds ratio of 1.8. The negatively correlated items include "I am self-sufficient" with an odds ratio of 0.7, "I am concerned about future career obligations" with an odds ratio of 0.7, "I have high career aspirations" with an odds ratio of 0.4, and "I do not mind sacrificing my personal time for my studies" with an odds ratio of 0.6.

Table 4 and 5 detail results for research question 3: How do these models vary between females and males?

Table 4: How do mathematics identity and personality characteristics predict career goals in a STEM field for females

(N=191)	Estimate	SE	Odds Ratio	Sig.
Intercept	5.155	1.499		***
Mathematics Identity	0.731	0.152	2.088	***
Self-Identified Characteristics				
I am spontaneous	-0.298	0.136	0.742	*
I am forceful with my opinions	-0.221	0.109	0.802	*
I earn good grades	-0.710	0.213	0.491	***
I am able to be "one of the guys"	0.292	0.128	1.340	*
I am academically motivated	-0.600	0.206	0.549	**
I am passionate about my major	0.352	0.167	1.422	*
I care about my appearance	-0.404	0.147	0.668	**

*p<0.05 **p<0.01 ***p<0.001

Table 4 indicates that mathematics identity significantly predicts female students' career goals in a STEM field with an odds ratio of 2.1. The results also indicate that several self-identified personality attributes are correlated with female students' career goals in STEM. The positively correlated items are "I am able to be 'one of the guys'" with an odds ratio of 1.3 and "I am passionate about my major" with an odds ratio of 1.4. The negatively correlated items include "I am spontaneous" with an odds ratio of 0.7, "I am forceful with my opinions" with an odds ratio of 0.8, "I earn good grades" with an odds ratio of .5, "I am academically motivated" with an odds ratio of 0.5, and "I care about my appearance" with an odds ratio of 0.7.

Table 5: How do mathematics identity and personality characteristics predict career goals in a STEM field for males

(N=378)	Estimate	SE	Odds Ratio	Sig.
Intercept	-0.751	0.915		
Controls				
Current math class	0.312	0.103	1.366	**
Mathematics Identity	0.270	0.115	1.310	*
Self-Identified Characteristics				
I am forceful with my opinions	-0.198	0.100	0.821	*
I earn good grades	-0.358	0.139	0.699	*
I do not mind sacrificing my personal time for my studies	-0.281	0.107	0.755	**
I am inquisitive	0.303	0.120	1.354	*
I am passionate about my major	0.378	0.104	1.459	***

*p<0.05 **p<0.01 ***p<0.001

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Table 5 indicates that mathematics identity significantly predicts male students' career goals in a STEM field with an odds ratio of 2.1. The results also indicate that several self-identified personality attributes are correlated with male students' career goals in STEM. The positively correlated items are "I am inquisitive" with an odds ratio of 1.4 and "I am passionate about my major" with an odds ratio of 1.5. The negatively correlated items include "I am forceful with my opinions" with an odds ratio of 0.8, "I earn good grades" with an odds ratio of 0.7, and "I do not mind sacrificing my personal time for my studies" with an odds ratio of 0.8.

Discussion

Our findings provide evidence that mathematics identity can be used as a way of explaining student persistence in STEM fields. Specifically, a shift in the mathematics identity proxy of one standard deviation corresponds to a 1.5 higher odds of having career goals in a STEM field and a 3.8 higher odds of having career goals as a mathematician or mathematics teacher. The odds ratio is much higher for career goals as a mathematician or mathematics teacher than for a general STEM field, as might be expected.

Our results also suggest that certain self-identified personality attributes are positively correlated to students' career goals in STEM. In particular, we found that "I am able to be 'one of the guys'" is positively correlated with having career goals in a STEM field. This finding might be a result of society's stereotypical belief that scientists and mathematicians are generally male (Picker & Berry, 2000). Therefore, individuals who believe that they can fit in as "one of the guys" may be more likely to choose a career in STEM. We also found that the attribute "I am passionate about my major" was positively correlated with choosing a STEM field. This, too, many be related to the belief that scientists and mathematicians are obsessed with their field (Piatek-Jimenez, 2008; Picker & Berry, 2000). Furthermore, we found that "I am inquisitive" was positively correlated with choosing a STEM field. We believe that this finding could relate to the fact that the field of science is often affiliated with inquiry, and other STEM fields, such as engineering and mathematics, are often related to problem solving.

There were also five negatively correlated self-identified personality attributes with choosing a STEM field. One of these attributes was "I am feminine". This may not be a surprising result given that, as previously mentioned, STEM fields are often believed to be masculine fields. This finding is consistent with that of Piatek-Jimenez (2015) who found that women mathematics majors often do not identify with being highly feminine. Another attribute that negatively correlated with wanting a STEM career was "I show concern for other people's well-being". This finding is consistent with Morgan, Isaac, and Sansone's (2001) work that shows college students believe that the physical and mathematical sciences are less likely to have "people-oriented" careers. Therefore, individuals who are highly concerned for other people's well-being may be less likely to choose a STEM career. Two items we found more difficult to interpret were "I earn good grades" and "I am academically motivated" as being negatively correlated with choosing a STEM field. Initially these both seemed counter-intuitive to us, given that STEM fields tend to be viewed as more rigorous fields. However, we believe this is the exact reason that "I earn good grades" did show up as a negative correlation. Because STEM fields are often seen as more rigorous, students in these fields may be used to earning lower grades than in other non-STEM fields. As of yet, we are still unable to determine why "I am academically motivated" was negatively correlated with STEM. In future work, we intend to do qualitative interviews with students to learn more about this finding.

In addressing our second research question, our results shown in Table 2 suggest that certain self-identified personality attributes are correlated specifically with career goals in a mathematics field, and that these are slightly different than for STEM careers, in general. In particular, we found that "I am concerned about future family obligations" was positively correlated with wanting a career in

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mathematics while "I am concerned about future career obligations" and "I have high career aspirations" were negatively correlated with wanting a career in mathematics. We believe that these findings may be a result of the fact that approximately three-fifths of the participants wanting a career in mathematics were intending to become a K-12 mathematics teacher. Given that the societal perception of teaching is that it provides a schedule more conducive to fulfilling family obligations (Anthony & Ord, 2008) than possibly other STEM fields may be a reason for this finding.

In order to address our third research question, we ran the model with regards to choice of STEM career separately for females and males. There were three personality attributes that remained consistent in all three models. We found that "I am passionate about my major" was positively correlated and "I am forceful with my opinions" and "I earn good grades" were negatively correlated in all three models. This finding shows that these personality attributes in predicting STEM career goals were not dependent upon gender. However, there were personality attributes that did depend on gender. Interestingly enough, the personality attribute of "I am able to be 'one of the guys'" was found to be statistically significant for female students wanting STEM careers but not for male students. We find this result to be important because it demonstrates the need for women to feel like they fit in as "one of the guys" when choosing a career in a STEM field. This result suggests that there may still be an embedded societal belief that the STEM fields remain male-dominated and male-driven and that in order to enter these fields, one must be able to be "one of the guys".

While having a strong mathematics identity is an important factor in choosing mathematics or other STEM career goals, it certainly is not the only factor influencing such decisions. Many factors play a role in career choice, and our work suggests that personality attributes may be one of those factors. Furthermore, we found that the personality attributes that correlate to choosing STEM careers differ slightly between males and females. If our goal is to encourage more students, and specifically more women, to enter STEM careers, a better understanding of the role that these personality attributes play in such decisions will allow us to better recruit talented students into these fields.

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