First-generation Low-income College Student Perceptions about First Year Calculus

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Abstract

The purpose of this study was to explore first-generation low-income students' experiences with first-year calculus, including their self-belief in being successful in math. As part of the Progress though Calculus project, one STEM-focused institution was studied with survey results from students enrolled in first year calculus, and interviews and a focus group of three first-generation low-income students who completed first year calculus. Qualitative findings emphasized the value of creating connections with other students and faculty, and faculty's impact on students' sense of belief in being successful in calculus. Quantitative results illustrated statistically significant higher rates of faculty interaction outside of class and increased confidence in math while taking first year calculus for first-generation low-income students, in comparison to their continued generation, higher income peers. Promoting non-cognitive factors such as student support and self-belief in math success may influence math completion of first-generation low-income students.

Key Words: First-generation low-income students, self-belief, first year calculus

Along with innovative pedagogies and curriculum enhancements to improve math education, it is also important to consider as part of the formula for student success in mathematics, the increasingly diverse student population, gaps of math completion with marginalized students, and non-cognitive factors such as self belief and support networks. The population of diverse students for this study was first-generation students as the first in their immediate family to be working towards a bachelor's degree, and low-income students.

In this study I explore the experiences of first-generation low-income students in first year mathematics from an asset approach, meaning I focus on what these students bring from their identities to support their success, as well as attending to barriers these students face. For decades college administrators and researchers have viewed the first-generation and low-income identities as "at risk", which is reinforced by the well documented national graduation gaps of these students. For instance, among 4.5 million college students from 1995-2002, six-year graduation rates for first-generation low-income students were 44% lower than continuing-generation higher-income students (Engle & Tinto, 2008).

To address these graduation gaps and move beyond the focus on the disparities of underserved students as a disadvantage to being successful in college, a paradigm shift is needed to to support students that attend college rather than require students to adapt to college. One way to provide support is focusing on first-year mathematics completion since it is highly correlated to graduation rates. By understanding what assets students bring to first-year mathematics success, we can better understand how to support a higher graduation rate among this population.

First-generation Low-income Students

Most prominent research on first-generation low-income students has focused on deficits as a disadvantage to being successful in college. Academic deficiencies of these students include: higher need for remedial courses (Chen & Carroll, 2005), undeveloped student success skill sets (Collier & Morgan, 2008), less academic and co-curricular engagement (Pascarella, Pierson, Wolniak, & Terenzini, 2004; Warpole, 2003), and lower educational aspirations (Pike & Kuh, 2005). Non-cognitive disparities include a lack of parental support (Ward, 2012), not as much social capital (Lin, 2011), lower levels of a sense of belonging (Aires & Seider, 2005; Ward, 2012), and a cultural mismatch with the university (Roberts & Rosenwald, 2001; Stephens, Fryberg, Markus, Johnson, & Covarrubias, 2012).

A different approach to defining deficits and expecting students to compensate for deficits is research done within the perspective of promoting the strengths and assets of students as an advantage for collegiate success. Although not as prevalent, research within an asset framework focused on self-authorship (Pizzolato, 2003), high motivation to attend college (Martin, 2012) , and a desire to contribute to society (Olive, 2009). Along with research on the strengths of these students, is the importance of meaningful individual connections to support students. For instance, a strong network of faculty who care and have high expectations, and peers who offer encouragement has been found to help first-generation college students transition to college (Coffman, 2011), and obtain a college degree (Lourdes, 2015).

Math Completion of First-generation and Low-income Students

In considering the success in math of first-generation low-income students, lower levels of math completion have been documented. An analysis of first-generation student college transcripts from 1992 to 2000 shared that 55% of first-generation students took at least one math course in college compared to 81% of students whose parents had a bachelor's degree (Chen & Carroll, 2005). Additionally, at Colorado State University (2016) after controlling for prior academic preparation, first-generation, students of color, and Pell eligible students were significantly less likely to place into college algebra and to complete three credits of math in the first year compared to their peers.

Self-belief Theoretical Framework

To begin to reflect on ways to enhance math completion with first-generation low-income students, one non-cognitive factor to consider is self-belief based on the power of positive psychology, which is the study of conditions that influence the optimal functioning of people (Gable & Haidt, 2005). Theories to inform this perspective of developing student assets are stereotype threat (Steele, 1997), which challenges college success, and self-belief (Bandura, 1977; Dweck, 2006), which can potentially mediate challenges and promote academic success. Stereotype threat theory asserts that negative stereotypes of one's performance based on his or her social group can put individuals at risk of lower performance (Steele, 1997).

In response to the negative influences of stereotype threat, positive psychology theories of self-belief are used with Bandara's theory of self-efficacy and Dweck's theory of a growth mindset. Bandara's theory of self-efficacy is a social cognitive theory based on the belief that one can achieve his or her goals (Bandura, 1977). Expanding upon self-efficacy is growth mindset, is the belief that one may improve through engagement with the learning process (Dweck, 2006).

Self-belief and Math Achievement

Research on the relationship of self-efficacy and math achievement is evident both with students who have not performed well in math along with engineering students with high levels of math performance. Investigating students who were repeating a developmental math course, they identified high self-efficacy as the essence of their persistence despite a low self-concept in mathematics (Canfield, 2013). For engineering students who usually excel in math, self-efficacy was correlated with mathematics achievement scores and cumulative grade point averages (Loo & Choy, 2013).

Reinforcing a growth mindset, research has demonstrated greater course completion rates in challenging math courses (Yeager & Dweck, 2012). Many studies have also focused on the growth mindset as a mediating factor to stereotype type threat of marginalized populations in math performance. Dar-Nimrod and Heine (2006) studied math achievement and gender, and illustrated that females with a growth mindset performed better than females with a fixed mindset on math assessments similar to the Graduate Record Examination.

Lower math completion rates of first-generation low-income students, along with the positive impact of self-belief and math achievement, warrant further investigation into ways that self-belief can enhance success in mathematics. The purpose of this study is to explore first-generation low-income students' experiences with first-year calculus, with particular focus on their self-belief in being successful in math. Specifically, the following research questions guide this work: (1) How do first-generation low-income college students experience first year calculus at a STEM focused institution? (2) How does first year calculus influence the self-belief of first-generation low-income college students to be successful in math?

Methodology

To provide context of this research, a broad overview of the Project through Calculus research that studied ways to enhance student calculus completion rates is summarized. A part of this research project was a pilot study at one STEM institution, which is the focus of this paper.

Progress through Calculus Research

The Progress through Calculus study is sponsored by the Mathematical Association of America and funded by the National Science Foundation (NSF) to research student success in calculus. Twelve higher education institutions were identified by the research project team as institutions using structural, procedural, curricular, and pedagogical approaches to the pre-calculus and calculus program that has been successful in higher math completion rates, especially with underrepresented students. Prior to researching the twelve institutions, three pilot studies were held at institutions based on geography, convenience, and access; to refine data collection content and procedures.

Research Design, Participants, and Data Collection

One of the pilot studies for the Progress through Calculus research was done at a private institution that is focused on STEM degrees. This study was implemented with five researchers including a two-day site visit with interviews, class observations, focus groups, and surveys.

The qualitative subset of the pilot study included three first-generation low-income students who were interviewed mid-semester and participated in focus group at the end of the semester. The students that participated were a first year white female, a junior African American female, and a third year Asian male. The student survey was developed by the Progress through Calculus Research team, and was distributed by the instructors in one of the first year calculus course sessions during the middle of the spring semester.

The mixed methods design was a convergent parallel design with both the interviews/focus group and the survey gathered and analyzed independently, and then the results interpreted together (Creswell & Plano Clark, 2011). For the interviews and focus group holistic data analysis was accomplished with an inductive process to identify relevant emerging themes (Yin, 2003), making sense out of the data collection (Miles, Huberman, & Saldana, 1994). To begin, the interviews and focus groups were transcribed and then coded with MaxQDA, a qualitative coding software program. The researcher began with a first-cycle coding process and then reviewed each code and coded segment to illuminate connections between the categories in the second-cycle coding process, and used a second coder to refine the codes (Miles et al., 1994). Survey questions on student self-belief and interactions with faculty and peers as support resources were studied with chi-square analysis.

Results

Studying this institution may offer insights to math success since they have decreased the first year calculus DFW rates from 22% in fall 2006 to 10% in spring 2015. The qualitative results from interviews and a focus group illustrated that a common theme of their math experiences was the major significance of working with faculty and other students outside of class.

In exploring faculty connections, key factors that emerged were the importance of how faculty responded to questions, and the value of small individual interactions. An example of how faculty reacted positively to questions is illustrated by the following statement by one student, "When you ask a question and a faculty member is really supportive and they don't look down on what you ask, they just answer this is what it is." A less supportive response is illustrated by the statement by another student, "if we ask a question that is dumb he looks down on us, so it's really intimidating."

In addition to responding to questions, short interactions with faculty had a big impact on the student's experiences in math courses. One student illustrated the impact of a faculty connection as being the most positive experience in calculus.

> "My math teacher was sitting outside on one of the picnic tables and I didn't want to sit with him and talk about math….so I sat on a bench …. He was going back into his office and he stopped by and was talking to me….How are your classes going? Then he said he didn't care about the other classes just mine, it kinda made me laugh… It was kinda of like your cool and we joke around now. I feel like I know him a lot better. Listening to him lecture I have that connection: you know what you're talking about I will believe what you are saying. I mean I guess it showed because I did a lot better on my last test. That was the best positive experience that I have had in calculus. It was getting that connection."

Along with faculty interactions, the importance of peer support was highlighted, describing how students worked with other students in math courses. Two students shared that they looked for students that were doing better than them, and then would ask them to be in a study group. Another example was a network of students beginning with two students working together, each branching out to other friends, and then coming back together to complete the homework. The value of peer support was further highlighted when a student shared that she would rather work with other students than a faculty member, even if it took longer to get the correct answer.

The other prominent research finding was the tremendous impact that faculty had on student's self-belief in being successful illustrated by the quote below.

> "I went in [to her office] and said I can't do Calc II, I'm a fraud, and she said yes you can. She said we are going to sit down and go through this exam and she went question by question and she said what did you do wrong? It's not like you don't understand what's going on sometimes you are reading the question incorrectly. You know the material you just need to interpret the question and answer it correctly. Okay that clicks. She didn't give up she didn't brush me aside as one of twenty students. She remembered my name which was important."

These results illustrate the power of faculty and student connections integral to first-generation low-income student experiences in math, and especially the impact of faculty believing in student success. Another student experience was how they were able to improve their low grades with new strategies and continued effort which relates to having a growth mindset.

Concerning the survey results, there was 322 respondents, with a 67% response rate. The questions analyzed in this study focused on faculty and student interactions, and self-belief in mathematics. Focusing on faculty interaction, survey frequencies found a higher percentage of first-generation students (21%) compared to continuing generation students (16.5%) saw their instructor outside of class. Chi-square results indicated a statistically significant association between first-generation status and faculty interaction, $\chi 2$ (5) = 11.879, $p < .05$. The effect size was small (Cohen, 1988), Cramer's V = .172. Focusing on interactions with peers for all students, there were higher percentages of working with peers than instructors, and higher percentages with first-generation and low-income students compared to their continuing generation and higher income peers. Aspects of self-belief studied were confidence, ability to do math, and growth mindset. The survey results indicated that most first- generation (66%) and continuing generation (53%) significantly or moderately increased their confidence in math by taking calculus. More importantly, chi-square results indicated a statistically significant association between first-generation students and increased confidence, $\chi 2$ (5) = 14.477, $p < .01$. The effect size was small (Cohen, 1988), Cramer's V = .19.

Along with confidence, findings about a student's ability to learn mathematics revealed that most first-generation students (68%) and low-income students (76%) said that their math ability "moderately or significantly increased" with taking calculus. Additionally, 73% first- generation students and 80% low-income students shared that their growth mindset "significantly or while taking first year calculus. There were no statistically significant differences of the ability to do math and growth mindset between first-generation and low-income students compared to their peers.

Discussion

A major highlight of this research was the importance of faculty and staff connections and the positive impact that calculus had on students' increased confidence in math which was higher for first-generation and low-income in comparison to their continuing generation and higher income peers. Although strong faculty and student connections reinforce well established high quality teaching practices, it is an important reminder to keep these qualities at the forefront especially in college courses. Additionally, in light of the research findings that first-generation low-income students are working with peers outside of class at higher rates than instructors, perhaps more intentional integration of student study groups would be impactful.

Although the survey findings are based on small sample sizes, results may suggest a possibility that historically marginalized first-generation and low-income students are gaining self-belief as part of their experience in calculus courses at this institution. This is an important finding considering the stereotype threat that is well documented with students having marginalized identities. Learning even more about how faculty can provide an environment for enhancing student self-belief is recommended. Additionally repeating this same study at other institutions as part of the Progress through Calculus research project, will provide cross institutional results and additional insights. These findings will hopefully suggest ways to create an environment that promotes self-belief in developing the talent of first-generation low-income students, thereby increasing success in math.

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