8-2018

Map of MathWorld: Identifying Core Practices for Successful Supplemental Instruction of Community College Math Students

Shannon A. Patterson
University of the Incarnate Word, spatt89@yahoo.com

MAP OF MATHWORLD: IDENTIFYING CORE PRACTICES FOR SUCCESSFUL SUPPLEMENTAL INSTRUCTION OF COMMUNITY COLLEGE MATH STUDENTS

by

SHANNON A. PATTERSON

A DISSERTATION

Presented to the Faculty of the University of the Incarnate Word
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

UNIVERSITY OF THE INCARNATE WORD

August 2018

ACKNOWLEDGMENTS

There are many people I would like to thank for their encouragement and support during my journey in completing my dissertation and doctoral studies. First and foremost, I want to give thanks, glory, and all honor to God for His guidance and strength. Truly, I acknowledge His footprints in the sand during those moments when I needed to be carried along the way.

Next, I would like to thank my dissertation committee:

- My committee chair, Dr. Alfredo Ortiz, thank you for your patience, guidance, and support during the dissertation process.
- My methodologist, Dr. Annette Craven, from your advice during our first consultation to serving on my dissertation committee, your encouragement and guidance have always been extremely valuable and greatly appreciated.
- My content expert, Renita Mitchell, words cannot express the treasured fellowship, inspiration, and assistance you provided since the very beginning, and I am extremely grateful to you.

I would also like to thank a team of people who supported me to complete this achievement:

- Dr. Judith Beauford, Dr. Norman St. Clair, and Dr. Osman Ozturgut who provided insight during my time in the doctoral program.
- Dr. David Fike, Dr. Robert Walling, and Dr. William Duffy who have been insightful mentors throughout my PhD studies.

Acknowledgments—Continued

- Dr. Charita Ray-Blakely and Sia Achica for their tremendous editorial support, time, and assistance in making recommendations and proofreading this work.
- Dr. Patricia Adams for supporting me during some pivotal moments in my life that also occurred during the course of my doctoral journey.
- My friends, coworkers, and fellow students who have encouraged me during this special chapter of my life.

Special appreciation goes to the amazing individuals who agreed to be involved in this study. You have been extremely instrumental in contributing to the body of knowledge, and your service to the community is invaluable.

Shannon A. Patterson

DEDICATION

This work is dedicated to my parents, Jackie and Bessie Patterson. You were my guardian angels on earth, and now you are in Heaven watching over me. As I reflect on my life and begin new adventures, my prayer is that I will continue to live my best life (with the help of the Lord) and make you proud. I honor you, I appreciate you, and I will always love you.

I also dedicate this work to my sisters, Deborah, Quida, and Jocelyn. When one succeeds, we all succeed. You earned and deserve this degree as much as I. Your constant prayers, listening ears, encouragement, and support mean more to me than you will ever know. I love you very much!

Shannon A. Patterson

MAP OF MATHWORLD: IDENTIFYING CORE PRACTICES FOR SUCCESSFUL SUPPLEMENTAL INSTRUCTION OF COMMUNITY COLLEGE MATH STUDENTS

Shannon A. Patterson, PhD

University of the Incarnate Word, 2018

MathWorld, a math support program at St. Philip's College, is designed to assist students with study skills and gaining understanding of math concepts. The overarching purpose of this study was to better understand and explore the impact of participation in MathWorld on student success in developmental math courses from the perspectives of math faculty and staff at a local community college.

For this study, a qualitative research design was utilized to explore the impact of participation in MathWorld on student success in developmental math courses. Through interviews, a survey, and student testimonials, the researcher sought to understand this from the viewpoints of the most relevant knowledge-holders: math faculty and MathWorld staff. They have a unique set of feelings and lessons learned from their experiences with the students that they serve.

The conceptual model of MathWorld is interactive in nature, because it requires the participation from students, as well as the math faculty and MathWorld staff. The integration of all three components, cultivating content-specific skills, supporting life skills, and providing holistic interventions for student transformation, make up the "secret sauce" of MathWorld. This study added to the existing body of knowledge, which identified best practices. These practices

could be replicated in math support programs at community colleges that desire to make positive, lasting, and consistent effects on student success in developmental math courses.

Three key conclusions were drawn from this research. First, the principal investigator discovered the Transformation through Dynamic Interconnectivity model. Second, this study uncovered a lack of attention given in research and practice in meeting developmental math needs. Third, this research revealed a need for a theory to explain learner dynamics in developmental contexts.

TABLE OF CONTENTS

Table of Contents—Continued

Table of Contents—Continued

Table of Contents—Continued

Table of Contents—Continued

LIST OF TABLES

LIST OF FIGURES

MathWorld: A Solution to Math Illiteracy

Context of the Study

At its core, this study is about developmental math which has been a problem in the United States for decades. According to DeSilver (2017), the United States ranked “an unimpressive 38th out of 71 countries in math [literacy]” based on results from the Programme for International Student Assessment (PISA) from 2015 (para. 2). The impact of math illiteracy in areas such as personal finances, college success, and reduced employment opportunities cannot be overlooked. For many jobs in this world economy, there is a high demand of workers who “are mentally fit—workers who are prepared to absorb new ideas, to adapt to change, to cope with ambiguity, to perceive patterns, and to solve unconventional problems” (National Research Council, 1989, p. 1). The ability to think mathematically can prepare workers to fulfill such expectations. Although occupations in science, technology, engineering, and math are increasing, “there is concern that the US is still not preparing a sufficient number of students, teachers, and professionals” in these areas (Sergeyev et al., 2018, p. 2). This lack of sufficient math preparation can result in loss of competitive advantage in many fields, and the aforementioned fields become filled through outsourcing or non-resident aliens. As a consequence, this means loss of higher paying jobs for U.S. citizens.

Math deficiencies can seriously impact lives as well as livelihoods. In the medical field, for example, a nurse or doctor who does not know about measurement and working with dosage could be fatal to a patient. Glover and Sussmane (2002) performed a study to assess medical residents’ abilities to perform “basic mathematical calculations used for prescribing medications to pediatric patients” (p. 1007). The results showed that the overall average test score of the

participants was 65%. It was also noted that “seven residents performed tenfold dosing errors and one resident performed a 1,000-fold dosing error” (p. 1008).

Math teachers, at different academic levels, have assisted students through struggles with math. Research suggests that although math is a necessary skill, some students often fare poorly in the subject. Because of that, many formal, math support programs have been developed to assist students.

Community colleges have a student body that is unusually deficient in math skills. These deficiencies make it particularly important to study. Fike and Fike (2008) state that

> the typical community college student possesses different characteristics than the traditional university student. ‘About 60 percent of adults (25 and older) who study at the undergraduate level are enrolled in two-year/community colleges’ (Aslanian, 2001, p. 29). Community colleges are also more likely to enroll higher percentages of minority students than the university. According to Cohen and Brawer (1996), ease of access, low tuition, and the open-door policy have contributed to the increased numbers of minority students in community colleges. Students from ethnic minority backgrounds are more likely to enroll on a part-time basis and are more likely to be from low-income families. Community colleges encourage part-time attendance and have lower tuition than universities. (p. 3)

There are other systemic issues that contribute to low performance in college-level math courses. Community colleges provide opportunities for incoming students to take developmental math courses in order to prepare the students for college-level math courses.

> In addition, community colleges tend to enroll more underprepared students than the university. …Because of the open-door policy, underprepared students are encouraged to enroll in a community college, where they can take advantage of developmental education, or remedial courses: ‘Ninety five percent of community colleges offer remedial education courses, most in multiple ability levels. Forty-one percent of entering community college students and 29 percent of all entering college students are underprepared in at least one of the basic skills (reading, writing, math). (McCabe, 2000, p. 4)

I have worked with several students whose math weaknesses have affected their performance. Some of the manifestations of this problem include math weaknesses, lack of

confidence, and socio-cultural factors. Many students may also not be aware of the various study strategies that can help them understand math concepts or how to use these study strategies. In addition, lack of confidence (albeit not as visible) is something that causes students to perform below their ability to do math. From a socio-cultural standpoint, many factors contribute to low math performance. These factors may include the following: students' parental education, importance of being a community leader, and "participation or leadership in community service" (Crisp & Nora, 2010, p. 178). Perhaps the students are reliving past experiences with other math classes and thinking that my class will be no different from what they have already experienced.

All things considered, St. Philip's College (SPC) endeavors to address this growing concern of math illiteracy in the United States. SPC is a community college that is "dedicated to meeting the educational needs of San Antonio's growing community" (SPC, 2017, p. 10). Founded in 1898, SPC is located in the southeastern part of San Antonio, Texas, and has an enrollment of over 11,000 students (p. 10). SPC serves a diverse community, as the majority of enrolled students are from underrepresented populations. As of the Fall 2016 semester, the student population comprised 11% African American, 56% Hispanic, 27% White, 2% Asian, 1% International, and 3% Other. SPC is federally recognized as a Historically Black College/University (HBCU) and a Hispanic Serving Institution (HSI) (St. Philip's College Viewbook: A Point of Pride in the Community, 2017). While there are a variety of academic assistance programs at SPC, there is one specific program that has become a solution to developmental math issues: MathWorld.

What is MathWorld?

MathWorld, a math support program at St. Philip's College, is designed to assist students with study skills and gaining understanding of math concepts. This program was the brainchild

of Mary Cottier, former Chair of the Math Department. Dean Cottier's desire was to see the passing rate for math improve at SPC. Unfortunately, the passing rate was considerably low (12%). By passing rate, I mean the percent of students who utilized the developmental math lab and subsequently passed their regular developmental math courses.

During her tenure, a candidate for a teaching position, Dr. Robert (Bob) Walling, caught her eye. Dr. Walling was a U.S. Air Force Veteran with expertise in the area of computer science and working on educational issues for the visually impaired. Prior to enlisting in the Air Force, Bob was a farm boy in a rural community in Washington State. He worked his way up to being a First Sergeant in the Communications Squadron in upstate New York, which gave him access to several colleges. He was one of the first enlisted people to enter a pilot program, leading to a commission in the Air Force. As a commissioned officer, he worked as a research scientist in the field of intelligence. Bob's service career spanned 24 years and took him to various places and enabled him to gain experience through the various jobs held worldwide.

During his time in the service, he was an adjunct faculty professor in several different disciplines to supplement his income. After retiring from the military, he took a position with the State, producing braille materials for the visually impaired. Upon establishing braille programs, Dr. Walling transitioned to a full-time employee at St. Philip's College, where he had been an adjunct faculty for several years. Bob continues to be active in community affairs to promote veterans.

Not only did he have the necessary qualifications to teach math, Dr. Walling—or Bob as he became affectionately known—was passionate about the subject and seemed intuitive when it came to reaching out and motivating students to utilize math tutoring. In 2005, SPC set up a developmental math lab in which there were 1,200 student visits (R. Walling, personal

communication, April 2018). In my interview with Dr. Walling, he recalled a discussion, during his initial meeting, with Dean Cottier about this problem:

> During that semester, Mary called me in and said, *We've got a problem with math…at a 12% passing rate.* And they tried having a math lab…a developmental math lab…for a year, but it really hadn't changed anything. And so, she said, *I know who you are*, *because I hired you for the computer science department…*

During that timeframe, former Dean Cottier was chair of a department that encompassed math, computer science, and business.

> *Have you got any ideas on how we can improve the math scores?* Well, you could try this, you could try that, you could try these things…I just gave her ideas. Just like I do right now, when people come in…you come in, and I say, Hey, how about trying this? How about trying that? If you do, okay. If you don't, eh…it's up to you. I gave her some ideas.

Dr. Walling elaborated on how MathWorld began:

> A few weeks later, still in that same first semester, she said, *I got it approved to start in the fall.* At that time, I was under the impression I was gonna die any day anyway, because I was retired-retired and just plain tired. And I told her, no, thank you. I appreciate the offer. She said, *No, you don't understand. You start in the fall.* …So, I said, Fine. … We were on the 3rd floor, and I came down to Mary. What did you really have in mind that I'm supposed to do? [She said] *Do whatever it takes to move this thing forward.*

Since 2006, MathWorld has helped students achieve success in math courses. According to Dr. Walling, more than 46,000 students have utilized the services of MathWorld (Personal communication, July 2018). In particular, developmental math students, who have visited MathWorld on a consistent basis, typically achieve a final score of A, B, or C in their math course. As identified by SPC's Office of Planning and Research, developmental math students who visit MathWorld an average of two times per week or more, successfully complete the course at a rate of 77%, compared to students who do not utilize MathWorld, whose successful completion rate is only 60%. This is important because St. Philip's College, like other community colleges, has a large enrollment of students needing developmental math courses.

Based on SPC's Fall 2015 Semester data, almost 25% of the student population require developmental math.

Overview of MathWorld

Students have access to personalized instruction and services in MathWorld, which is located in the William C. Davis Science Building on the main campus (Martin Luther King) of St. Philip's College. Students may use the facility to complete homework and prepare for unit quizzes, tests, and final exams in their math courses. MathWorld has four main areas: Computer Lab, Looney Bin, Pencil Pavilion, and Engineering Station.

Computer lab. The Computer Lab has 64 computers that contain math programs and online learning management system platforms. ALEKS, MyLabsPlus, Connect Math, and Hawkes are examples of the online learning management system platforms that students use in their course. In this space, students may work independently or by classroom groups on assignments, in their respective math program, for their course. Students also receive MathWorld orientation by Dr. Robert "Bob" Walling during the first week of each semester. Dr. Walling has been dedicated to delivering every orientation since his arrival at MathWorld in Fall 2006. During the orientation, Dr. Walling goes through what the expectations are in MathWorld, where everything is located, and helps students register for the computer-assisted math program that corresponds to each math course.

Looney bin. Named in honor of the late Ms. Looney, a former MathWorld staff member, this area contains two computers, one long table, and two dry erase boards. Students who prefer to work in a quiet area or in small groups may reserve this room. Students also receive supplemental instruction in this location.

Pencil pavilion. The Pencil Pavilion contains eight tables with six chairs apiece, along with bookshelves of math textbooks, four fixed dry erase boards, one moveable dry erase board, math handouts (e.g., formula sheets), and office supplies (e.g., pencil sharpeners, writing utensils, and staplers). This space is designed for students to collaborate in small group study sessions and class projects. Students may also work independently using their own electronic devices.

Engineering station. This area contains 10 computers, one cloud printer, one 3-D printer, one long table, and one dry erase board. The Engineering Station is a space reserved for engineering students and those pursuing a STEM (Science, Technology, Engineering, and Math) degree and currently enrolled in the STEMed Immersion Program.

The clientele of MathWorld is not limited to students enrolled in developmental math courses and is not exclusive to students attending St. Philip's College. Students who take online math courses (developmental or college-level) also attend MathWorld. Students from other colleges within the district, such as Palo Alto, Northwest Vista, Northeast Lakeview, and San Antonio also visit MathWorld, because we do have students that attend more than one college. Students may receive tutoring help in any area of MathWorld.

What about Bob? The uniqueness of MathWorld's paraclete delivery system. The following is an excerpt from my interview with Dr. Walling, the Coordinator of MathWorld. In the excerpt, he described the origin of the "Bobs."

> Thursday, I started running into classrooms. As you can imagine this, you're a teacher in the classroom. You're trying to factor a polynomial on the board, and some idiot runs in and says, Hi! I'm Bob! I'm your Bob! Come on down to MathWorld and pass this class! and ran out. The teachers are up there, *What the…? I didn't ask for any of this…* The kids were amused. They started coming down, and coming down, and coming down.

As the number of student visits to MathWorld increased, Dr. Walling recognized the need to increase the number of staff:

> And so then, we started filling up and stuff. I gotta get some tutors, and the first two tutors I hired were Tom and John. And *that's* where the Bob-thing started. Because I'm running into classrooms saying, Hi! I'm Bob! I'm your Bob! Come on down to … you know. Because I was only kidding around 'cause I was only going to be here for, like, *a* semester. And I *really* want you to understand this whole thing was a joke. It was not planned out that it was going to be a success, and we were gonna help kids and all that jazz. It was just a big joke.

In his recollection of MathWorld's inception, Dr. Walling described an initial conversation between the students and the two tutors, Tom and John.

> So, when people came in and they said, *I need help. Are you Bob?*
> *No, I'm Tom*.
> *Well, no. No. I want Bob.*
> *Well, you know, actually people have always called me Tom Bob.*
> And John, *Well, I've always, you know, thought of myself as John Bob.* And that started the Bobs.

"Bobs" are math support program specialists named after Dr. Walling. They represent a wide demographic population with regard to age, gender, ethnicity, and private and public sector experience. All "Bobs" have a Bachelor of Science degree or higher in Math or a related field, such as accounting, engineering, physics, business, biology, and chemistry.

The "Bobs" also have a unique paraclete delivery system, which brings significance to the name. The term *paraclete,* which means advocate, comforter, or support is used by the researcher because of the observed behaviors of the Bobs as they interact with students (Paraclete, n.d.). They establish and maintain a rapport with the students that enter MathWorld. Instead of solving the problem for the student, the "Bobs" utilize scaffolding questions and provide resources for the purpose of facilitating and reinforcing instruction in the classroom. Subconsciously, they also serve as models and mentors for the students. Dr. Walling often says the phrase, "You and your 'Bob' can pass math" during Orientation Week. He usually combines

the saying with a symbolic gesture of putting his fists together: one fist represents the student, and the other fist represents the “Bob” that provides math support for that student, hence, the paraclete model.

Conceptual Model of Math World

I credit my content expert, Mrs. Renita Mitchell, for the diagram that illustrates the conceptual model of MathWorld (Figure 1).

The visual representation of the conceptual model is meant to be read from bottom to top. It appears as a figure of a house, which suggests that at the bottom the house, there is a foundation. In the context of this study, my thought is that the developmental math courses serve as the foundation. Many of the students who attend SPC take developmental math courses because, at the onset of their college career, their math skills are not sufficient to be successful at the college level. Successful completion of at least one college-level math course is one of the graduation requirements in obtaining any degree. However, there is something that needs to happen between the foundation (developmental math classes) and the ultimate goal (success in college-level math).

While developmental math classes provide a foundation for students to learn, understand, and master the math concepts necessary for college-level math courses, they are not solely the important elements that play a critical role in student success in college-level math courses. Also, the developmental math courses do not always provide maximum flexibility of time and space for customized attention in addressing study skills (such as becoming better problem solvers). MathWorld, however, is a math support program that provides four pillars of support in tandem with the developmental education courses. These four supporting elements are: hard skills, soft skills, critical thinking skills, and self-efficacy.

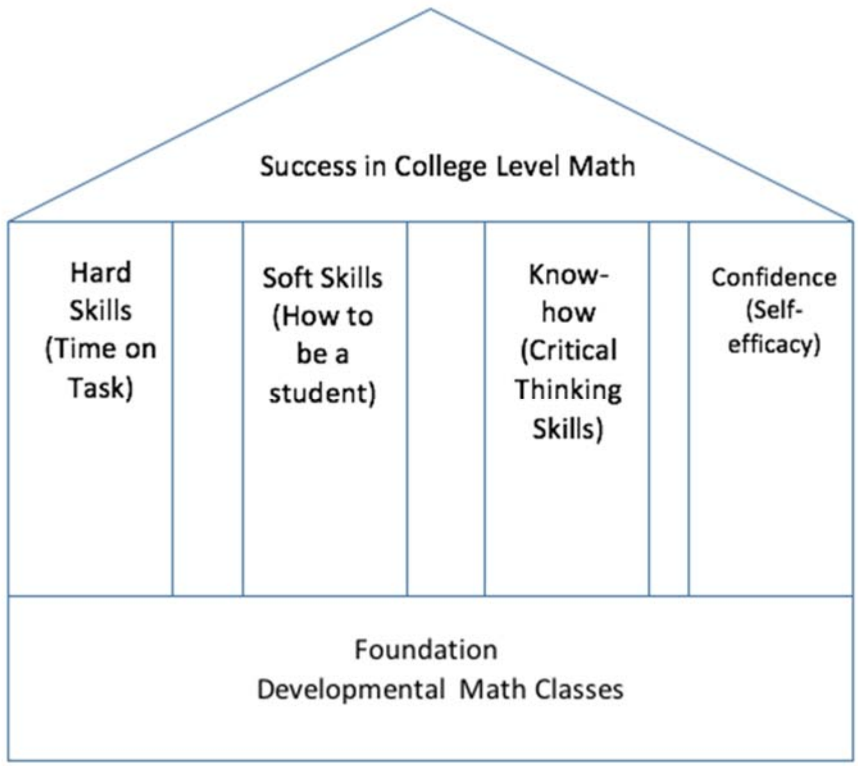

Figure 1. Conceptual model of MathWorld, courtesy of Renita Mitchell.

Hard skills are skills which can be taught, such as reading, math, and writing. Soft skills include how to study, how to do homework, and how to manage time. Critical thinking skills consist of trouble-shooting, recognizing mistakes based on common sense, and applying problem-solving skills. Finally, self-efficacy deals with improving students' beliefs in their math abilities and helping other students.

Problem Statement, Purpose of the Study and Research Questions

Math literacy is a fundamental issue in education, from Pre-K through college. Although there is no shortage of developmental education, e.g. tutoring, in college campus environments, very little is known about how math support programs support student effectiveness in developmental math courses. Perin (2004) suggests "there is little research into the ways in which they aid in the enhancement of the academic skills of either developmental education or college-credit student" (p. 561). An exhaustive review of the literature revealed only three case

studies exploring developmental math in the community college environment (Galbraith & Jones, 2006; Finney & Stoel, 2010; Cafarella, 2014).

A study is currently needed to understand how MathWorld uniquely contributes to student success in developmental math courses. Bettinger, Boatman, and Long (2013) suggest that finding “ways to improve the quality and delivery of these support systems remains a key challenge for administrators and practitioners, as does identifying the specific components of successful interventions” (p. 108). I will investigate and identify the *secret sauce* of MathWorld, or important core practices that have a lasting, positive effect on student performance in math. Specifically, I will link these core practices into a conceptual model of success for developmental math students.

Therefore, *the overarching purpose of this study is to develop a deeper understanding and explore the impact of participation in MathWorld on student success in developmental math courses, from the perspectives of multiple stakeholders (faculty, staff, students, researcher) at a local community college.* In order to gain understanding about MathWorld’s influence on developmental math students, the following research questions were formulated:

1. What is the conceptual model and the underlying core practices for the success of developmental math students?
2. How does usage of MathWorld support the development of math competencies and affective behaviors necessary for student success in developmental math courses?

Summary of Appropriate Method

For this study, I explored the impact of participation in MathWorld, specifically by developmental math students, through the lived experiences of math faculty and staff at a local

community college. I used Creswell's (2013) design for qualitative research, which he defines as:

> Qualitative research begins with assumptions and the use of interpretive/theoretical frameworks that inform the study of research problems addressing the meaning individuals or groups ascribe to a social or human problem. To study this problem, qualitative researchers use an emerging qualitative approach to inquiry, the collection of data in a natural setting sensitive to the people and places under study, and data analysis that is both inductive and deductive and establishes patterns or themes. The final written report or presentation includes the voices of participants, the reflexivity of the research, a complex description and interpretation of the problem, and its contribution to the literature or a call for change. (p. 44)

Although I drew from Creswell, I used my own hybrid qualitative approach to study a case to identify the core practices of MathWorld that provide enduring positive effects of student success in developmental math. A case study approach, according to Yin (2017), "allows an investigation to retain the holistic and meaningful characteristics of real-life events" (p. 3). I explain these choices in more detail in chapter 3.

Creswell and Poth (2017) describe several essential features of qualitative research that apply to my study: natural setting, researcher as key instrument, emergent design, and reflexivity (pp. 43-44). The natural setting was MathWorld, the place where the "participants experience the issue or problem under study" (p. 43). The role of researcher as key instrument was demonstrated by way of collecting the data through interviewing the participants (p. 43). The emergent design was evident during the development of the study as the interview questions, survey, testimonials, and data collection methods were generally prescribed (p. 44). With regard to reflexivity, I conveyed my lived experiences as a math instructor and sought to achieve my personal goals and practical goals (p. 44). I sought knowledge about best practices in helping students understand math concepts, increase their awareness of the applicability of the subject to their everyday lives, and improve their dispositions toward the subject.

Research Strategy

In this case study, I developed "an in-depth description and analysis" (Creswell & Poth, 2017, p. 67) of how MathWorld uniquely achieves its impact on developmental math students based on the viewpoints of the math faculty and MathWorld staff. According to Creswell and Poth (2017), "many forms of qualitative data, ranging from interviews, to observations, [and] to documents" (p. 98) are germane to the case study method because the process involves relying on more than one source of data. In alignment with this process, I used interviews, a survey, and student testimonials as multiple sources of data. Qualitative research served as an appropriate method because there is a need to identify MathWorld's core practices and link them into a conceptual model of success for developmental math students.

Role of the Researcher

As a full-time math instructor at St. Philip's College, most of my teaching assignments have been developmental math courses such as Beginning and Intermediate Algebra. These courses are designed to help students prepare for the college-level math course they need, as required by their major.

As part of the Alamo Colleges System, St. Philip's College's student body includes of 63% minority students, the majority of whom are African American and Hispanic. According to the results of the math placement exams, at least half of incoming minority students are required to take developmental math courses. At present, St. Philip's College provides several math support programs, in addition to their coursework, to assist students to improve their mathematical abilities. Unfortunately, many students struggle in developmental math courses due to personal issues, academic background, and/or affective behavior.

My lived experiences as a math instructor and current research reflect a fundamental challenge in teaching math at the community college level. A universal study of students' deficiencies in math at post-secondary institutions is necessary.

Theoretical Framework

I used four theoretical models to help me conceptualize this study: Graham and Weiner's (1996) Attribution Theory, Astin's (1999) Student Involvement Theory, Mezirow's (1991) Transformative Learning Theory, and McClelland's (1961) Theory of Needs. Explanations for these theories will be provided in Chapter 2.

Significance

This study promises to add to the developmental math literature by revealing the impact of math support programs on the success of minority students attending a community college. Perin (2004) suggests that "there is little research into the ways in which they aid in the enhancement of the academic skills of either developmental education or college-credit students" (p. 561). In addition, this study can generate and promote possible best practices for the necessary level of participation in developmental math courses to minimize struggle. Moreover, it will create opportunities for practitioners and policyholders to replicate these core practices at other community colleges to ensure consistent and sustained success in the subject. Future researchers will also find interest in determining correlations between quantitative data (such as number of student visits to a math support program) and each component of the conceptual model of success for developmental math students.

Definition of Terms

The following terms are defined to understand their use within the context of this study:

Hard Skills—"specific, teachable abilities that can be defined and measured, such as typing,

writing, math, reading and ability to use software programs" (Investopedia, 2018).

Soft Skills—"character traits, attitudes, and behaviors—rather than technical aptitude or knowledge. Soft skills are the intangible, nontechnical, personality-specific skills that determine one's strengths as a leader, facilitator, mediator, and negotiator" (Robles, 2012, p. 457).

Critical Thinking Skills—"analyzing, judging, hypothesizing, explaining, and many other cognitive activities besides deciding and problem-solving" (Lipman, 1987, p. 5).

Self-Efficacy/Confidence—"a person's own judgment of capabilities to perform a certain activity in order to attain a certain outcome" (Zulkosky, 2009, p. 95).

Developmental Education (DE) Courses—"refers to the continuum of undergraduate courses and services ranging from tutoring and advising to remedial coursework and other instruction to prepare students for college level (and therefore work-ready) courses and continued academic success" (THECB, 2008, p. 1).

Developmental Mathematics (DM) Courses—a sequence of "mathematics courses that starts with basic arithmetic, then goes on to pre-algebra, elementary algebra, and finally intermediate algebra, all of which must be passed before a student can enroll in a transfer-level college mathematics course" (Stigler, Givvin, & Thompson, 2010, p. 4).

Community Colleges (CCs)—"sometimes called junior colleges, are two-year schools that provide affordable postsecondary education as a pathway to a four-year degree" (U.S. Department of Homeland Security, 2012).

Historically Black Colleges/Universities (HBCUs)—

> The Higher Education Act of 1965, as amended, defines an HBCU as: "…any historically black college or university that was established prior to 1964, whose principal mission was, and is, the education of black Americans, and that is accredited by a nationally recognized accrediting agency or association determined by the Secretary [of Education]

> to be a reliable authority as to the quality of training offered or is, according to such an agency or association, making reasonable progress toward accreditation." HBCUs offer all students, regardless of race, an opportunity to develop their skills and talents. These institutions train young people who go on to serve domestically and internationally in the professions as entrepreneurs and in the public and private sectors. (U.S. Department of Education, 2018)

Hispanic-Serving Institutions (HSIs)—

> an institution of higher education that (A) is an eligible institution; and (B) has an enrollment of undergraduate full-time students that is at least 25 percent Hispanic students at the end of the award year immediately preceding the date of application. (U.S. Department of Education, 2016)

Core Practices— "identifiable components…that teachers enact to support learning. Core practices include both general and content-specific practices and consist of strategies, routines, and moves that can be unpacked and learned by teachers" (Core Practice Consortium, 2018).

Limitations of the Study

This study was no exception to limitations. The first challenge was scheduling the participants. Schedules were limited to the week of final exams, which varied based on the instructors' availability. Some individuals came after final exams were administered. Others either came in between departmental duties or had family obligations and could not participate.

Another limitation was regarding the sample size of the qualitative study. Only 11 participants who were connected with MathWorld were interviewed. Therefore, findings cannot be generalized to other learning labs at other institutions. A third limitation was that the study was limited to one school, an HBCU, in one state. With these limitations, the findings might not be generalized in any shape or form to another location.

A fourth limitation is based on the wording of the last interview question: How would you describe the student impact of MathWorld? This question should have been modified to:

How would you describe MathWorld's impact on student success? A fifth limitation to the study was the timing of the data collection for the interviews. Ten of the 11 participants were interviewed a week before Christmas break during the week of Fall 2017 final exams. The 11th participant was not available for the interview during that time frame because of prior commitments out of state. Arrangements were made with this participant to conduct her interview the week before the Spring 2018 semester officially began. If the researcher attempted to conduct the interviews weeks before Christmas break or weeks after the start of the Spring 2018 semester, then there would have been a possibility of receiving more negativity in the responses or a low response rate.

How to Read This Dissertation

Chapter one introduces MathWorld and the study purpose, which is to identify MathWorld's core practices and link them into a conceptual model of success for developmental math students. In chapter two, I review literature to help me frame the study in more detail, and explain what other researchers have to say about the research background, problem and purpose. In chapter three, I explain the steps I took to collect and analyze data for this study. In chapter four, I present the findings. Lastly, in chapter five, I interpret the findings from the study, along with conclusions and recommendations for future research.

Review of the Literature

As stated in chapter one, math illiteracy is a problem in the United States. In order to explore the nature of how this problem relates to developmental education, with developmental math in particular, I reviewed the available literature, focusing predominantly on post-2000 research because of the impact technology has had in the way we function in the educational environment. I used ProQuest, Google Scholar, ERIC, and Academic Search Complete databases to search and gather scholarly journal articles and book chapters. In addition to related research, the following are a few areas of study that the researcher explored to better understand how stakeholders (administrators, educators, and students) address the problem of math illiteracy: (a) developmental education, (b) developmental math, (c) community colleges, (d) minority-serving institutions, and (e) relevant theories. Taking a comprehensive look at the problem of math illiteracy through these lenses help shape the rationale for this study and identify gaps in literature and research.

Developmental Education

The developmental education program has gained increasing national attention throughout the years. Developmental education courses are designed to support students who are deficient in the skills that are necessary for college-level courses and overall academic success. Bettinger et al. (2013), in their article, discussed various aspects of developmental education. For example, they described the population of students who are typically underprepared and in need of developmental education: recent high school graduates, adult workers, and individuals who speak English as a second language (p. 95). The authors also described the various delivery structures of developmental education courses, such as a “semester-long format” and “multiple levels of remedial and developmental courses within a subject area” (pp. 95-96). As I mentioned

in Chapter One, the majority of the developmental education students I have worked with have struggled in the course due to personal issues, poor academic backgrounds, and/or affective behavior. Some students, for example, have requested a withdrawal from the course due to changes in their work schedules, in their own health issues, or other family emergencies. This confirms what Bettinger et al. (2013) describe as the numerous difficulties that students in developmental education programs encounter upon entering college, such as “inadequate preparation, competing obligations to work and family, and limited experience navigating the complexities of collegiate systems and requirements” (p. 94).

In their article, Boylan and Bonham (2007) reviewed the “context and history of the field of developmental education served by the National Center [for Developmental Education at Appalachian State University] during the past 30 years” (p. 2). Boylan and Bonham (2007) mention the integration of “study skills and learning strategies, critical thinking, and other approaches” (p. 2) in some developmental courses to address the students’ intellectual and emotional necessities. This illustrates the point that Bailey (2009) made regarding the implementation of tutoring services and learning assistance centers made available by colleges. Virtually all developmental courses at SPC incorporate activities that address a wide variety of topics, ranging from notetaking tips to managing stress, to help students navigate through their college experience. In addition to MathWorld (for Math and Engineering), SPC currently provides tutoring services in the following locations: MathSouth (for Math Bridge Program to assisting Applied Science courses), Tutoring and Technology Center (TnT), Rose Thomas Writing Lab, Reading Lab, and the Dr. Lanier E. Byrd Sanctuary (for science courses). The tutoring staff at each location assists students in various courses and subjects.

Bailey, Jeong, and Cho (2010) conducted a quantitative study to determine the correlation between students' referral to developmental education and actual enrollment. In addition to monitoring students' academic progress throughout the developmental course sequence, the authors investigated the demographic and institutional features that are associated with "the completion of sequences and exits at different points along them" (p. 2). Bailey et al. utilized a dataset that comprised Achieving the Dream: Community Colleges Count, a national community college initiative, and the National Education Longitudinal Study of 1988. Multivariate analyses were used to discover the relationship between the attributes (student and college) and the prospect of continuing through developmental education. The results showed that over 50% of the community college student population have registered for at least one developmental education course during their college experience.

Many scholars have acknowledged the benefits of developmental education. For example, Shields (2005) mentioned that the program offers an assortment of support services to address the students' academic and psychological needs, such as tutoring, counseling, learning assistance centers, and supplemental instruction. One of the challenges regarding the program, however, is that some policy makers and critics of developmental education have sought to remove it as a budgeting effort as well as a means to raising curriculum standards (Shields, 2005). In her article, Shields (2005) offered suggestions for administrators and faculty to "take proactive measures" in the survival of developmental education programs (p. 47). Hiring instructors who have "command of the subject matter, knowledge of adult learning theory, the ability to vary instruction, the ability to implement technology, the skill to integrate practical classroom and laboratory exercises, and a true desire to teach developmental classes," for example, is critical. The author also posits that developmental instructors should endeavor to

establish a rapport with developmental students. In addition, Shields (2005) stated that the evaluation of developmental education programs, along with professional development for faculty and staff, and support from institutional leaders, are essential to the survival of these programs. Boylan and Bonham (2007) noted that many institutional leaders from multiple states are aware of the need and impact of developmental education and are attempting to incorporate best practices based on research to provide these services.

In the monograph entitled *Developmental Education: A Twenty-First Century Social and Economic Imperative,* McCabe and Day, Jr. (1998) stated the following:

> With increasing workforce demands and growing diversity, postsecondary developmental education is a social and economic imperative for the nation. Community colleges are the best, if not the only, hope for delivery of developmental services. In the spirit of their mission of educational access and opportunity, community colleges are committed to develop an educated citizenry that contributes to national prosperity and equity. To achieve this promise, community colleges must be unequivocally sanctioned to respond to the needs of all students. (p. 32)

This is consistent with SPC’s Mission Statement:

> St. Philip's College, founded in 1898, is a comprehensive public community college whose mission is to empower our diverse student population through educational achievement and career readiness. As a Historically Black College and Hispanic Serving Institution, St. Philip's College is a vital facet of the community, responding to the needs of a population rich in ethnic, cultural, and socio-economic diversity. St. Philip's College creates an environment fostering excellence in academic and technical achievement while expanding its commitment to opportunity and access. (Mission, Vision, and Values/Strategic Plan, 2018, para. 1)

McCabe and Day, Jr. (1998) recognized that developmental education has been and will continue to be an essential element of higher education throughout history. Stakeholders (administrators, faculty, and students) at SPC also acknowledge the necessity of developmental education. SPC faculty and administrators, in particular, actively participate in professional development throughout the academic calendar to enhance their knowledge and skills in topics such as developmental education.

Developmental Math

Research continues to validate the significance of developmental math in higher education. In a study conducted by Abraham, Slate, Saxon, and Barnes (2014), the purpose was to "examine the college readiness in math of Texas community college students using archival data from the THECB [Texas Higher Education Coordinating Board]" (p. 28). Statistical procedures were used to analyze the data. The results of their study showed there were no statistical differences in the scores for college readiness in math. For example, the "percentage of FTIC [first time in college] developmental students who scored below the Texas college readiness standards in math were 40.63% in 2003 and 41.07% in 2008" (Abraham et al., 2014, p. 25). The authors also noted that SPC "ranked as having the highest percentage of FTIC students who were enrolled in developmental math classes" (p. 32). In the article, Table 1 showed that SPC had 73.84% of its FTIC population enrolled in developmental math courses in 2008 (Abraham et al., 2014, p. 32). Abraham et al., in their article, provide implications to their study, which include reform at the K-12 [grade] level, "more rigorous immersion in college preparatory mathematics by students at the secondary level," and the promotion of "more efficient and effective methods of developmental mathematics instruction" (pp. 38-39).

Researchers have cited a variety of reasons and challenges for the increasing number of students enrolled in developmental math courses. Since the majority of the student population enrolled in these courses are nontraditional, these students are more likely to attend a postsecondary institution on a part-time basis and are more likely to come from ethnic minority backgrounds as well as a low socioeconomic status (Fike & Fike, 2008). According to SPC's *Fall 2016 Quick Facts*, 88% of the student enrollment at SPC was at a part-time status (p. 1), and 73% of the student population came from minority backgrounds (p. 2).

Scholars have identified several factors that contribute to students' lack of success in developmental math courses. One such barrier is poor attendance. In a quantitative study conducted by Gupta, Harris, Carrier and Caron (2006), their purpose was to identify factors that contributed to student success in basic math courses. The authors used a questionnaire to collect data from a random sample of 30 classes from a public university, and "performed univariate analysis [of the data] using Mann-Whitney and the Kruskall-Wallis tests, and multivariate analysis using ordinal logistic regression modeling" (para. 1). The results, via statistical analysis, revealed that students who missed more class meetings tend to have lower success rates. Also, "students who had taken more remedial mathematics courses tended to receive lower grades" (Gupta et al., 2006, para. 21). The authors implied that "instructors can still design their teaching methods to improve student attitudes and foster student success" (para. 26). Although the study conducted by Gupta et al. took place at a four-year university, it supports this study. Virtually, all SPC math faculty have encountered a variety of student attendance issues. Some students may not have any difficulties with math per se, but personal and/or professional circumstances (such as family illness, job loss, or change in work schedule) might interfere with their progress and affect their attendance.

Other challenges that many students in developmental math courses face are in their lack of study skills, insufficient academic behavior, and deficient work habits. In his interview with Boylan (2011), Dr. Paul Nolting shared his ideas on some reasons behind a considerable number of students placed in developmental math courses and reasons for many of those students neglecting to complete such courses. Nolting, a public authority on the development of effective student learning strategies, asserted that students do not possess sufficient math study skills to reinforce their learning (p. 21). Zientek, Schneider, and Onwuegbuzie (2014) conducted a study

to explore contributing factors of students' minimal success in developmental math courses. They sought to gain understanding of this phenomenon through the lens of developmental math faculty members in community colleges. A survey was used to collect the data, and the identification of codes and themes were developed to analyze the data. Of the 17 themes that emerged from the study, the academic behaviors and work habits of developmental math students were recognized by almost 70% of the participants as impediments to student success. The aforementioned articles support my study because the SPC math faculty and MathWorld staff have experience working with students who do not have sufficient study skills and work habits to be successful in math.

Many studies have also shown that another contributing factor to students' lack of success in developmental math courses is low retention of content. Givvin, Stigler, and Thompson (2011), for example, conducted a study to discover students' understanding of mathematics. The researchers used two sources for data collection: placement tests results and a survey completed by students enrolled in a developmental math class at a community college. The results showed that students entering community colleges struggled with mathematical procedures. Since these procedures are not always coupled with conceptual understanding of basic math concepts, students tend to retain very little. Givvin et al. (2011) provide the following three implications to their study:

> Element One: We must find a way to reawaken students' natural disposition to figure things out and resocialize them to believe that this is a critical element of what it means to do mathematics.…Element Two: Necessary to convincing students to think is providing them with productive things to think about. Specifically, rather than asking students to call to memory what they've learned about procedures, ask them to consider the implications of concepts that seem obvious and make those concepts explicit.… Element Three: Finally, once students begin to appreciate the value of figuring things out and have begun to lay the foundation of powerful concepts, we can reintroduce procedures into the curriculum. (pp. 14-15)

The study conducted by Givvin et al. (2011) supports my study, as the SPC math faculty and staff strive to ensure that students not only gain a conceptual understanding of math, but also foster a positive disposition towards the subject.

Community Colleges

Community colleges are at the forefront of helping students who have not reached a sufficient level of success in college-credit courses. The U.S. Department of Homeland Security (2018) defines a community college as a “post-secondary, undergraduate educational institution offering lower-level (freshman and sophomore) classes” (Glossary section, para. 2). According to the American Association of Community Colleges (2017), there are 1,108 community colleges in the United States. Community colleges, nationwide, have a significant role in higher education (Lundberg, 2014), and the challenges they encounter in fulfilling their responsibilities are worth mentioning (Dougherty, Lahr, & Morest, 2017).

There are several defining characteristics of community colleges. In an article by Dougherty et al. (2017), the authors “describe the social roles and organization of community colleges in the United States, analyze their social contributions, and identify the challenges they face” (p. 1). Dougherty et al. (2017) noted that a key attribute of two-year institutions is their open access to the public. Also, community colleges provide lower tuition rates (Crawford & Jervis, 2011), various modes of instruction and course scheduling, such as evening, weekends, and online, and a broad selection of “programs and credentials” (Dougherty et al., 2017, p. 5). Crawford and Jervis (2011) stated that community colleges are likely to focus more on general education. In their article, the authors reviewed the latest demographics of community colleges, compared the characteristics of community colleges to “proprietary colleges in post secondary education,” and shared research initiatives that are designed to improve the community college

system (p. 1). With these attributes in mind, community colleges also "tend to enroll students who are more academically, economically, and socially disadvantaged than do other postsecondary institutions" (Karp, Hughes, & O'Gara, 2010, p. 70).

In a qualitative study conducted by Karp et al. (2010), the purpose was to "explore the ways that integration does and does not occur in the community college" and to "understand whether academic and social integration are distinct constructs or interrelated" (p. 4). Academic integration refers to student experiences with the "intellectual life of the college"; social integration develops as students interact with each other outside the classroom setting (p. 3). A total of 44 students from two urban community colleges participated in the study by way of in-depth interviews. The authors analyzed the data using a software program, NVivo, for the transcribed interviews. The findings revealed that 70% of the participants said they felt "a sense of belonging on campus," which was defined as "*integration*" by the authors (p. 7). An analysis of the themes that emerged from the data revealed that "*information networks*" was essential to promoting integration (p. 8). The authors defined "*information networks* as social ties that facilitate the transfer of institutional knowledge and procedures" (p. 8). One of the implications was that studies of integration "in the community college should not ignore social integration, but should examine the ways in which social integration is encouraged by academic activities" (p. 18). This finding by Karp et al. (2010) supports my study because SPC math faculty and MathWorld staff encourage opportunities for students to connect with each other. For example, students can do this by forming study groups, making appointments with their instructors during office hours, and meeting with MathWorld staff during operating hours.

Lundberg (2014) performed a quantitative study to test "the extent to which student interaction with faculty, student peer teaching situations, student organization involvement, and

discussion with diverse others contributed to self-reported learning for students involved in an ethnic-specific or multicultural student organization" (p. 79). The author utilized the Community College Student Experiences Questionnaire (CCSEQ) as an instrument for data collection. The participants in the study comprise 239 students, and Lundberg tested the model using multiple linear regression. The following five learning outcomes were reported: "general education, intellectual skills, science and technology, personal development, and career preparation" (p. 79). The study revealed that frequent "student interaction with faculty was the strongest predictor of learning for each of the five outcomes" (p. 88). One implication from Lundberg's study is that student-faculty interaction, as well as peer interaction, can have a significant impact on "student learning at the community college level" (pp. 89-91). This implication by Lundberg (2014) supports my study because the environment in MathWorld is rich with constant interaction between students and MathWorld staff. As part of their duties, the full-time SPC math faculty collaborate with students and MathWorld staff.

Many scholars have identified several challenges that exist in community colleges. Although community colleges are generally more involved in their neighborhoods with offering various "cultural activities" (Crawford & Jervis, 2011), Lundberg (2014) reported that student engagement "outside the classroom is relatively uncommon" (p. 90). Additionally, Crawford and Jervis (2011) pointed out a variety of barriers to student success in community colleges, such as "a lack of basic educational skills, particularly in math, overwhelming and ill-defined programs of study and inability to navigate the application and financial aid process" (p. 30). Another challenge that community colleges face is addressing the wide variety of needs for the students. For instance, many students who attend community colleges "more often have family caregiving responsibilities. As a result, they more often need to take outside work, attend part-time, and

interrupt their studies" (Dougherty et al., 2017, p. 8). According to SPC's *Fall 2016 Quick Facts*, 88% of the student population at SPC were enrolled on a part-time basis (p. 1).

Minority-Serving Community Colleges

St. Philip's College (SPC) certainly has been at the forefront of unconventional approaches to helping students succeed. For instance, students have a variety of options in teaching modalities and course offerings. Flexible scheduling, distance learning, and online and hybrid courses are available to students. The faculty at SPC are amenable to working with students who encounter various personal conflicts, such as family issues and job changes. Additionally, SPC is the only community college that is recognized federally as an HBCU and an HSI. Therefore, a review of the literature regarding community colleges, HBCUs, and HSIs is relevant to this study.

HBCU/HSI. Many scholars have identified underserved populations as the emerging majority of students who attend community colleges. In the first chapter of *New Directions for Community Colleges*, for example, Laden (2004) reviewed the change in demographic trends in the United States and described the characteristics of contemporary community college students. Laden observed that the "number of minority students is rapidly increasing in community colleges" (p. 18). Additionally, the author provided recommendations for establishing and maintaining a successful environment for the emerging majority. The following is a list of recommendations resulting from case studies of two community colleges (Community College of Denver and LaGuardia Community College) that serve emerging majority students: (a) welcome and celebrate students' diverse cultures, (b) create holistic approaches, (c) teach navigational skills, (d) develop an early alert system, (e) increase proportions of faculty and administrations of color, and (f) seek student perspectives (pp. 16-18).

Gasman, Nguyen, and Conrad (2015) also acknowledged the increased diversity in colleges and universities nationwide. In their article, Gasman et al. (2015) presented a summary "of the rise of Minority Serving Institutions [or MSIs] as context for understanding the contemporary place of these institutions in our broader system of higher education" (pp. 120-121). The authors commented that, as the United States has an increased diverse population, authority figures "have an unprecedented occasion and obligation to provide citizens from across racial, ethnic, and socioeconomic difference with the chance to pursue a college education" (p. 120). In their article, Ponjuán and Hernández (2016) provided "a comprehensive discussion about the educational experiences of Latino males in community colleges and provide[d] empirically supported recommendations that address their unique needs" (p. 2). For instance, the authors stated that "Latino males represent a growing number of these non-traditional students at two-year institutions" (p. 10). According to SPC's *Fall 2016 Quick Facts*, 56% of the student population at SPC were Hispanic, and 11% were African American (p. 2).

As the number of emerging majority attending community colleges continues to rise, it is imperative for leaders and members in the neighboring areas to actively participate with students in an "academic, social, and cultural" manner to ensure their success (Laden, 2004, p. 18). In an effort to address the needs of minority students in pursuit of higher education, the U.S. Department of Education initiated various program efforts, which include "Title III and Title V of the Higher Education Act" (Laden, 2004, p. 12). At St. Philip's College, Title III funds were used to provide for MathWorld, the Engineering program, and resources, such as course workbooks.

Gasman et al. (2015) provided a descriptive account of the number of HBCUs and HSIs throughout the United States:

> Spread across 20 states largely in the South, the District of Columbia, and the U.S. Virgin Islands, the 105 HBCUs are nonprofit institutions, roughly split between public and private, and predominantly 4-year institutions (nearly 90%)....Overall, the 105 HBCUs are predominantly Black institutions---in 2012 more than 75% of the undergraduates served by these institutions were Black….Scattered across 15 states and all institutional sectors, these 254 [HSI] institutions--just over 6% of all degree-granting institutions--enroll almost 4 million undergraduates, including one quarter of all minority undergraduates in higher education in the United States, and nearly one half of Hispanic graduates. These institutions are predominantly public and 2-year, urban, and significantly underresourced. (p. 134)

Given this population, Laden (2004) states that emerging majority students “need to see faculty and administrators who look like them and who can serve as role models, mentors, and advisers....At present, the proportion of emerging majority students is much higher than the proportion of faculty and administrators of color” (p. 17). However, Ponjuán & Hernández (2016) observed that higher education institutions “have not recruited and retained Latina/o faculty members to reflect the increasing enrollment rates of Latina/o students” (p. 13). This is relevant to my study because at SPC, the ethnicity of the Bobs and other MathWorld personnel mirrors the ethnicity of the student population. This may be a contributing factor to the high usage of MathWorld by students. While not specifically addressed in this study, it does relate to self-efficacy and soft skills in terms of building connections and relationships with relatable individuals. In other words, students may be more comfortable with instructors and tutors who look like and understand them. Gasman et al. (2015) stated that

> many students choose HBCUs because they offer a supportive environment in which they feel they belong and at which they believe they will find cultural support, a sense of belonging, and a feeling of pride, as well as an opportunity to develop a racial identity. (p. 135)

This is relevant because SPC offers a variety of programs to foster a rich and empowering college experience for students. SPC Men of Color, Culture Fest, SEG Grant, Black Men on the

Move, I Am Woman, Future Latino Leaders United, and 100 Black Men are several examples of such programs.

Additionally, Jackson (2013) noted that "community colleges may be more effective at fostering success among minorities in STEM because of their emphasis on teaching, smaller student-to-teacher ratios, active learning in classrooms, lab experiences and positive learning environments" (p. 258). Jackson conducted a qualitative study "to explore the experiences of seven African American community college female transfer students who are currently enrolled at an HBCU in a STEM [science, technology, engineering, mathematics] bachelor's degree program" (p. 256). Data was collected by way of interviews and Photovoice, which allowed the students to capture their reactions and feelings of their college experiences. "Qualitative data analysis procedures were used to analyze the photos, photo descriptions, narratives and the interview transcripts" (Jackson, 2013, p. 259). The results of the study showed that their experiences

> at both the community college and HBCU assisted in their success as a STEM student. The participants elaborated on three themes: (a) consistent relaying of information: as long as I know; (b) career capital: now what? and (c) development of a STEM identity: it's a community thing. (Jackson, 2013, p. 262)

Similar to the implications made by the aforementioned scholars, Jackson (2013) identified the importance of the community college faculty's role in the students' academic experiences.

According to SPC's *Fall 2016 Quick Facts*, the student-to-faculty ratio is 16:1 (p. 8). In addition, the majority of the SPC math department faculty have received certification as a Master Teacher and Distance Learning Instructor. In both certification programs, faculty members have acquired and enhanced their skills in facilitating student learning and creating an atmosphere conducive to learning.

Related Research

Many studies have been conducted to explore best practices to reaching students taking developmental math courses. The following key words were used in the database search: *developmental math*, *minority-serving institution*, and *community college*. Full text, scholarly journals, and peer reviewed articles from 2000 to current were also selected. As a result of that combination, 54 articles appeared. Of these 54 articles, 15 were quantitative studies, 15 were qualitative studies, and the remaining 24 articles were either mixed methods studies, other studies, or overview articles.

As shown in Appendix A, the following information was provided for each of the 15 quantitative and 15 qualitative studies: (a) name of reference, (b) purpose of study, (b) methodology, and (d) key results.

Of the 15 quantitative articles, none of the research specifically addressed developmental math. If math was mentioned in the articles, it was in the context of STEM-related issues, or issues related to science, technology, engineering, or math. In fact, one article specifically focused on first-semester biology majors in college. Some of the studies incorporated the setting of a minority-serving institution, whether it was an HBCU or a HSI, but there appeared to be an even mix of community colleges and universities.

Although one of the 15 qualitative articles mentioned developmental math, the focus was on peer mentoring at a public urban university. Some of the remaining articles mentioned math, but it was under the umbrella of STEM. The setting of most of these studies occurred at a four-year institution rather than a community college. Almost half the articles addressed minority-serving institutions or had emerging majority populations as participants of their studies.

From my viewpoint as a historically quantitative person, it is my opinion that the benefits of MathWorld could not be understood solely from a quantitative perspective. The qualitative approach allows the researcher to perform an in-depth investigation of the phenomenon and gain a rich understanding of its characteristics. Therefore, as a researcher, I believe that there is substantial value in conducting this study using a qualitative approach. Three studies, in particular, fairly resemble the purpose, methodology, and setting of my research.

Galbraith and Jones (2006) reported a case study with the following purpose:

> The balance of the art and science of teaching is essential if the learning and teaching process is to be successful. The highlights of a 3-year dialogue held with Elizabeth, a developmental mathematics instructor at a community college, provides a personal perspective on that balance. (p. 21)

The participant in their study taught at a small, rural community college. Galbraith and Jones stated that although their work did not "represent a systematic collection of data with analysis," they "introspectively examined and personal experience related to teaching to identify elements essential to the art and science of teaching" (p. 21). The following eight themes emerged as an organizing framework for teaching and learning: (a) creating a vision, (b) linking vision to practice, (c) setting the climate, (d) understanding expectations, (e) planning for learning, (f) connecting learning, (g) conceptualizing strategies, and (h) celebrating the experience (Galbraith & Jones, 2006, p. 21). Two of the above-mentioned themes, setting the climate and connecting learning, support my study. Whether the students are in the classroom or in MathWorld, the SPC math faculty and MathWorld staff make certain that the atmosphere is conducive to learning. Also, the instructors and tutors find ways to connect math concepts to real-world applications. One of the implications from the study is that the technical aspects of teaching is not enough: "Technique alone will not be sufficient to bring about a meaningful and successful learning journey….However, to sustain and promote an effective teaching and

learning environment and milieu, balancing the art and science of teaching is essential" (Galbraith and Jones, 2006, p. 24).

Similarities and differences exist between Galbraith and Jones' (2006) study and this study. Both studies were similar in its research purpose to identify best practices through the lens of developmental math faculty. However, Galbraith and Jones narrowed their focus to in-class strategies. This study identified activities that occurred within and outside the classroom setting. Although the community college setting was similar to both studies, Galbraith and Jones' study was conducted in a small rural community college, while this study was conducted in a large urban community college. While both studies used a qualitative method and used interviews as an initial basis for collecting data, Galbraith and Jones interviewed only one participant (a math instructor), whereas I interviewed multiple participants who were both instructors and Bobs.

Finney and Stoel (2010) also reported a case study in which they examined a best practice through the lens of an instructor. Julie Phelps, the only participant in their study, was a recipient of the 2010 Virginia B. Smith Innovative Leadership Award. The authors explained the significance of this prestigious award:

> The Virginia B. Smith Innovative Leadership Award in Higher Education recognizes individuals whose leadership in higher education has resulted in better ways to educate people to participate in and improve an open and inclusive democratic society. Winners have demonstrated innovative leadership qualities, yet are at a stage in their careers when they will still make significant contributions in the future. The award is meant to encourage and support those seeking sustained improvements in higher education. (p. 38)

Phelps taught at a large, urban community college. Supplemental instruction became the highlighted best practice in Finney and Stoel's study. In the interview, Phelps defined SI as follows:

> … cooperative learning outside and inside a class. A student who has taken the class and been successful is asked to sit through the class, listen to the lectures, be part of the class

> discussion, take notes, take the tests, and then model how to study outside of class. (Finney & Stoel, 2010, p. 38)

This description of supplemental instruction fits well with this study, because virtually all MathWorld staff attend various math classes periodically throughout the semester. Attending the classes allow the MathWorld staff to become familiar with the instructors' teaching styles, routines, and class expectations, and incorporate that information into their tutoring sessions with the students when they visit MathWorld. In the interview with Finney and Stoel (2010), Phelps shared success with this strategy, as they eventually increased the number of SI courses by demand. These courses originally began in tandem with developmental education courses, and later expanded to include college-level courses. This was done so that students would be able to see a model of the necessary characteristics, such as appropriate attitude, behavior, and study habits at that level.

Similarities and differences exist between Finney and Stoel's study and this study. Both studies were conducted at an urban community college. Also, both studies were similar in its research purpose to identify best practices through the lens of developmental math faculty. However, Finney and Stoel narrowed their focus on one specific strategy: supplemental instruction. This study identified a variety of best practices. While both studies used a qualitative method and used interviews as an initial basis for collecting data, I interviewed multiple participants who were both instructors and Bobs, whereas Finney and Stoel interviewed only one participant (a math instructor).

In 2014, Cafarella reported a "basic interpretive, qualitative study" to understand the best practices through the lens of 20 developmental math instructors (p. 43). The purpose of his study "was to gain an in-depth understanding of the best practices utilized by a group of developmental mathematics instructors at an urban community college" (Cafarella, 2014, p. 36). The 20

participants in the study taught at a large, urban community college. Cafarella used pre-interview questions in which the participants responded in writing before the face-to-face interviews. He analyzed the data by using constant comparison. "According to Merriam (2002), constant comparison is when units of data that the researcher believes to be meaningful are compared with each other in order to generate tentative categories" (p. 45).

The following themes, which represent best practices, emerged from Cafarella's (2014) study: communication, organization and structure, cooperative learning, and regular low stake assessments (p. 48). The implications from the study are as follows:

> Effective communication should be established between developmental math instructors and students as well as among developmental math instructors. Developmental math faculty ought to work with their students in developing their organizational skills. Developmental math instructors should couple the implementation of frequent low stake assessments with student outreach. Collaborative learning can be beneficial to some developmental math students, but instructors must take into account the composition of the class as well their own comfort level with collaborative learning. Accelerated instruction should be reserved for higher ability developmental math students with a strong work ethic. Lastly, college administrators must recognize and respect instructor comfort level. (Cafarella, 2014, p. 35)

The first two implications, effective communication and organizational skills, are relevant to my study. SPC math faculty and MathWorld staff collaborate with students and each other on a consistent basis. Also, helping students improve their notetaking skills is an example that demonstrates how the math faculty and MathWorld staff assist students with organizational skills.

Similarities and differences exist between Cafarella's study and this study. Both studies were conducted at a large urban community college. Also, both studies were similar in its research purpose to identify best practices through the lens of developmental math faculty. In addition, both studies used a qualitative method and used interviews with multiple participants as an initial basis for collecting data. Although Cafarella interviewed 20 participants (math

instructors), I interviewed multiple participants who were both instructors and Bobs to achieve robust findings.

The purpose of my study is similar to the studies by Galbraith and Jones (2006), Finney and Stoel (2010), and Cafarella (2014) in that all four studies focused on identifying and understanding best practices in developmental math through the lens of the instructor. The qualitative method was utilized in all four studies, and, specifically, interviews were used as the basis of data collection. Finney and Stoel, however, only examined one effective strategy for student success. In addition, Galbraith and Jones limited their study to effective best practices that occurred inside the classroom setting. Although Galbraith and Jones, Cafarella, and I share a similar research purpose, methodological differences are evident. In particular, Galbraith and Jones interviewed only one participant who was an instructor; Cafarella interviewed multiple participants who were also instructors; and I interviewed multiple participants who were both instructors and Bobs. Moreover, this study potentially extends the field of knowledge regarding best practices in developmental math education.

Relevant Theories

I considered four theoretical models for underprepared students for this study: McClelland’s (1961) Theory of Needs, Weiner’s (1996) Attribution Theory, Astin’s (1999) Student Involvement Theory, and Mezirow’s (1991b) Transformative Learning Theory. These theories fit several issues I have observed with the students I have worked with over the years: personal issues, academic background, and affective behavior. Each theory also connects to at least one component of the conceptual model of MathWorld, which was introduced in Chapter One. The following theoretical model of developmental math was created to demonstrate the anticipated connections among theory and practice (Figure 2).

The name of each theory, plus the key phrase *developmental math*, was typed in the database search to identify the relevant studies for each theory. Full text, scholarly journals, and peer reviewed articles from 2000 to current were also selected. Unfortunately, as a result of that combination, no articles appeared for any of the theories. On the next attempt of searching the database, the name of each theory, plus the key phrase *community college*, was typed. The rationale behind utilizing this combination is to determine which studies, if any, were conducted at a similar setting as this study: community college. As a result of that combination, 18 articles appeared. Of the 18 articles, two were related to Theory of Needs; five were related to Attribution Theory; six were related to Student Involvement Theory; and four were related to Transformative Learning Theory. A description of each theory, along with review of the literature relevant to this study, are provided in the following sections.

Theory of needs. McClelland's (1961) Theory of Needs states that we all have a set of needs that are based on the need for achievement, affiliation, or power. This theory fits well with my research because of the connection among the three problem areas: academic background, personal issues, and affective behavior. The student's academic background connects with the need for achievement as well as two supporting elements of the conceptual model: critical thinking skills and hard skills (Figure 2). The student's personal issues connect with the need for affiliation, in addition to the soft skills supporting element of the conceptual model. The student's affective behavior, especially if it is negative, connects with the need for power, along with the confidence/self-efficacy supporting element of the conceptual model.

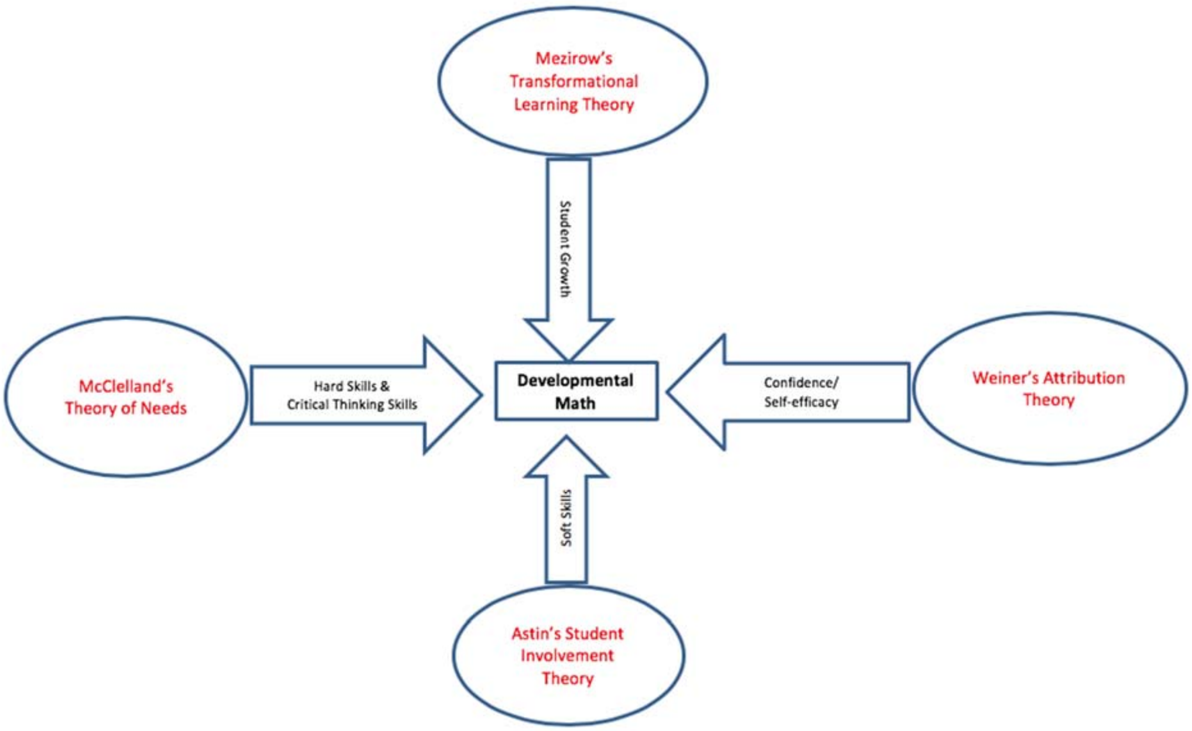

Figure 2. Theoretical model of developmental math.

As mentioned earlier, two out of 18 articles appeared as a result of the database search. Moore, Grabsch, and Rotter (2010) conducted a qualitative study with the following purpose:

> The purpose of this study, conducted as part of a larger study, was to explore why students participated in a voluntary, residential learning community focused on leadership. More specifically, this study intended to determine if students were motivated to participate because of their need for Achievement, need for Power, or need for Affiliation. Therefore, the guiding research question for this study was "What was your primary motive for participating in the Leadership Living Learning Community [L3C]?" (p. 26)

Eighty-nine students participated in the study. The participants' responses to "an open-ended question that asked…what their primary motive for participating in the voluntary, residential leadership learning community" were collected as data for the study (Moore et al., 2010, p. 22). Moore et al. (2010) analyzed the data using deductive content analysis techniques. The results of the study showed that "while all three needs were found within the responses, the need for Achievement and the need for Affiliation were more common motives for joining the voluntary,

residential leadership learning community" (pp. 22-23). One of the implications from the study is for the L3C program coordinators and instructors to "continually revise the academic component of the program to ensure it remains relevant to the lives of the students while at the same time challenging them to meet high standards of academic success" (p. 31).

In her article, Nash (2005) evaluated "current practices in the use of learning objects in online courses," reviewed best practices, and recommended novel approaches that incorporate learning theory (p. 217). The author discussed ways in which the need for affiliation can be met in an online learning environment:

> In an online environment, affiliation needs are often satisfied by means of an interactive discussion board or chat area. Instant messaging also often satisfies that need. Any learning object that helps improve collaboration and interactivity among learners is likely to help a learner or user achieve affiliation needs. Further, any learning object that encourages learners to want to identify with the identity of the institution, and to improve self-concept through affiliation is also likely to increase an individual's sense of power and achievement. (Nash, 2005, p. 224)

Upon reviewing these two articles from the database search, it is apparent that administrators, instructors, and staff must be cognizant of the needs of students and use appropriate strategies to ensure their success. As the "Bobs" in MathWorld interact with the students, they are mentally assessing which of the three needs are prominent and they formulate their rapport with the students to mentor them based on those needs. For example, if Bob identifies that a student has control or power issues, he may bring the student into his office for one-on-one counseling to help instill confidence.

Attribution theory. Some students have a negative mindset towards math because of their previous experiences with the subject matter or the social environment (such as classroom size, teacher-student interaction, and peer-to-peer interaction). This is a representation of Weiner's (1996) Attribution Theory, which "describes how individuals interpret events and how

their interpretation influences motivation for learning as well as future learning behaviors" (Demetriou & Schmitz-Sciborski, 2011, p. 6).

As a result of typing *Attribution Theory* and *community college* in the database search, five articles materialized. In their articles, the authors described their studies which incorporated a quantitative approach. The following topics were the focus of these studies: mental illness, College Algebra (which is not a developmental math course), cooperative learning in a classroom setting, relationships among effort, attribution, interest, and ability, and psychosocial factors.

A study by Corrigan, Markowitz, Watson, Rowan, and Kubiak (2003) connected the attribution model to public discrimination towards people with mental illness. This quantitative study of 518 community college students demonstrated that "causal attributions affect beliefs about persons' responsibility for causing their condition, beliefs which in turn lead to affective reactions, resulting in rejecting responses such as avoidance, coercion, segregation, and withholding help" (p. 162). In a quantitative study conducted by Cortés-Suárez and Sandiford (2008), the purpose was to examine the difference in the attributions between passing and failing College Algebra students. After analyzing the data provided by 410 urban community college students, the results showed that there was statistical significance in the following areas: locus of causality, stability, and personal controllability (Cortés-Suárez & Sandiford, 2008, para. 1).

Ahles and Contento (2006) studied whether attribution theory could account for helping behavior in a classroom that applies cooperative learning in a mutually supporting environment. Upon statistical analysis of student responses, the quantitative study revealed that attribution theory served as a suitable framework for describing student responses pertaining to helping behavior. Siegle, Rubenstein, Pollard, and Romey (2010) measured 149 college freshmen's

perceptions about their proficiencies in 15 talent areas. After performing statistical analysis of the students' responses to the questionnaires, Siegle et al. (2010) discovered that a positive relationship existed between students' interest in a talent area and their aptitude in that area. In a quantitative study by Fong et al. (2017), the authors investigated the relationship between psychosocial aspects and community college student success. The results of the study, upon statistical analysis, revealed that there were "small but meaningful relationships with community college persistence and achievement" (Fong et al., 2017, p. 1).

Attribution Theory is one of the five major theories of motivation by Graham and Weiner (1996), and this theory connects well with the confidence/self-efficacy supporting element of the conceptual model (Figure 2). Graham and Weiner provided an example of someone who perceives failure due to their lack of ability when they take tests and fail them each time, even while others in the class pass those tests. This theory describes a confidence phenomenon that is evident both in research and in my lived experiences as a math educator. As shown in the results of these five studies, students' perceptions about their abilities in play a critical role in determining their success. Students who visit MathWorld are in a unique position to acquire a better mindset and experience with math over time as compared to their prior experiences.

Student involvement theory. Another theory, that is appropriate to consider for this study, is Astin's (1999) Student Involvement Theory. Some students withdraw from developmental math courses due to changes in their work schedules and other emergencies such as a change in employment status (new job or loss of job) or death of a family member. According to Astin (1999), Student Involvement Theory "refers to the amount of physical and psychological energy that the student devotes to the academic experience" (p. 518).

As a result of typing *Student Involvement Theory* and *community college* in the database search, six articles emerged. Of the six articles, two were quantitative studies, two were qualitative studies, and two were overview articles. The following topics were the focus of these articles: Student engagement, transitioning to college, terminology, overview of theoretical foundations/applications to community college research, and student retention.

Both quantitative studies focused on student engagement. Kuh, Cruce, Shoup, Kinzie, and Gonyea (2008) conducted a study to find out the relationships between significant student behaviors and the institutional systems and circumstances that cultivate student success. After analyzing data produced by 6,193 students, Kuh et al. (2008) discovered that there was a positive relationship between educationally purposeful activities and academic outcomes "as represented by first-year student grades and by persistence between the first and second year of college" (p. 555). In their quantitative study, Zhao and Kuh (2004) investigated the relationships between "participating in learning communities and student engagement in a range of educationally purposeful activities of first-year and senior students from 365 4-year institutions" (p. 115). Statistical analysis of the data showed that there was a constant, positive association between participating in learning communities and student engagement in educationally meaningful activities.

The qualitative study conducted by Terenzini et al. (1994) identified the "people, experiences, and themes in the processes through which students become (or fail to become) members of the academic and social communities on their campus" (p. 57). Upon analysis of the focus groups, Terenzini et al. discovered that the "transition from high school or work to college is an exceedingly complex phenomenon" (p. 61). In the qualitative study conducted by Wolf-Wendel, Ward, and Kinzie (2009), the purpose was to explore "the concepts of involvement,

engagement, and integration to determine how they are unique, how they overlap, and the extent to which the concepts are similar" (p. 408). After analyzing the information provided by seven participants, Wolf-Wendel et al. (2009) found out that the terms involvement, engagement, and integration were used interchangeably in research application and practice. The authors also discovered that there was "significant overlap and confusion relative to the use of these terms" (p. 416).

The main purpose of Chaves' (2006) article was to provide an orientation to the various theoretical foundations that could be used to understand the complex problems encountered by community college students. In the article, the author expressed the following ideas regarding the importance of student affirmation, as well as student/teacher involvement:

> Inside the classroom, it is essential to affirm and validate adult students' experiences, highlighting the social and academic connection between students, their teachers, and the college in general. Moreover, educators must include experiential learning in curricular designs and coursework and create opportunities for dialectical learning experiences whereby students and teachers can challenge or affirm old knowledge and at the same time create new understandings. (Chaves, 2006, p. 150)

In an overview article by Wild and Ebbers (2002) highlighted central issues concerning student retention: (a) definitions, (b) theoretical models, and (c) current research and analysis within the community college environment. The authors noted that identifying the institution's retention goal, criteria, definitions, and data for monitoring progress toward the retention goal is essential to designing and implementing a retention program (Wild & Ebbers, 2002, p. 1).

Students' chances of success increase as their time and effort, in their academic studies, increase. One way this can be measured is by how well students follow their commitment. At St. Philip's College, students are expected to complete the "Student Commitment Form." Additionally, the soft skills component of the conceptual model connects well with Student Involvement Theory (Figure 2). Upon reviewing these six articles from the database search, it is

clear that student engagement is essential to their success. SPC math faculty and MathWorld staff, in their interactions with students, convey the message that active participation is necessary to acquiring a better understanding of math concepts.

Transformative learning theory. Mezirow's (1991b) Transformative Learning Theory deals with "an enhanced level of awareness of the context of one's beliefs and feelings, a critique of one's assumptions, and particularly premises, and an assessment of alternative perspectives" (p. 161). As a result of typing *Transformative Learning Theory* and *community college* in the database search, four articles appeared. Of the four articles, one was a quantitative study and the remaining three were overview articles. The following topics were the focus of these articles: learning styles, overview of Mezirow's Transformative Learning Theory, and teaching for transformation.

In a quantitative study conducted by Miglietti and Strange (1998), the following research questions were formulated:

> (a) What, if any, is the relationship between students' ages and their ideal classroom expectations and preferred learning styles? (b) Are varying levels of academic achievement, sense of accomplishment, and overall course satisfaction a function of the interactions of differing teaching styles, classroom environments, and learning styles?" (para. 3)

After analyzing the questionnaire responses provided by 156 students, the researchers found that learner-centered classes were associated with higher grades, a greater perception of achievement, and greater overall fulfillment among underprepared students.

In Chapter Six of *Lifelong Learning*, Mezirow (2008) summarized the chronology and main characteristics of transformative learning. He also addressed various critiques and additional recommendations that were offered since the inception of transformative learning theory. In essence, Mezirow provided the following explanation of transformative learning:

> Transformative learning is a rational, metacognitive process of reassessing reasons that support problematic meaning perspectives or frames of reference, including those representing such contextual cultural factors as ideology, religion, politics, class, race, gender and others. It is the process by which adults learn how to think critically for themselves rather than take assumptions supporting a point of view for granted. (Mezirow, 2008, p. 103)

An article by Kitchenham (2008) also provided an overview of Mezirow's theory and its variations over time. The author noted that the theory "will, undoubted, continue to influence adult learning praxis across many disciplines" (p. 120). Cranton (2002) also provided an overview of transformative learning. In the article, the author expressed the following ideas regarding the goals of transformative learning in teaching:

> There are no special methods that guarantee transformation, although transformation is always one of our goals. In every strategy we use, we need to provide an ever-changing balance of challenge, support, and learner empowerment. Sometimes to ask the right challenging question at the right moment is the most important thing we can do. At other times, it is essential to validate a student's thoughts or feelings. And at yet another time, we need to say, "This is up to you now," because in the end, it is the student who chooses to transform. (p. 6)

When students are actively engaging in the learning process within and outside the classroom, their experiences can lead to an increased awareness and appreciation of math in their daily lives. In addition, students can have an improved and healthy disposition toward math as they persevere and become more patient with the problem-solving process. MathWorld is not only focusing on math per se, but also the transformation of the student as a math learner. For these reasons, Transformative Learning Theory connects well with all four supporting elements of the conceptual model: hard skills, soft skills, critical thinking skills, and confidence/self-efficacy (Figure 2). Upon reviewing these four articles from the database search, it is evident that proper implementation of various teaching strategies with knowledge of various student learning styles can facilitate student success over time. As SPC math faculty and MathWorld staff work

with students, they are adept at understanding students' learning styles. However, perseverance and consistent work habits on the students' part are necessary to ensure success.

Taking into consideration the above theories and the conceptual model of MathWorld, the model was reframed to incorporate how the theories aligned (Figure 3).

In the same manner as the Conceptual model of MathWorld (Figure 1) that was introduced in chapter one, the visual representation of the Theoretical Alignment of the conceptual model of MathWorld is meant to be read from bottom to top. Figure 3 visually represents the connection of each theory to my study. For instance, while developmental math courses serve as the foundation, I surmise that students, over time, gradually increase their capacity to sharpen their skills (hard, soft, critical-thinking, and confidence) and increase their success in college-level math. This idea of student transformation is visually represented by way of the upward arrow labeled *Mezirow's Transformative Learning Theory.*

Chapter Summary

Chapter two explored the relevancy of this study with the review of the current literature. Since St. Philip's College is recognized federally both as an HBCU and an HSI, a review of the literature concerning community colleges, HBCUs, and HSIs were included in this chapter. Research indicates that the developmental education program has been, and continues to be, an essential element in higher education. Developmental math, in particular, is worthy of consideration because the majority of students attending community colleges are enrolled in such courses.

Of the quantitative articles that appeared as a result of a detailed database search, none of the research specifically addressed developmental math. If math was mentioned in the articles, it was in the context of STEM-related issues, or issues related to science, technology, engineering,

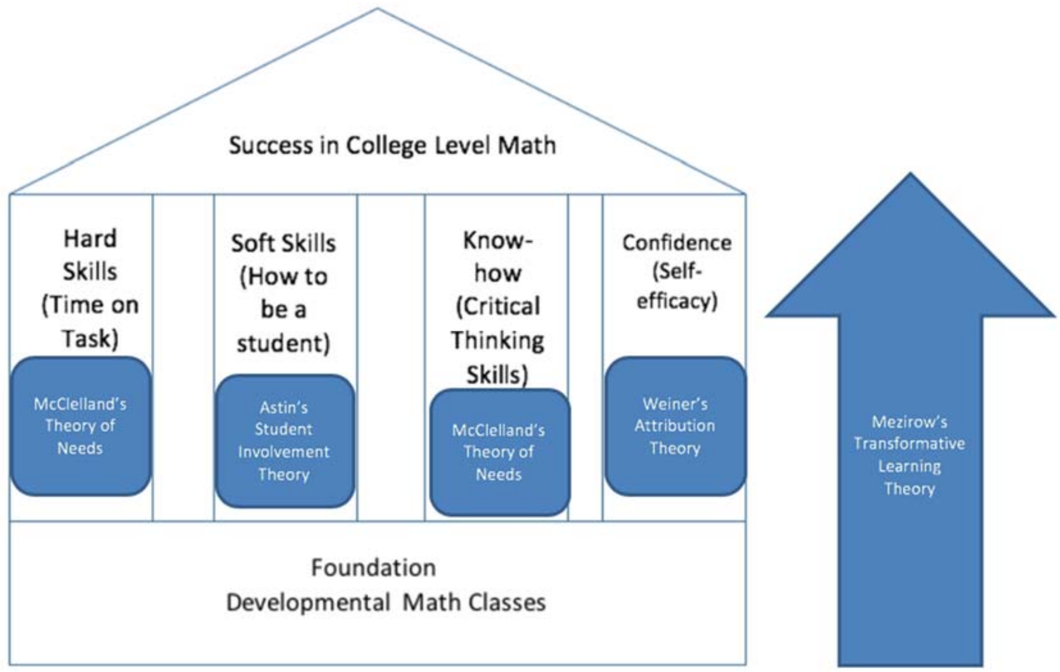

Figure 3. Theoretical alignment of the conceptual model of MathWorld.

or math. In fact, one article specifically focused on first-semester biology majors in college. Some of the studies incorporated the setting of a minority-serving institution, whether it was an HBCU or a HSI, but there appeared to be an even mix of community colleges and universities. Although one of the qualitative articles from the aforementioned database search remarked on developmental math, the focus was on peer mentoring at a public urban university. Some of the remaining articles mentioned math, but it was under the umbrella of STEM. The setting of most of these studies occurred at a four-year institution rather than a community college. Almost half the articles addressed minority-serving institutions or had emerging majority populations as participants of their studies.

Gaps in existing research also supported a need to reveal the impact of math support programs on the success of minority students attending a community college. The four theoretical models (Theory of Needs, Attribution Theory, Student Involvement Theory, and Transformative Learning Theory) mentioned in this chapter connect with at least one supporting

element of the conceptual model of MathWorld that was introduced in Chapter One. Research questions that guided this study, in addition to the description of the participants, setting, data collection, and data analysis will be discussed in detail in Chapter Three.

Methodology

This chapter explains the steps that the researcher took to collect and analyze data for this study. The chapter is divided into the following areas: research design, setting and population selection, and data analysis.

Research Design

A qualitative approach to a case study was used to explore the impact of MathWorld on student success. The impact of participation in MathWorld, in particular, was explored through the lens of math faculty and staff at a local community college. The following primary research questions guided this study:

- What is the conceptual model and the underlying core practices for the success of developmental math students?
- How does usage of MathWorld support the development of math competencies and affective behaviors necessary for student success in developmental math courses?

Qualitative Approach to Case Study

This research used case study as a container to explore MathWorld's impact on student success in developmental math through the lens of math instructors, Bobs, and instructors who were former Bobs. Thomas (2015) defines cases studies as follows:

> Case studies are analyses of persons, events, decisions, periods, projects, policies, institutions or other systems which are studied holistically by one or more methods. The case that is the subject of the inquiry will illuminate and explicate some analytical theme, or object. (p. 23)

Thomas (2015) further states that the case study is specifically beneficial for "getting a rich picture and gaining analytical insights from it" (p. 23). Case study research has been used throughout history in various disciplines, such as psychology, medicine, law, and political science (Creswell & Poth, 2017, p. 97).

Identifying the specific case and its parameters are two of several defining features of a case study (Creswell & Poth, 2017, p. 97). “Examples of a case for study are an individual, a community, a decision process, or an event” (p. 97). MathWorld is the specific case for this study. With regard to parameters, Hancock and Algozzine (2016) stated that “the phenomenon being researched is studied in its natural context… [and] context is important in case study research” (pp. 15-16). For this study, “certain people involved in the case may also be defined as a parameter” (Creswell & Poth, 2017, p. 97). Specifically, the participants who were both instructors and Bobs served as parameters to the case because of their MathWorld experiences.

According to Tellis (1997), case studies “are designed to bring out the details from the viewpoint of the participants by using multiple sources of data” (p. 1). I used interviews, a survey, and student testimonials as multiple sources of data in this study. In case studies, interviews are “one of the most important sources” (Tellis, 1997, p. 9). The interviews in this study facilitated a case study analysis of MathWorld’s core practices and link to a conceptual model of success for developmental math students.

Setting and Population Selection

Maxwell (2013) states that the researcher’s choices about participant selection and location of the research are “an essential part” (p. 96) of the research process. This allows the researcher to discover and explain the uniqueness of a math support program in a given context.

Setting. The interviews took place in a location such as the Looney Bin, a quiet and reserved area of MathWorld. MathWorld is located in the William C. Davis Science Building at the main campus of St. Philip’s College. Student testimonials were existing documents accessible in MathWorld. Additionally, my lived experiences of working with students in

MathWorld occurred, as part of my duty hours, as a full-time math instructor over a two-year period.

Participants. My participants in the study were “selected deliberately to provide information that is particularly relevant” (Maxwell, 2013, p. 97) to my research questions and purpose. I sought to better understand the phenomenon through the lens of math faculty and staff at St. Philip’s College. These participants are the most relevant knowledge-holders, and they have a unique set of feelings and lessons learned from their experiences with the students that they serve. In order to understand the particulars of these core practices, it is sensible to obtain that information from those who live that reality. Since the research questions are asking about the core practices of MathWorld, the implication is to discover what MathWorld staff and math faculty do in delivering developmental math assistance to students. Subsequently, the students are on the receptive end of the learning continuum and are not privy to the core practices of MathWorld. Additionally, the research questions are not specifically about the experiences of the students. Hence, students were not considered as participants for the purpose of this study.

The participants consisted of five Bobs (as defined in Chapter One), four instructors, and two instructors who were former Bobs (Figure 2). Seven were male and four were female. Each participant has varying years of employment at St. Philip’s College, as well as varying years working in education. Four identified as White/Non-Hispanic, another five were Hispanic/Latino, one identified as Black/Non-Hispanic, and one identified as other. The participants are college-educated. Four received their bachelor’s degree, six received their master’s degree, and one received their doctoral degree. All of the study participants are full-time employees. They come with a range of years of experience in education. Three participants worked in education for 16 or more years, one participant for 11-15 years, two participants for 6-

10 years, and five participants for 0-5 years. The demographic information of the participants was highlighted to demonstrate the diversity of backgrounds and education levels, which are diverse like the student population that they serve.

The Venn Diagram is a visual representation of my targeted population for the one-on-one interviews (Figure 3). To maintain confidential information, each participant was assigned an abbreviated title and a number. For example, instructors were labeled “I” with a number, Bobs were labeled “B” with a number, and instructors/former Bobs were labeled “M” with a number.

Charmaz (2014) states that when “researchers pursue straightforward research questions to resolve problems in local practice in applied field, a small number of interviews may be enough” (p. 106). In this study, I focused on the phenomenon through the lens of the math faculty members and staff, a targeted adult population who work with students enrolled in developmental math courses.

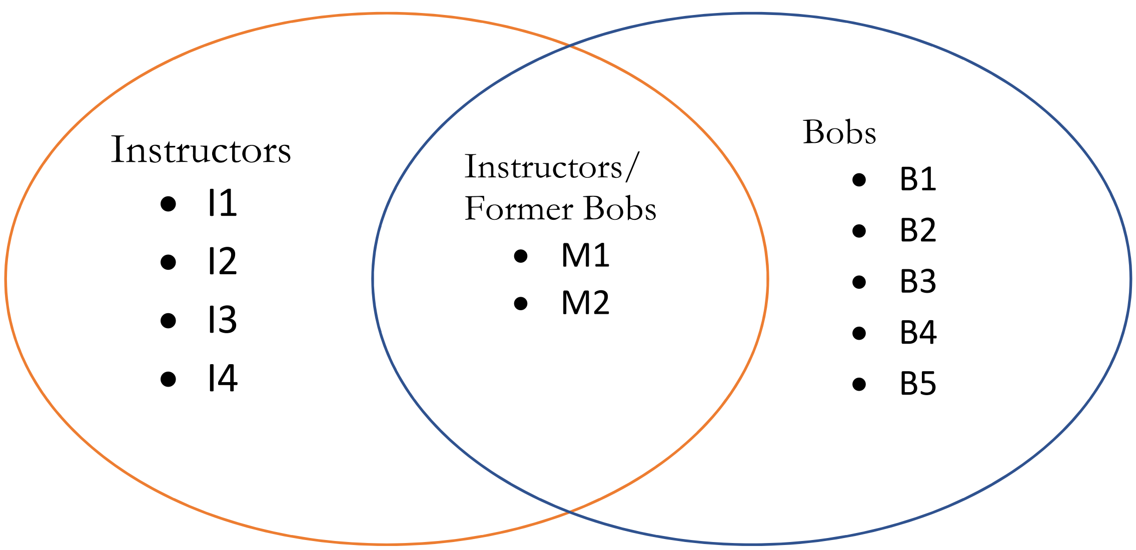

Figure 4. Venn diagram of participant population for one-on-one interviews.

The consent form contained an explanation of the purpose of the study and the description of the participants’ involvement. Participants were assured they had the right to refuse participation without penalty of any kind. Any publication that follows this study will only

display group data, and interview quotes will be recorded anonymously. I did not anticipate any risks to the participants in this study other than those encountered in day-to-day life.

Data collection. Bobs, instructors, and instructors/former Bobs who participated in this study completed a one-on-one, semi-structured interview. The goal was to analyze how participants perceived the impact of participation in MathWorld on student success in developmental math courses, by referring to the following qualitative research questions:

- What is the conceptual model and the underlying core practices for the success of developmental math students?
- How does usage of MathWorld support the development of math competencies and affective behaviors necessary for student success in developmental math courses?

Participants answered every question regarding the following categories: description of MathWorld's core practices, rationale for preferred core practices, additional core practices for consideration, existing core practices which inhibit/create barriers, identifying an individual core practice, and MathWorld's impact on student success. I incorporated Creswell's (2012) five steps in the qualitative data collection process (p. 233).

Step one: Use purposeful sampling of participants and sites. A total of 11 participants were selected through purposeful sampling. Participants were selected to represent a wide demographic population with regard to age, gender, ethnicity, and private and public sector experience. In addition to the typical professional duties, participants were selected intentionally for having a Bachelor of Science degree or higher in Mathematics or a related field, such as Accounting, Engineering, Physics, Biology, and Chemistry. In addition to the typical professional duties, each participant demonstrated their experience in assisting students in MathWorld.

Step two: Gain access to individuals. The selected individuals were invited in person to participate in the study. After the individuals agreed to participate, I provided the informed consent document. I confirmed the individuals' dates and times of availability.

Step three: Select forms of data to be collected. After the participants signed the informed consent, one-on-one, semi-structured interviews were conducted. An audio recorder was used to capture the participants' responses. The questions for the interview were prearranged, but the participants were welcomed to respond on their own accord. I used open-ended questions for the interviews. This format of questioning allowed the researcher "to probe a little deeper and explore the many possibilities that individuals might create for a question" regarding their experiences with MathWorld (Creswell, 2012, p. 386).

Step four: Develop a procedure for collecting data. The process of structuring the interviews and careful notetaking is critical for data collection (Creswell, 2012, p. 225). For this reason, I incorporated at least five elements of a qualitative interview protocol as indicated by Creswell (2012): a header, a set of open-ended questions, clarifying questions, designated space, and closing notes.

A header included information, such as the date and time of the interview, the job title of the participant, and their educational background. After the header, I listed six questions for the semi-structured interview. The types of questions allowed the participants to describe their lived experiences as they related to MathWorld, to the core practices of MathWorld, and to student learning. In addition to the predetermined six questions, I used, as suggested by Creswell (2012), "probes to encourage participants to clarify what they are saying and to urge them to elaborate on their ideas" (p. 226). I designated space in the interview protocol to make brief notes during the session. The notes included any observable behavior, such as non-verbal communication from

the participant. Also, I included reminders to thank the individuals for their participation and "assure them of the confidentiality of the responses" (p. 227). I created a timetable to arrange the dates and times of the interview sessions with the participants.

As stated by Creswell and Poth (2017), "case study collection involves a wide array of procedures as the researcher builds an in-depth picture of the case" (p. 162). One-on-one, semi-structured interviews served as a main procedure in my study. The duration of an interview session was approximately 30 minutes, and the session was located in MathWorld. Clarifying questions such as *What do you mean? Could you elaborate?* were asked by the participants. Initially, the duration of each interview was expected to run 30 minutes. Instead, they ranged from five to 38 minutes.

Supplemental materials, such as audiovisual equipment and documents, are commonly used in data collection (Creswell & Poth, 2017, p. 162). I used an Olympus voice recorder to capture the verbal responses of the participants. A smartphone with VoiceText installed was also used to convert the participants' responses into text format. I took detailed notes of my observations of the participants' non-verbal communication.

Participants' confidentiality was protected during the entire research process. The subjects were given an informed consent to assure that participation was strictly voluntary. Participants received a signed copy of the consent form at the completion of their interview. I kept the original copies and secured them in a locked home office. None of the participants displayed any signs of discomfort during the interviews. All participants appeared relaxed and comfortably answered the interview questions. No one in this study displayed any uneasiness or asked to leave during the interview.

The first 10 interviews were conducted on the campus of St. Philip's College, inside the Looney Bin area of MathWorld, on the first floor of the William C. Davis Science Building. The interviews were conducted during final exams of the Fall 2017 semester (December 11-15, 2017). The 11th interview was conducted in the William C. Davis Science Building, but in my office, on Friday, February 2, 2018. During these dates, the interviews started at 7:00 a.m. and ended by 1:00 p.m.

For the math faculty and MathWorld staff, I used the following six questions to help generate rich data from which a theory of how MathWorld's core practices could be constructed for student success:

1. Can you describe the core practices that take place in MathWorld?
2. Which core practices work better for you and why?
3. What additional core practices, based on your experience with MathWorld, do you think would enhance student success?
4. Which of the existing core practices inhibit or create barriers?
5. What is an individual core practice that you use that did not come from the "Bobs"?
6. How would you describe the student impact of MathWorld?

Step five: Consider field issues and ethical issues. Creswell (2012) lists several categories of field issues that may occur during data collection, such as access, observations, interviews, documents, and audiovisual materials (p. 229). I ensured gaining access to each participant by confirming the scheduled date and time of the interview. Also, considerable time was given to transcribe the audio recordings.

Ethical issues, such as "informing participants of the purpose of the study, refraining from deceptive practices, sharing information with participants (including your role as

researcher), being respectful of the research site, reciprocity, using ethical interview practices, maintaining confidentiality, and collaborating with participants" must also be taken into consideration (Creswell, 2012, p. 230). There are benefits and risks of involving employees from an education institution as research subjects (Rose & Peitri, 2002). Benefits from the study include increased knowledge and insight into the best practices of support programs outside the classroom. However, the possible risks may include a compromise, declination, or cancellation in the employees' ability to give consent (Rose & Pietri, 2002).

The confidentiality of the participants is extremely critical (Rose & Pietri, 2002, p. 252). Participants were assured that their decision to participate or not in this study would not affect their professional status. Complete anonymity was maintained. Names did not appear in any data collected, and participants could not be identified from what demographic data was collected. As the researcher, I was the only one who had access to the recordings

Before this study was conducted, approval from the University of the Incarnate Word (UIW) Institutional Review Board and the St. Philip's College (SPC) Institutional Review Board was obtained. I am certified through CITI training.

Additional data collected. As previously mentioned, being dependent "on one source of data is typically not enough to develop" a deeper understanding of MathWorld's impact on student success (Creswell & Poth, 2017, p. 99). In addition to the one-on-one interviews with the participants, artifacts and an open-ended, follow-up survey were used to collect data. The artifacts were existing testimonial letters written by students who described their experiences in MathWorld.

I used the following 21 survey questions to gain additional insight from the participants regarding the four supporting elements from the conceptual model of MathWorld:

1. What hard skills do you think a student needs in order to be successful throughout their college experience and beyond?
2. Why do you believe these hard skills you have identified are essential for student success?
3. Which of the hard skills you have identified do you think the MathWorld experience generates for students?
4. Which of the hard skills you have identified does MathWorld need to do more to help students develop?
5. Which of the hard skills you have identified does MathWorld currently prioritize?
6. What soft skills do you think a student needs in order to be successful throughout their college experience and beyond?
7. Why do you believe these soft skills you have identified are essential for student success?
8. Which of the soft skills you have identified do you think the MathWorld experience generates for students?
9. Which of the soft skills you have identified does MathWorld need to do more to help students develop?
10. Which of the soft skills you have identified does MathWorld currently prioritize?
11. What critical thinking skills do you think a student needs in order to be successful throughout their college experience and beyond?
12. Why do you believe these critical thinking skills you have identified are essential for student success?
13. Which of the critical thinking skills you have identified do you think the MathWorld experience generates for students?

14. Which of the critical thinking skills you have identified does MathWorld need to do more to help students develop?
15. Which of the critical thinking skills you have identified does MathWorld currently prioritize?
16. What confidence-building skills do you think a student needs in order to be successful throughout their college experience and beyond?
17. Why do you believe these confidence-building skills you have identified are essential for student success?
18. Which of the confidence-building skills you have identified do you think the MathWorld experience generates for students?
19. Which of the confidence-building skills you have identified does MathWorld need to do more to help students develop?
20. Which of the confidence-building skills you have identified does MathWorld currently prioritize?
21. Any additional comments or questions?

These additional sources, the artifacts, and survey, were integrated to facilitate "reaching a holistic understanding of the phenomenon being studied" (Baxter & Jack, 2008, p. 554).

Trustworthiness and credibility. A researcher's trust must be established and maintained throughout a study. For this qualitative study, participants were reminded that any personal information mentioned in the one-on-one interview would not identify them and would remain confidential. Before, during, and after the study was conducted, they were guaranteed that their decision to participate or not would not affect their professional status. Participants were reassured that information captured in voice records and transcription software during one-

on-one interviews would not reveal their identities and that data collected would be kept in a safe place.

In order to demonstrate dependability, I established a process of triangulation. Mathison (1988) stated that triangulation improves research practices and aids in eliminating bias (p. 13). A researcher may triangulate by using the following methods: data triangulation, investigator triangulation, and methodological triangulation (Mathison, 1988). In this study, data triangulation was used by referring to “several data sources” (p. 14). Eleven participants were interviewed and student testimonials examined to collect as many sources of data as possible. Mathison (1988) added that a researcher must take into consideration “time and space” (p. 14) to test the phenomenon in different conditions. The interviews were conducted in two different rooms, participants were asked to choose between four days (Tuesday, Wednesday, Thursday, and Friday), between the hours of 7:00 a.m. to 1:00 p.m., and the interviews were audio-recorded. There was a mix of Bobs, instructors, and instructors/former Bobs on each day, and 30 minutes between each session to avoid any uncomfortable run-ins.

Credibility was established through the triangulation strategies which Mathison (1988) refers to as convergence, inconsistency, and contradictory (1988). Convergence is the outcome “when data from different sources or collected from different methods agree” (p. 15). This strategy was achieved by submerging and engaging in the data collection and evaluating the saturation of the data when hearing or seeing recurring themes with no new data (Merriam & Associates, 2002). The data from the interviews, survey, and student testimonials were triangulated and compared between and within emerging themes.

Inconsistency is when “data obtained through triangulation may be inconsistent” (Mathison, 1998, p. 16), and contradictory is when “data are not simply inconsistent but are

actually contradictory" (p. 16) and lacks a basis of comparison. Steps to avoid inconsistency and contradiction involved asking participants to read transcripts of their interviews, include comments or feedback, and verify and confirm their responses represented them accurately. These steps eliminated researcher biases and assumptions. A verification of participants' statements would assist in validating data collected. All of the participants confirmed the accuracy of the transcriptions.

Compensation and risk analysis. This study did not include compensation. With regard to risk analysis, there is always potential risk as subjects encounter day-to-day life situations. This study, however, was about identifying core practices that MathWorld uses to ensure a lasting, positive effect on student performance in math. If participants felt uncomfortable about answering questions, they were permitted to stop at any moment during the interview. As such, the risk was minimal, and I did not gather personalized data beyond the scope of the study.

Data Analysis

Due to the nature of case study, data analysis is a recurring process during and after data collection. Creswell and Poth (2017) represent this process as a spiral image, since "the researcher engages in the process of moving in analytic circles rather than using a fixed linear approach" (p. 185). The five steps to data analysis and representation, as suggested by Creswell and Poth (2017), were utilized.

Step one: Manage and organize the data. The voice recordings were transcribed by converting them into a Word document by way of my personal laptop. The laptop was password protected and was always locked in a home office or in my possession.

Step two: Read and memo emergent ideas. As I reviewed the transcriptions, I made notes in the margin and formulated initial codes based on the participants' responses.

Step three: Describe and classify codes into themes. Creswell and Poth (2017) describe the open coding phase as the moment in which "the researcher examines the text (e.g., transcripts, field notes, documents) for salient categories of information supported by the text" (p. 203). During my review of the transcriptions, artifacts, and survey, I "described the case and its context" (p. 199).

Step four: Develop and assess interpretations of the data. In this step, as stated by Creswell and Poth (2017), the researcher used "categorical aggregation to establish themes or patterns" (p. 199).

Step five: Represent and visualize the data. The researcher used "direct interpretation" and developed "naturalistic generalizations of what was 'learned'" (Creswell & Poth, 2017, p. 199). For my study, this was the step in which I described how MathWorld's core practices impact student success.

Excerpts from the interview transcripts, surveys, and student testimonials were arranged into tables I created in a Microsoft Word document. The commonly used words and phrases from the data sources were highlighted in yellow. Themes were devised by looking at words and phrases that were commonly used by the participants in the interviews, as well as how they elaborated on their thoughts in the surveys. These words and phrases were compared to the student testimonials to notice if there was recurrence of the theme. Initially, the words and phrases were compiled into two groups: cognitive domain and affective domain. However, upon continued review of the data, reflection of the research questions, and the conceptual model of MathWorld finally emerged as three themes, or core practices. Within each theme, there were multiple occurrences of reference to ideas that reflected the following: (a) processing of information (e.g., taking notes, problem solving, and checking for understanding), (b)

demonstration (e.g., showing examples, error analysis, and modeling), and (c) connection (e.g., asking questions, providing encouragement, and humor).

Chapter Summary

Chapter three explained the approach and rationale for using the case study design to address the research problem of the study. A review of demographics, trustworthiness, and ethics were also included in this chapter. An explanation of Creswell's (2012) five steps to data analysis and representation was provided. These five steps were implemented, and Chapter Four displays the results of the analysis.

Findings

The purpose of this study was to better understand and explore the impact of participation in MathWorld on student success in developmental math courses, from the perspectives of math faculty and staff at a local community college. In this chapter, from the lens of the relevant knowledge holders, I explore how MathWorld uniquely achieves its impact on developmental math students, identify core practices that have a lasting, positive effect on student performance in math, and link these core practices into a conceptual model of success for developmental math students.

The findings are based on the data I collected from 11 participants through one-on-one interviews, the follow-up survey, the student testimonials, and my lived experiences. The findings are presented as follows:

1. Reconceptualization of the MathWorld model in which the three thematic areas represent the core practices of MathWorld.
2. Thematic areas in which categorization of sub-themes is scaffolded in the following way:
   a. Participant perspectives
      i. What MathWorld staff and faculty need to provide.
      ii. What students need to bring.
   b. Researcher perspectives
3. Ancillary results:
   a. External and internal challenges.
   b. Impact of MathWorld.

4. Integrative characteristics of the reconceptualized MathWorld model: processing information, connection, and demonstration.

Reconceptualization of the MathWorld Model

The three themes that emerged from my analysis were (a) cultivating content-specific skills, (b) supporting life skills, and (c) providing holistic interventions (Figure 5). The reconceptualization of the MathWorld model is visually represented as three circles with connecting lines. Each circle in Figure 5 signifies the core practices used by the Bobs and math faculty. The lines connecting each circle denotes the characteristics of these core practices, which will be introduced later in this chapter. The integration of these core practices, which represents the *secret sauce* of MathWorld, in addition to its characteristics, yield success.

Theme 1: Cultivating Content-Specific Skills

Cultivating content-specific skills is a core practice by which the Bobs and instructors guide the students to a better understanding of various math subjects. This involves an assessment of what the student knows, in addition to employing various strategies (teaching, tutoring, and learning). As most of the participants described the interactions with students in MathWorld, their behaviors emphasized modeling procedures and process-oriented strategies. These strategies, for the most part, incorporate the *I do, we do, you do* format, which is introduced by MathWorld staff. *I do* refers to the initial action from the Bobs, *we do* indicates the simultaneous performance from the Bobs and student, and *you do* signifies the subsequent individual practice from the student. A description of how participants and the researcher help students develop a better understanding of various math topics follows.

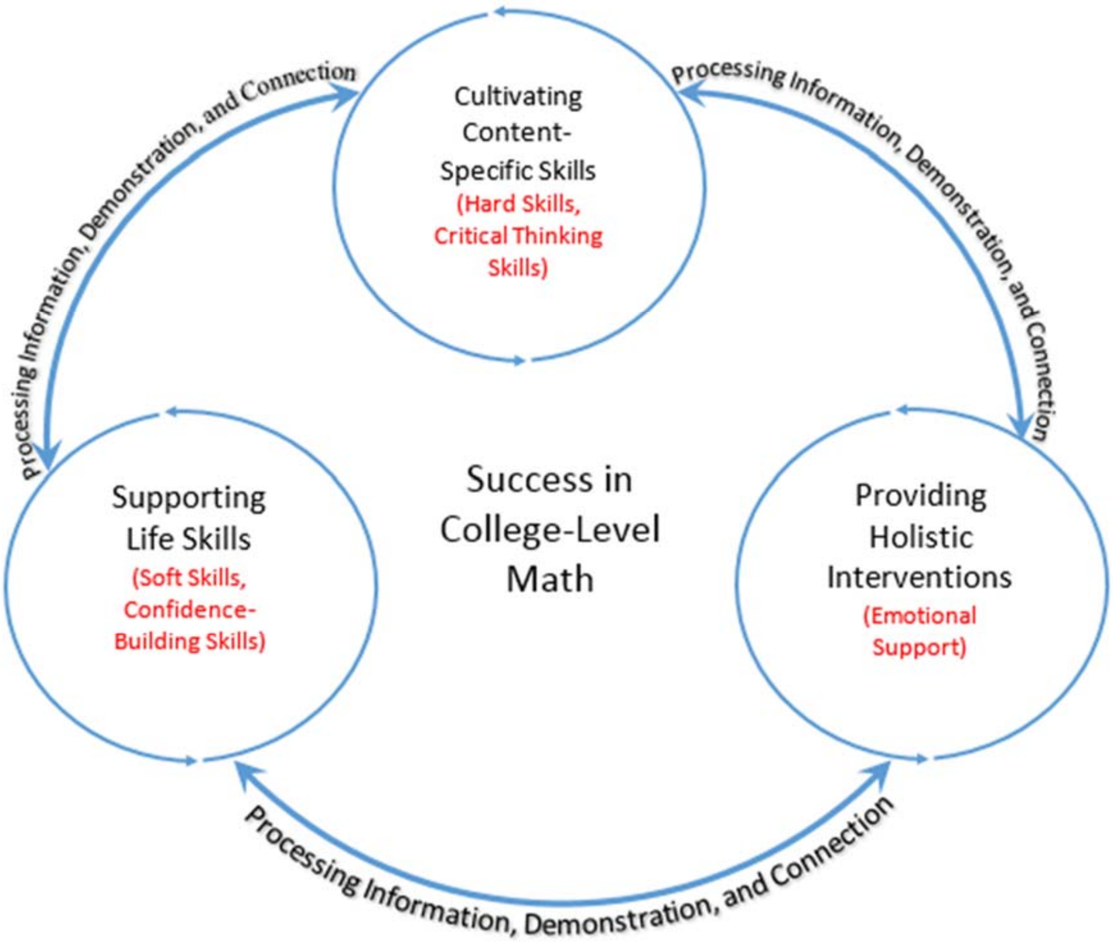

Figure 5. Reconceptualization of the MathWorld model.

Participant perspectives. Cultivating content-specific skills is exemplified in the data, such as working through examples, listening for the problem, and persisting with help. Participant B2 said, “I usually ask them to describe their problem to me, whether they’re not understanding the concept, or they just got stuck.”

A former Bob-now instructor shared her typical routine of working with students in MathWorld:

> If I don’t know the student, I will ask okay, “What are you working on?” and the first thing that I will do, I will look at an example. “Where are you stuck? Okay, then let’s work an example. Let’s look at an example that you’re showing me.” And I will work that problem, make sure I understand that problem correctly, and then I’ll say, “Okay,

> now let's look at your problem. Okay, what are you not understanding? Tell me where you're stuck. (M1)

What students need to bring. Responses revealed the importance of certain content-specific skills in the following areas: basic math, notetaking, organization, technology, time management, communication/collaboration, and studying. One response, in particular, outlined three identifiable types of skills in the following math topics: problem solving representation, basic algebra, and basic arithmetic.

Notetaking. Some of the participants specifically referred to the notetaking workshops that MathWorld currently offers to students. Participant P5 explained the rationale for promoting notetaking strategies:

> One of the more recent focuses in MathWorld has been on student note taking. We have really tried to emphasize the important role good note taking plays in student success by encouraging students to use their notes when completing assignments as well as providing Note Taking Workshops to help students improve their note taking skills.

Another participant, P8, agreed: "Each time a student visits MathWorld, tutors will examine and critique the student's notes. MathWorld has begun offering workshops for students on notetaking and organization." The notetaking workshops exemplify the theme of demonstration, as this strategy addresses student accountability. Students are expected to bring their notes from their math course to MathWorld before they may receive assistance. Participant P9 elaborated on this expectation:

> This semester we are prompting students for their notes and their workbooks before we begin a tutoring session and reminding students of the expectation of these tools when they come to MathWorld. I believe most students are following this expectation very well this semester.

One implication of this might be that adopting good notetaking habits could help students gain proficiency at identifying specific math topics. Some of the students, in their testimonials, mentioned specific examples of math topics in which they needed to understand, improve, and

eventually become adept. These topics include operations, classifying numbers, word problems, equations, and formulas. One student, for example, identified math topics that ranged “from all the difficult equations to simple mathematical formulas.” Another student mentioned “addition, subtracting, multiplying, and dividing negative and positive numbers.” A third student said that a Bob helped him to “understand the word problem regarding degrees and height.” One student, in his testimonial letter, recalled his receiving assistance and practice in MathWorld with Mathzone, an online math program: “I like the computer operated program and I am very glad that I can access the Mathzone [program] through my home computer as I tend to do some of my homework late in the evenings.” Many students acknowledged that they not only needed to take initiative of their learning experiences, but they also should know what resources are available to them and how to use them in meaningful ways. One student said, “I’ve used this [MathWorld] lab to the full capacity.” Another student shared, “I have literally lived in MathWorld. I get there when it opens, and I was in there constantly, but I know it was worth it in the end.” These comments demonstrate the need for students to be determined about how and to what extent they utilize the services of MathWorld.

Many of the testimonials described instances of students learning math concepts from different points of view. These perspectives are not only from the Bobs’ personalities per se, but also from the explanations of the math problems. One of the students said that a Bob “has given me a new way to approach this [math] course.” Another student, in her testimonial, described her MathWorld experience in this way:

> I go there as many times as I can. Every time that I go, I receive help. And if I do not understand the way that one helper is explaining it, they go and see if they can find another way to explain it to me.

One student recognized the Bobs for their “outstanding problem-solving, solution-finding” abilities, and stated that “Math has become my favorite class” for those reasons.

Problem-solving. According to one of the participants, problem-solving representation consists of “transferring mathematical ideas to words” (P6). Basic algebra skills include “simplifying and solving linear equations, simplifying mathematical expressions, and linear and nonlinear factoring” (P6). Basic arithmetic involves “adding, subtracting, multiplying, and dividing” real numbers (P6). Another participant, P10, listed fractions and integers as specific examples of real numbers. In addition, participant P2, included “order of operations, properties of math, [and] terminology” as important math skills. Participant P8 suggested that students’ abilities to perform operations (such as addition, subtraction, multiplication, and division) by hand, along with “memorization of multiplication facts,” would be of great benefit. Some of the participants identified note-taking skills as a hard skill. According to participant P4, student notes should be “accurate.” Participant P5 also believed the notes should be “well-developed.” Aside from having the ability to “adapt” (P9) and “utilize” (P10) different software programs, no additional examples or specifics were given in their responses.

Also, the concept of *guidance and repetition*, although not rising to the level of a theme, appeared frequently in student perspectives. In the testimonials, some students expressed that the Bobs’ guidance and repetition of explaining the math concepts to them was helpful. One student, in particular, said, “I feel I enjoy math more because I get the help. I need to understand it with guidance and repetition.” Another student said, “I know that several of them [Bobs] have even answered the same question for me over and over again.” A third student expressed her appreciation for a Bob, “who would go over concepts with me until I understood what was happening.”

What MathWorld staff and faculty need to provide. Many of the participants preferred using core practices of demonstration, such as problem-solving strategies, additional examples, visual representations (such as colors to highlight specific steps or math concepts), and guiding questions while assisting students. One Bob mentioned, in her interactions with students, that she connected math to real-world situations:

> I try to relate it to real life, relate it to money, relate it to, like, siblings and food and stuff and see if that approach can work. Maybe put the idea together and help them realize that math is just not numbers and this crazy thing that you do that you never use in life. (B4)

Assessment of student knowledge. Some participants discussed assessing students' conceptual understanding by first reviewing the students' work and assessing students' related behaviors. Knowing where students were foundationally in their math skills was an essential step in assisting them. Participant I4 said that she regularly began her sessions with the students "by assessing their conceptual understanding." In her response, she continued with a list of questions she incorporated during the benchmarking process of each student: "Is there a conceptual understanding? Do they have the right structure? Do they have the right notes? Are they attending class? Are they, you know, doing their part?" Likewise, B1 assessed students by viewing their attempted work: "So the first thing I do is say, 'Show me what you've done.' That way I can pick apart where they're making mistakes. I can find exactly where the issue is and then go from there."

In addition, as the Bobs and math faculty gauge the students' level of understanding, they reinforce student accountability. Some participants ensured student accountability by verifying they were doing their part. For example, Participant B2 stated that it was very helpful for her when the students have already attempted the problem. "The whole purpose of the…asking the students for their notes is to make sure that they *have* reviewed it on their own…and I can help

them point out, 'This is where your procedure is a little messed up.'" Another participant, I4, mentioned that she was "trying to understand, trying to see if *they* are doing what they're supposed to be doing also as students." Participants agreed that students should be held responsible for taking an active role in their learning experiences and become more self-sufficient.

Teaching/tutoring/learning strategies. Participants identified analysis as an essential critical thinking skill. Hence, facilitating higher-order thinking skills is a strategy used to assist students. Participant P10 agreed that the ability to analyze "is the critical thinking skill most students need." Participant P3, in essence, provided a list of six tasks of which students should be able to do in order to enhance their critical thinking skills:

1. Be able to identify the real issue or problem.
2. To research all the fact and understand the creditability of the source of those facts.
3. To identify and challenge bias within oneself and the sources of facts (i.e., is there a hidden agenda).
4. In a given problem, the ability to determine what are the most relevant facts.
5. To make a reasoned conclusion based on the facts and sources one has found.
6. To apply what has been learned to other scenarios.

Participant P6 affirmed the importance of connecting and extending concepts outside the classroom setting:

> The ability to think beyond the stated facts and make connections between what is presented in class and what they [the students] see in the homework. Being able to consider extensions of what is presented in the classroom is very important.

Other participants' individual core practices addressed developing a deeper conceptual understanding of math topics using various strategies. For instance, one of the Bobs emphasized problem-solving by showing the students how to break down the problem into smaller parts:

> A lot of times, especially with things like word problems, I see students start to panic because it's too much information at once. So, I try to show them how to break that down into, "What are we looking for? What are we given? Okay, given that information, what do we need to do to find our answer?" That's probably the biggest thing that I do that's different from the other Bobs. (B2)

Her approach with the students resembled Polya's (1945) four steps to problem solving: understand the problem, devise a plan, carry out the plan, and look back.

Participant I4 stressed the importance of promoting precision over shortcuts

For students. "Teach 'em the *why* behind everything, so that they're able to, in the future, decide to come back and take more classes," according to her, would help increase student motivation.

Another instructor incorporated teaching and learning strategies while

assisting students in MathWorld:

> I'd like for them to see the core step, and I also like for them to see *why* I'm doing every step. I like to have a conversation with the students for them to remember why we do certain things in math. (I1)

Participant I3 mentioned that he spent more time assisting students through explanation: "I do try to spend a little more time with them and try to explain *why* I'm doing…or why we're doing what we're doing on a particular problem that they're having an issue with."

When asked to identify her individual core practice, a former Bob-now instructor asserted that she was adaptable and provided accommodations for her students. She broke down problems into simpler parts and found that special needs techniques worked well for other learners:

> I always tell students that I see things the way a lot of students see things that I work with. I said, "I may be able to see it 'high' [level] in a textbook, but I know how to break it down 'low' [level], you know. I like to incorporate…and I find that a lot of things that

> instructors, or a lot of practices that instructors use for students that have special needs, work for all students. (M1)

Some participants acknowledged that the explanation of the math concepts is a core practice associated with MathWorld. Specifically, providing explanations in smaller, manageable sections is quite common. Participant P11 stated, “MathWorld’s priority is explaining.” Many students, in their testimonials, used the phrase “broke things down” to describe how the Bobs explained the math concepts. For example, one student wrote, “He broke things down in a much simpler manner than the book itself.” Another student shared, “They [Bobs] broke things down in a way that made complete sense to me.” The explanation of these math concepts in smaller, manageable pieces seemed to benefit the students greatly.

Most participants recognized that they learned some of those strategies from their colleagues. Hence, the concept of *learning from others* appeared in participant perspectives. Participant I2 acknowledged that he mimicked what other Bobs did. He said, “I think I pretty much use *everything* they [the Bobs] come from.” Participant I3 agreed, “I try to mimic as much as possible what the Bobs do while I’m in here.”

In his attempt to identify one of his unique core practices, one of the Bobs gave credit to his colleagues for learning. His response to this question revealed that he valued humor as an aid to interaction. He also asked students for constant feedback and affirmation, and used a soft-spoken style to reach students:

> I’ve learned so much from everyone here. I’d be lying if I didn’t say that humor didn’t come from here. I love joking with the students. But along the way, I’m constantly… I’m asking guided questions, but then I’m asking them back, you know, “Is that okay with you? Are you okay with this method?” Um, speaking softly is kind of something that I’m known for (laughs). Some of the tutors are a little louder than other, and some students really enjoy that, but I know that some students enjoy, you know, “Don’t be loud. Don’t call me out.” So, kind of speaking softly and slowly, I think helps the students here. A lot of what I do is what I’ve learned from watching others…so it’s hard for me to pinpoint one that’s just uniquely mine. (B1)

Most of the participants were keenly aware of their colleagues' teaching methods and, inherently, added those strategies to their instructional toolkits.

Researcher perspectives. As previously noted in Chapter Three, my lived experiences of working with students in MathWorld occurred as part of my duty hours as a full-time math instructor for a few years. In my lived experiences, I have observed that many students were not aware of the various study strategies to help them understand math concepts. Some took notes in class, but they were not able to make the transfer and use the same procedure on similar problems from the homework and/or the test. For instance, in my Flex 2 Math 0320 (Intermediate Algebra) course, I had several students who asked, "Did I get this right?" or say, "I'm stuck, and I don't know what to do on this problem." Then I would either redirect them to their notes, where they have written down the steps to examples I reviewed during the lecture. Sometimes I would ask them to compare and contrast the examples from the notes with the homework problem on which they were working. Some students were able to continue with the problem once they saw that the problems were similar. Perhaps they just needed a visual cue and/or a verbal reminder of how to get started. Additionally, there were students who became easily frustrated when they went through the steps and still got the wrong answer. They did not realize the importance of checking their work, and they soon discovered that they did not pay attention to detail, such as forgetting the correct sign or using the wrong operation.

To address the aforementioned issues, I periodically use error analysis as an assessment method throughout the semester. After providing examples of specific problems and giving students the opportunity to practice similar problems, I assign another problem and "deliberately" make a mistake or two in the steps which eventually leads to the incorrect answer. I intentionally pause to allow students to identify the error(s) and subsequently, the students are

required to provide me with an explanation of what corrections should be made. The rationale behind the error analysis is at least two-fold:

1. It reinforces the importance of attention to detail when solving problems.

2. It raises awareness of common misconceptions that students may have when performing certain math skills.

Another observation I have made in MathWorld is that some students work diligently at trying to understand math concepts. They take the initiative in raising their hand to ask questions when they are not sure how to work out a problem, whereas others only seek "the answer" and do not consider the process or procedures that lead to arriving at the solution. I am concerned with their ability to persevere and understanding that some problems actually do require more than one step to solve. In that respect, I feel like I am a "talking question mark" whenever I interact with any student in MathWorld. I try to model some think-aloud strategies for students to use as they approach and attempt to solve a problem. I ask guiding questions to help them think about the context of the problem, the information that is given, what they are being asked to find, what strategies they tried/should consider using to solve the problem, and whether the solution makes sense. In many respects, I take them through Polya's problem solving steps by way of guided questioning. Based on my observations in working with students in MathWorld, not many of them know what strategies to use when solving problems. Some of them seem to be so quick to give up because the problem may require them to perform more than one step. My experiences are fairly identical to the participants' experiences in working with students in MathWorld. It is evident that the significance of assessing what students know and using appropriate instructional/tutoring strategies to help students better understand math can play a critical role in student success.

Theme 2: Supporting Life Skills

Supporting life skills and maintaining and establishing a positive relationship among the students, faculty, and Bobs is another critical supporting element of the model of MathWorld. Making the student feel comfortable, building a rapport and commonality, in addition to providing individualized attention and reducing power distances, are ways in which the math faculty and Bobs connect with students. As previously mentioned in Chapter One, soft skills encompass character traits, mindsets, and mannerisms that are exercised in interpersonal relationships. Therefore, supporting life skills is a core practice by which the Bobs and instructors create an atmosphere of relatability and gauging the socioemotional well-being of the students. The following section describes how the participants and the researcher model appropriate socio-behavioral cues for the students.

Participant perspectives. Some participants discussed acknowledging and reducing anxiety, while others focused on identifying the socio-behavioral cues of students and the need to respond to diverse personalities, including gauging the social and emotional well-being of students while assisting them. For instance, according to Participant B3, many students "…have anxiety issues. When I speak to them, I try to make it fun a little bit, you know, try to bring their anxiety down a little bit."

Another Bob confirmed the importance of identifying the socio-behavioral cues of students:

> I like to think that we have a holistic approach to learning, because there are some students who come in with low self-esteem and low confidence towards math. And when we spot those kinds of behavior in a student, we want to sit down with them first a little bit to make sure that we get them over that in some way, so that they can be able to learn. (B4)

A description of what students need to bring, in addition to what MathWorld staff and faculty need to provide, with regard to supporting life skills, follows.

What students need to bring. According to the data, displaying a positive attitude and exercising resilience were identified as important confidence-building skills for students to possess in order to achieve success. An explanation of these distinctive abilities follow.

Positive attitude. Three of the participants identified positive thinking/attitude as a vital confidence-building skill for student success. Participant P6 described this ability as having an “I can do this” attitude. Participant P10 mentioned that students “need a certain level of self-confidence so that they believe they can accomplish any goal.” Some of the participants noted that, as students set “meaningful and achievable goals” (P3), they should reflect on their accomplishments and celebrate them, whether those achievements are major or minor. Participant P8 provided an example of how students could increase their self-confidence:

> Students can gain confidence by seeing success one problem at a time. Often students see 30 problems of homework and throw in the towel. A lot of students postpone their work until the end of the week or right before a test. Students need to stay up to date in their studies and seek help early to maintain confidence.

At some point in acquiring math skills, students may experience fear and anxiety. In her testimonial, one student declared that she needed to confront the fear in order to gain more confidence: “I decided to face the fear and defeat it with the help of the instruction and professors in MathWorld.” The modeling of life skills by the Bobs is exemplified in the data, such as stress management, analysis, positive attitude, celebrating milestones, and resilience. Two of the participants asserted that stress management is another important soft skill that students must have in order to be successful. In their testimonials, a few students recognized the importance of practicing productive coping strategies when they encountered difficulties with math. One student, in particular, mentioned that a Bob “and I have often shared math humor and enjoyed it.” Another student recalled that a Bob “also made me laugh a lot,” in addition to exhibiting patience in his tutoring skills.

Perseverance. Two of the participants identified exercising resilience as an important confidence-building skill. Participant P8 mentioned that students "need to understand that there will be some failure along the way." A student's ability to recover after making mistakes and learn from them is critical for success.

Many students expressed a sense of pride with their improvements and achievements in math. One student exclaimed, "I carry a sense of pride knowing that Math is NO LONGER a struggle, as well as obtaining the tools to becoming successful in Mathematics." Another student shared his feelings upon receiving a high score on a quiz: "I scored a 95 on my first quiz. It was like a high for me. I smiled all evening after the quiz was returned to me." A third student gave the following account of his MathWorld experience:

> I walk into my classroom with pride and determination to success. And yes, the midterm was difficult, but with the help from…the tutors from MathWorld, I was able to pass my midterm.

Many students credited the Bobs in facilitating their increased level of confidence. A fourth student expressed her gratitude in this way: "Thank you all for boosting my math confidence! For the first time ever, I feel like I am 'good at math,' and that is a really nice feeling." Another student provided his acknowledgement of the Bobs:

> Now, I can proudly say that because of you and your staff, I started out in [Math] 0301 [Elementary Algebra], and now I am on my way to registering in the summer for Math 1442 Elementary Statistics and Math 2412 Precalculus.

Communicating with students on an even level is essential to facilitating students' positive attitude and perseverance. When asked to identify an individual core practice, a former Bob-now instructor said that he kept his interactions with the students on an even social level. He wanted to be relatable as a math friend, and believed that students needed to be comfortable to open up during the conversation:

> I guess I always try to be relatable. I feel like the student [should] feel like I'm not an instructor. I'm not their tutor. We're just friends doing math together. Make them feel comfortable. Once they're comfortable, they will talk about whatever and they actually pay attention more 'cause it's like… When your friend explains it versus when your teacher explains it, you pay attention more for whatever reason… Being comfortable and relating to them as a person, I always try to bring 'em to the table. (M2)

What MathWorld staff and faculty need to provide. The diversity of math support specialists in MathWorld lends itself to a variety of personalities. "Having various personalities…can better fit each type of student" in need of assistance (M2). When a Bob or a faculty member explains a problem "in a different way, or maybe just with a different tone, or a different personality" to a particular student, he or she is more likely to be receptive and gain a better understanding of the math concept (M2).

Engagement. One Bob in particular believed that humor, comfort level, and commonality were key elements in encouraging students to engage:

> Humor is extremely important. We don't have Dr. this, Dr. that. We have Bobs. It's the old joke about drive a hundred miles and go to a gas station, and the gas station attendant is called "Bob." You know? The object is to make the student feel comfortable. So, one of the first things I try to do with every student is to build a rapport and build some commonality… Whether they like cars, or whether they're athletes, or whether they were in the military, or…anyway I can get a common bond that they and we are the same. (B5)

Participant B5, whose background is in clinical psychology, stated that his ability to communicate with students "on a psychological as opposed to an intellectual level" was one of his unique skill sets. For some of the participants, their individual core practices involved ensuring that students felt comfortable during their learning experiences.

Many participants acknowledged the importance of establishing and maintaining open lines of communication with students. For example, Participant P1 believed that, in doing so, the goal of making "every student feel special and valuable" is achieved. Participant P10 also agreed that communication is something that MathWorld prioritizes. "I would say communication. Just

trying to get the students to convey what they are needing help with" (P10). When students visit MathWorld, they receive individualized attention. As one student observed, "What make the 'Bobs' different is that they constantly work one-on-one with students in an upbeat atmosphere." Many students appreciate the rapport and commonality among the Bobs and themselves. In fact, humor is a common expression of connection with the students. Another student mentioned that he and a Bob "have often shared math humor and enjoy it."

Some of the participants acknowledged the importance of learning the student first, approaching with an open mind, establishing rapport, and interpreting whether their homework was done or not:

> I *first* learn the student. So, when the students ask me for help for the first time, I have an open mind. So, I go there and talk to the, ask them how they're doing, and I look at the problem they're having. So, the way they ask me the question tells me whether they've done the homework or not. (B4)

As mentioned earlier, various personalities are represented in MathWorld due to a wide diversity of the faculty and staff. A former Bob, now instructor, discussed the importance of people being themselves by pointing out that "personality is a big deal, and I just figured that it means I should be myself….And if we weren't ourselves, then that would defeat the whole purpose" (M2).

Participant B1's response to this question included noticing student enjoyment and striving for a comfortable environment. He explained that "students really enjoy coming here. They enjoy talking with the tutors, [and] they don't feel intimidated. Making this place a comfortable place to work is definitely something that we all strive to do."

Another Bob stated that students' preconceived opinions about their math abilities could create barriers. He felt that some students were in self-denial about math needs and that students needed only small reasons to doubt themselves:

> More and more students want to hide behind that political correctness as opposed to facing what we're doing and trying to move forward. "Well, if I can't do it [math], any reason I've got is a good reason." And so, "Bob #2 said something about the women in math, etc. Therefore, since I am a woman, I can't do the math." Well, no, he said, "Women do better at math." You know what I mean? And so…a lot of out-of-context stuff. (B5)

Patience. Another set of life skills were categorized as emotional support. Emotional support was exemplified in the testimonials, such as encouragement, sense of comfort, positive energy, patience and kindness, and willingness to help. Many students, in their testimonials, expressed their appreciation for the encouragement they received from the Bobs. For example, one student said, "I think the encouragement meant more to me than I can express in words. Your staff encouraged me to keep on going." Many participants understood the importance of giving students encouragement. Participant P5, for example, explained the various ways in which they encourage students:

> In MathWorld, we do our best to encourage students and help them maintain a positive attitude about math. This ranges from simply giving students a "Good job!" to sometimes pulling a student aside to address their concerns and give them a "pep talk."

Several students also remarked about how comfortable they felt during their MathWorld experiences. One student recalled, "I was a nervous wreck, and you were tremendous for putting me at ease." Another student shared, "I feel very comfortable going in [MathWorld]. No one makes me feel stupid. They just help and support." One student mentioned that the Bobs "didn't show any signs of negativity." Another student described his MathWorld experience in this way: "MathWorld cares about the same thing the students care about, which is passing math.... The place is constantly overflowing with students from every grade…in an open environment with a positive energy towards Math success." Many students often acknowledged the patience and kindness that the math faculty and staff extended to them. As one student aptly put, "Thank you and everyone else for all your patience and kindness with me." In addition to patience and

kindness, several students seemed to greatly appreciate the Bobs' willingness to assist them with their math problems. One of the students made the following observation: "From my point of view, they [the Bobs] were very helpful [and] very patient."

Researcher perspectives. In my experience, the students who cross the threshold of MathWorld come with a variety of backgrounds and personal issues. It is difficult, if not impossible, to take a cookie-cutter approach to how one interacts with these students. I have discovered that using a variety of techniques that allow the students to practice life skills, while also creating a positive environment for learning, contributes to student success. For example, during the beginning of each semester, I use an icebreaker activity, which consists of a short multiple-choice quiz about myself. The students had to guess, for example, my favorite soda, what happened to me on July 7, 2007, my favorite entrée from The Olive Garden, and the number of years of teaching experience.

Since there are some students who already come anxious and apprehensive about a math course, I like to start the semester with that activity to remind them of the following:

1. Math teachers are human and not machines.
2. Students can find at least one other person in the class that share common interests.

At the end of the quiz, they were required to share two things about themselves with their classmates. (During one semester, I had at least four students who were Harry Potter fans!)

In addition to the icebreaker activity, another way that I try to build relationships with students in/out of the classroom is through a phone application called Remind 101. This app allows for secure and confidential communication between the instructor and students, whether through individual messages or group announcements. I use the app to reply to individual messages and to send announcements or notifications to the class, such as a modification in the

course timeline. Many of my students use this app to inform me of their late arrival or absence due to traffic, an appointment or an emergency situation, or to ask me questions about the coursework.

Theme 3: Providing Holistic Interventions

Providing holistic interventions for student transformation is another essential element to the *secret sauce* of MathWorld. Specifically, customization of MathWorld responses to student situations is necessary for student success. Providing holistic interventions is a core practice by which the Bobs and instructors discern the academic and socioemotional needs of the students and utilize appropriate interventions. This includes offering emotional support by way of intuitive listening and accommodations based on student situations. A description of how the participants and the researcher provide holistic interventions follows.

Participant perspectives. MathWorld staff and faculty have provided various holistic interventions for students. For example some SPC students are homeless and do not have regular meals. Because of this, the math department created food pantries containing a variety of snacks and canned goods for those students in need. Often, the only way to know a student has a need in one of these areas is by listening, observing, and intuiting the external factors which impacting the student's ability to be successful in math. Providing intuitive listening and customizing approached to student situations are other ways holistic interventions occur.

Intuitive listening. Dr. Walling, a retired Air Force veteran, relates to students who are active duty, veterans, people with disabilities, and individuals who may have post-traumatic stress disorder (PTSD). He connects with these students by acknowledging anyone who visits MathWorld in military uniform, striking up conversations with them during Orientation Week and throughout the semester, and helping them to develop a plan that will increase their success

in math. In my interview with Dr. Walling, he explained his philosophy of MathWorld, which emphasizes inclusion, diversity, and relatability:

> This is hard to explain, hard to write down, or even think about: I am rude, crude, vulgar, socially unacceptable and politically incorrect. That really endears me to a significant number of students when I tell 'em, once you come through these doors, race, gender, the way you dress, your background and stuff, it does *not* matter. Well, that sets the stage. And being Bob instead of Dr. Walling. *That* sets the stage.

Dr. Walling and the Bobs behave in such a way that it is clear to everyone who crosses the MathWorld threshold is the same—they are all having difficulty with math. Any other differences (gender, ethnicity, religion, etc.) are irrelevant. The purpose of MathWorld is to help students learn.

> When I hear that women can't do math, or Blacks can't do math, or Hispanics…. *No, no. Anybody can do math.* Don't tell me you can't drive a stick-shift automobile. I can guarantee you before the class burns out, I can teach you how to drive a stick-shift automobile. And that is the philosophy of MathWorld, along with selecting people that have different mental makeups….That's kind of the philosophy, what made it work.

Customization to students' situation. It is evident throughout the data that MathWorld plays a critical role in student success.

One of the Bobs mentioned the importance of stepping back and considering all aspects of the student's attitude and behavior:

> You have to be able to connect with the student, and then after that, then find out what they know, basically. And if that can't be done, then there's no way to transfer the information because there's a mutual respect that has to be developed. I've seen that in a lot of student, because of what's happening at home, [and] their work situation. They come in here and if you don't gauge it and you ask them a simple question, then they'll sometimes take it out on you. And you have to be able to just, you know, absorb it and just move on. And that's why we have more than one Bob, and maybe someone can connect. (B3)

Participant B3's final comment in this quote is reflective of Dr. Walling's reference to "different mental makeups." The differences among the Bobs and their approaches are conducive to working with students who arrive with differences in background, ability, and attitudes.

The following is a descriptive account of an administrator's lived experience in using MathWorld to assist a student with Autism. A pseudonym will be used to protect the identity of this student.

Ms. Mitchell, SPC's current Math Department Chair, met Jim towards the end of last semester when a student worker encouraged him to see her because of the challenges he was having in his math class. Jim felt like no one was listening to him. After the first meeting, Mrs. Mitchell recognized the problem. She was disheartened because she believed his semester could have been more productive had she known about his issues from the beginning. Jim's condition, Autism, presented some challenges for him. While these challenges were not academically related, they became an obstacle to his success.

Last semester (Fall 2017), Jim was put in an evening class with an adjunct. Mrs. Mitchell stated that she would not have put him in an evening class, nor with adjunct faculty members because they are not readily available to assist students. Also, the class had a total of 29 students. For Jim, being in a large class setting was too much stimulation. This large class size does not always allow adequate time for an instructor to address each student individually. This situation typically poses a problem for all developmental education, and it was worse for Jim. Another difficulty that Jim faced was the primary mode of instruction: traditional lecture. From a personal perspective, Mrs. Mitchell recognized this as a challenge. Talking and writing on the board, as sole practices from the instructor, did not work for Jim. Mrs. Mitchell recalled,

> Had I known about him in the first few weeks of the semester, I would have immediately put him in the immersion program. He has the mind. My Engineering faculty member talks about how brilliant he is. His issue is not the concepts. His issues are in the delivery, interaction, routine, and environment. None of these things were in place for him in the Fall [2017 semester].

While Jim's routine needed to be structured for him to cope, his learning did not. He understood the academic aspects, but he struggled with implementation and direction. That was not clearly demonstrated for him in the Fall 2017 semester math course.

During the current Spring 2018 semester, however, Jim has made great progress since the incorporation of MathWorld into his new math course schedule. He is currently taking a daytime math class from 9:30 a.m. to 1:30 p.m. with a full-time math instructor. Mrs. Mitchell has met with the instructor to explain Jim's issues and gave suggestions on how to interact with Jim. This semester, the new course has less than 10 students in it. Jim, as well as his classmates, can receive one-on-one attention. This math immersion course also has a supplemental instructor (a Bob) assigned to the class, so Jim has additional help. Also, the math immersion course allows Jim to work at his own pace and receive help as needed. While he is expected to complete all the required assignments for the courses in this semester, he is able to adjust how long he spend on one course. For instance, Jim has already completed the Math 0410 (Elementary Algebra) content and is moving on to the Math 0320 (Intermediate Algebra) content. He is taking advantage of the tutoring in MathWorld, as well as the services in the Tutoring and Technology Center (TnT). On a personal note, I have witnessed Jim attending MathWorld on a regular basis, and he works diligently. He especially prefers to work in the Looney Bin, a quiet and reserved area of MathWorld. Mrs. Mitchell met with Jim and his mother before the semester began and gave him a prescriptive plan for each day. This plan helps him to stay focused and remain on track for completion. It also alleviates the stress or triggers he experiences due to his Autism.

Researcher perspectives. The capacity to provide interventions for students with special needs, for example, is reflected in my lived experiences as a developmental math instructor within the classroom setting, as well as in MathWorld. One practice I have used throughout my

instructional career is implementing accommodations for students with special needs. I have worked with students who have requested and received disability services across the Alamo Colleges. For these students, it is standard practice for instructors to receive a letter of accommodation from SPC's Office of Disability Services. The letter contains specific individualized strategies for each student in need of such services to facilitate learning. Extended completion time on homework assignments and tests, preferential seating in the classroom, additional audio/visual aids, and allowed use of mathematical formulas on tests are a few examples of such strategies.

Another practice I have used is dividing the course material into smaller, manageable sections for the students. In my Math 0320 (Intermediate Algebra) class, for example, Chapter 10 (Radicals and Complex Numbers) is a chapter that is considered to be the longest, the richest in content, and the most challenging. In my regular 16-week courses that meet Monday through Thursday for 50 minutes a day, I was flexible with my course timeline by extending one lesson past a day or two because of the rich content.

A third practice I have used in my lived experiences is giving my students opportunities to improve their score on a unit test. However, these opportunities are realizable only if the students take the initiative. Once students have expressed to me their interest in earning a passing score on a test, I inform them of the test retake arrangements. For example, I use the Google Doodle app as an online scheduling tool for students enrolled in my face-to-face classes. Students use the link I provide for them via the app to sign up to select a date and time for their test retake. When students arrive to my office for the test retake, I explain that this opportunity is a moment of redemption. They have the possibility of earning points that are needed to bring

their test score to passing with a 70 or above. For example, if students make a 50 on a test with the hopes of earning a 100, then they would need to earn 50 points to reach that goal.

During the retake session, I fill out a “Student Success Initiative” form that includes a snapshot of their current average (test and overall) and keeps track of how many questions they are willing to complete (at the same point value) to earn those points. For instance, if students want to earn 50 points, then they may decide to work only five problems at 10 points each. I will then select the five problems they need to complete. These five problems are not the same problems from the original test. Rather, they are similar problems, and they reflect the concepts that the students missed completely or received partial credit on the original test. For each problem, I will give the students up to three attempts to arrive at the correct answer, but they must show their work to justify their answer and their work must be mathematically correct, since no partial credit would be given. If they answered three of the five problems correctly on the first “round” or attempt, then they have earned 30 points (three problems at 10 points each) toward their original score of 50, which would bring their updated test score to 80. During the second attempt, they would only need to focus on the remaining two problems that they missed. If a third attempt is necessary, then they would make the necessary corrections and I would update their test score accordingly. It is apparent, from the participants’ and researcher’s perspectives presented in this section, that intuitive listening and customizing to students’ situations are vital to providing holistic interventions.

Ancillary Results

This section describes the following ancillary results of the data: (a) external and internal challenges, and (b) impact of MathWorld.

External and internal challenges. While the goal of success is ideal, success does not come without challenges. The following themes emerged from extensive review of all data resources: external challenges and internal challenges. External challenges, such as varying levels of student preparation and accountability, represent the obstacles that Bobs and math faculty face as students enter MathWorld. Internal challenges, resource-oriented in particular, represent the issues Bobs and math faculty encounter as hindrances to student success.

External challenges. Upon entering MathWorld, students bring varying degrees of abilities, some of which can pose as challenges for Bobs and math faculty. Specifically, many of the participants have identified two primary abilities that students often lack: self-sufficiency and goal-setting. Self-sufficiency is the student's ability to initiate tasks and use resources with minimal assistance from faculty and/or staff. Goal-setting is the student's ability to create and achieve tasks within a given time frame (e.g., study schedule, completing homework assignments by the due date).

Some of the participants indicated that students should take more ownership in their learning experiences, become self-starters, and follow tasks through to completion with less frequent help from the Bobs and/or instructors. For instance, Participant P4 mentioned that students should be taught to become "more independent." Participant P10 observed, "MathWorld needs to do more to help students with their basic math skills. I believe the tutors in MathWorld give students answers to their question more often than getting the student to understand what they are doing." Also, Participant P11 said,

> I don't feel it's MathWorld's responsibility to develop student skills. It's each student's responsibility for his or her learning. MathWorld is a support system for students who want to maximize their learning potential. MathWorld can assist in that process by helping students understand and maneuver in the various computer programs that are attached to each course at St. Philip's [College].

One of the Bobs acknowledged that students needed more guidance on how to use their available resources, such as their notes, the course textbook (paperback or electronic) or educational websites, instead of relying solely on the Bobs to provide the answer to a problem. Expressing fear of generating dependence in students was evident in his response:

> I think a lot of times we as tutors can do too much work for the student… I think ensuring that they do use all the resources available and not just use us as their first line to go to is important. If we don't do that, that's inhibiting their growth as a student for doing the work for them. (B1)

Some participants also noted that students need to learn how to set relevant and attainable goals for themselves. Participant P3, for example, believed that these goals should be "meaningful and achievable." Participant P6 described the process as "What are you aiming for and how do I get there?"

Internal challenges. In addition to the difficulties that occur from outside MathWorld, the Bobs and math faculty also experience hindrances from within the program that are resource-oriented. Many of the participants have identified two primary resources that faculty/staff often lack: insufficient lab staff and pedagogical issues. The data suggests that there are not enough people working in MathWorld; the student demand exceeds the staff supply. Also, the data revealed that training is needed in teaching/tutoring strategies and learning styles. Many of the participants expressed the need for more hours and resources, and believed that additional time with students was the priority. For example, Participant M2 stated that "more funding" would be beneficial since tutors "can't be here as much, because there's not enough money." An instructor also agreed:

> It seems like, if we had a tutor or tutors available that could spend more time with students, that would help. I know it's a money-crunch, but it's the issue. And it's not that we wouldn't provide it if we could. It's a money issue because that takes time and money

> to be able to pay somebody that can just sit at a table for 30 minutes or whatever helping one or a group of students from a class. (I3)

During previous semesters, MathWorld's hours of operation were Monday through Thursday, from 8:00 a.m. to 7:00 p.m., and Friday and Saturday, from 8:00 a.m. to 1:00 p.m. When 10 of the 11 participants were interviewed during the Fall 2017 semester, however, MathWorld was only available Monday through Thursday, from 7:00 a.m. to 7:00 p.m., due to administrative changes.

Another instructor affirmed the large demand and associated reduction in response (quality) with high demand:

> We really got hit hard with it being closed Friday and Saturday…and they're times you get in here and it's mobbed. And you've got four hands going up, you cannot help everyone. I know that makes it very frustrating for the students. You want them to have this seamless experience. (I2)

As aforementioned, MathWorld's limited hours of operation during the Fall 2017 semester became a significant barrier to student progress. This barrier, according to Participant I3, resulted in failure to provide customized support. He stated that "some students feel they can't get enough help just because it's more like the tutors *and* the instructors walking around and helping students with a particular question, versus, 'I need help on a topic.'" A former Bob/now instructor described her feeling of pressure to not give too much individualized attention. When M1 recalled her experience of being told not to "sit with a student for a long period of time," she realized that "that's not always doable. Sometime, and depending on where that student's level is, you cannot." Acknowledging a variety starting points for students and prioritizing sustainability over quick fixes were evident in her response:

> Another barrier is, a lot of our students lack the foundation, and so you may not be able to explain what you need to explain in five minutes and then move on to another person. We want all the students to be successful, so it's not a quick fix. You may not be able to work with students for a couple of minutes and then move on to another student. You may

> spend 20 minutes with a student, you know, to make sure that student has a good understanding about whatever that material is. (M1)

Many of the participants stated the need for more consistency regarding the core practices among the Bobs and faculty in the area of pedagogy. One of the instructors suggested that the Bobs' teaching practices were not as strong as their content knowledge. Hence, training for the Bobs in teaching and learning strategies would be beneficial. He stated, "Perhaps the Bobs might not understand the teaching practices versus learning practices. They understand *how* to do a problem, but may not be aware of the students' learning styles" (I1).

Another instructor expressed the need for a consistent approach between Bobs and faculty members. He provided an example regarding the implementation of an online math program which follows a specific learning path: Learn, Practice, and Certify. Posters are displayed throughout MathWorld to serve as reminders to everyone that students may receive limited assistance on the first two learning paths, Learn and Practice. However, students are expected to work on the Certify portion of the learning path without assistance. Expressing harm done from inconsistency between Bobs and faculty members was evident in his response:

> You're not supposed to help students on the Certify, and the Bobs are very good about doing it and being very consistent. But you got, a professor will be in here [MathWorld] and they'll be helping them on the Certify, which defeats the purpose of that item. So, there is some more need for consistency if you're going to have faculty being in here, trying to get everyone on the same page. (I2)

Impact of MathWorld. Extensive review of all data sources revealed two themes which describe the impact of MathWorld: anticipated outcomes and actual outcomes. An explanation of these themes follows.

Anticipated Outcomes. The participants expressed their anticipated outcomes of MathWorld on student success. These anticipated outcomes are illustrated in the interviews and survey, such as student preparation and student transformation. The data suggests that the end

result of student success is not limited to just numbers; rather, it encompasses a holistic approach through human interaction.

Student preparation. According to the SPC Math Department website (n.d.), the department mission statement is as follows:

> Through our programs, you can expect to receive a quality educational environment which stimulates critical thinking, develop an understanding of mathematical concepts and their applications, and foster an **appreciation** for all of these. Further, our college works toward deepening learning experiences by engaging students in internships with local partner industries. (About Mathematics at SPC, 2018, para. 1)

Many of the participants remarked that students' development of the content-specific skills and life skills, mentioned in the previous section, are essential to success because these skills help to provide a solid foundation in math and in life. Participant P2 observed, "Math is a course where building blocks/skills are essential in the survival and mastering objectives. Without these hard skills, a student is forever lost and defeated." Participant P7 agreed, "They [skills] are the foundation of learning and improving any type of skill in life." Participants also mentioned that these skills are needed in order to fully function in today's workforce. For instance, Participant P3 said, "These are fundamental skills that students need to be successful in the 21st century global economy." Also, Participant P9 noted that "students who are able to use problem-solving skills on their own can be more successful in college and beyond." Participant P5 added, "In MathWorld, we try to show students how to recognize what type of problem they are working on and how to break it down into more manageable pieces to solve." Participant P10 mentioned that "software skills transfer to many other classes in their [students'] education and it is a skill that is used in almost all jobs."

In addition, these content-specific skills and life skills help to facilitate retention. For example, Participant P5 stated that "good notetaking skills will help students retain and recall

important information more easily." Also, "Students need to learn early in their college career how to evaluate and solve problems effectively, otherwise when they start learning more complex material they may become overwhelmed and feel discouraged" (P6). Another way that these skills help with preparation is they allow students to see the connection between math and other subjects more efficiently. Participant P6 noted, "Mathematics plays a crucial role in understanding other subjects. Many of the challenges that students face in their college career are often influenced by a poor mathematical background, usually, in the areas of arithmetic and algebra." In addition, P6 noted:

> Being able to receive a concept during a lecture and apply the concept to a different problem where the concept has been extended to consider a different situation perhaps with different facts is more reflective of what they will experience in the real world in their profession.

Another participant, P10, agreed: "Basic math skills seem to keep students from understanding concepts in other classes." Participant P8 commented, "Knowing multiplication facts and understanding how to perform basic math operations not only saves the student time during problem-solving, but also allows them to advance their mental math and deductive reasoning skills."

Student transformation. In addition to the participants' desire for student preparation, the desire for student transformation was also revealed in the data sources. Most of the participants expressed the need for students to not only grow in their knowledge of math, but also in their personal and social skills. Moreover, they observed that growth in these areas are possible if students are willing to take more ownership in their learning experiences through inspiration, consistency, and persistence. Participant P2 observed, "Students lack in motivation, determination, and dedication. I have seen many students falter in math because of their lack of time commitment and they have not found the right study skills to help them in math." In the

survey, Participant P6 elaborated on the importance of responsibility, communication, time management, critical thinking, and study skills:

> Responsibility: Students need to be held accountable for their share of responsibility in their academic success. Communication: In today's world, it is very important to be able to communicate well with others not only in school but other environments as well. Time management: As multi-tasking is becoming more common in today's world, time management is perhaps one of the most important skills for student success. Critical thinking: thinking beyond the stated facts is crucial in today's complex society Study skills: The ability to efficiently and effectively study the course material given constraints such as scarcity of time or multiple responsibilities.

Participant P8 made the remark that students should know that perseverance is a key to success in math:

> When students work problems on their own successfully, they begin to trust their ability to learn new topics. Students need to understand that failures will occur throughout their career. Understanding this sooner than later will allow the students to maintain the confidence and drive to push forward.

In addition to students' personal growth, the participants explained their desire for students' well-developed social skills. These skills will help students balance life's demands, and effectively navigate through personal responsibilities of work and family, while they are learning math. Participant P5 said, "Learning to manage time efficiently helps students better balance their school, work, and home life and reduce stress." Participant P10 agreed, "These are skills that are needed for education, employment, family, and everyday life." Participant P11 added, "I feel personal habits is essential for student success. Personal habits will show students what's going on in their lives and force them to manage their time and create a routine/structure to meeting homework deadlines and studying for tests."

Actual Outcomes. The participants also described the actual outcomes of MathWorld on student success. These actual outcomes are illustrated in the interviews and survey, such as support of content-specific skills and support of life skills.

Support of content-specific skills. Many of the participants described the skills that MathWorld currently prioritizes. With critical thinking skills in particular, the Bobs and math faculty emphasized the analysis process in their responses to the survey. Participant P3 explained that, "in a given problem," students are guided on "the ability to determine what are the most relevant facts."

Some participants noted the overall knowledgeability of MathWorld staff and faculty. An instructor, I2, also affirmed the resourcefulness of MathWorld by stating that "the Bobs a lot of times know what you're looking for in your class, and they work well with the faculty in that respect." When asked about MathWorld's impact on student success, some of the participants shared at least one testimonial that was either student-related or faculty/staff-related.

In addition to receiving assistance with math topics, students who visited MathWorld were also guided in the appropriate direction regarding other college-related issues. One of the Bobs explained the value of the Bobs' helping in overall advising and saw MathWorld as a holistic place where students could really grow:

> …and another thing that I think helps is having Bob here, because when they're having most of the time like issues with signing up for classes, other issues that are related to math that we don't tutor for, or that are not related to tutoring, Bob is able to help. So, I think they can get pretty [much] all their problems solve in MathWorld even if it's not math-related because Bob and all of us are a good reference. If they want to register, we can tell them to go to the Welcome Center or something like that. So, not only is it changing lives in terms of passing math and everything, but I think it's a holistic place where you can really grow. (B4)

Support of life skills. All of the participants used positive words to describe MathWorld's environment and its impact on student success. The most common positive descriptors used were the following: positive, comfortable, warm, informal, personable, welcoming, confidence-building, and supportive.

Some participants expressed the value of an informal learning environment for math and noted student confidence in the help they will get from MathWorld. For example, Participant I1 stated that MathWorld was "a very informal environment, where it's not intimidating to the students. Math is very intimidating as it is, so I think students feel they like coming into a room where intimidation is not an obstacle." Participant M2 also described MathWorld as a "good working environment." She continued, "It's a place where you come where you *know* that you're gonna get help. When they [the students] leave, they *feel* that confidence, you know? And I *love* being a part of something like that."

The participants agreed that MathWorld is a valuable resource for students. A former Bob-now instructor, for example, promoted MathWorld as a key ingredient. She shared how she encouraged students to make the most of all that MathWorld has to offer: "In the classroom, I tell my students, 'This [MathWorld] is your help. You just have to figure out what works for you, but *this* is a resource that is here for you, and you wanna take advantage of it'" (M1). In the survey, Participant P8 described the notetaking workshops and word problem strategies that take place in MathWorld:

> Each time a student visits MathWorld, tutors will examine and critique the student's notes. MathWorld has begun offering workshops for students on notetaking and organization. In order to practice reading/comprehension, MathWorld tutors will often have the students read through a given problem and write out the important information. MathWorld tutors will often push students to perform more math without the use of calculators in order to strengthen the student's mental math skills.

The participants recalled moments of students visiting MathWorld to say hello and express their gratitude for the help they received. Participant M2 said that there are "many students that return and give their thanks, 'cause there's quite a few that would not have succeeded without this place" (2017). An instructor began her reply by sharing students'

accounts of their experiences in MathWorld, and hypothesized that MathWorld gave students confidence (and attracted students who lacked confidence):

> …and this comes from conversations from students whom I've met. I met with one in particular last week and I asked him about it. And he said, overall, it is a very positive experience and they find it very helpful especially because *most* of them who go to MathWorld do not feel very confident about being by themselves doing their own homework. So, in fact, just know that there's someone there in case they get stuck, that will increase their confidence. (I4)

In her response, B2 expressed hearing accounts of success and excitement. She mentioned that many students would "come in at the end of the semester and tell us, like, 'I passed my final [exam]!' and they're so excited" (2018). Another Bob gave an account of former students returning to the facility to attribute MathWorld to their success in math:

> I've seen students who have come back, but they're now doing science and they're in the science department now. Like, they're done with math, and I asked them, "Have you factored a polynomial?" and they say, "No," but they've got that [math] credit done and that they're now in the science department or somebody's transferred to UTSA. There's one kid that came in here. (laughs) He was the [Homecoming] king. I can't remember his name, but he became the king and then he went on to Engineering. He came back last semester just to say hi, and he's still going to school at UTSA, and he's going to get a scholarship. (B3)

In his response, one of the instructors noted a significant change in his students' passing rates. However, he attributed decreased scores with reduced MathWorld hours. He pointed out that hours of availability in MathWorld was a critical factor:

> You can see a dramatic difference this semester with the tutoring not being available on Fridays and Saturdays, 'cause it really limits…really hurts my College Algebra students on… My passing rates will be down significantly this semester, compared to previous semester. Before we had MathWorld consistently, I was having passing rates in the 20- and 30 percents. *Now*, with MathWorld and ever since MathWorld's implemented, that's climbed to between 60 and 70 percent. So it's really pretty much more than doubled my passing rates. (I2)

Some participants shared observations of student progress in their attitude, behavior, and work habits during their visits to MathWorld over time. They also felt rewarded as the students

progressed. Participant B1 noted that MathWorld has a positive impact "definitely, on students…both with, you know explicitly with their grades, but also with their attitude towards math." Participant B2 also agreed:

> We see them all semester long. We see the hard work that they're putting in and that they're trying, and they're coming in… They're asking good questions, not just, you know, "Can you do this [math problem] for me?" They're actually asking, like, "Help me understand this [math problem]." And I think that's… That's one of the most rewarding things about this job, being able to see the progression of the students throughout the semester. (B2)

The data also revealed that the MathWorld experience generates confidence-building skills by conveying positivity. Participant P1, for example, simply stated, "we show them they 'can do it.'" Participant P4 attributed this positivity to MathWorld's "environment and how the tutors interact with the students." Participant P5 describes how the Bobs and math faculty communicate positivity to students who visit MathWorld:

> In MathWorld, we do our best to encourage students and help them maintain a positive attitude about math. This ranges from simply giving students a "Good job!" to sometimes pulling a student aside to address their concerns and give them a "pep talk."

One participant, P10, was "not sure that MathWorld directly generates help in this area [confidence-building], but over time, students can develop more self-confidence by working in the [MathWorld] lab." Participant P11 stated that "MathWorld generates a 'Never Give Up' attitude."

Integrative Characteristics of the Reconceptualized MathWorld Model

The following emerging themes, as shown in Table 1, represent the characteristics of the core practices emerged from the data sources: (a) processing information, (b) demonstration, and (c) connection. The following is a summary of the findings of those themes as well as a discussion of how they relate to existing knowledge.

Processing information. Listening for the problem, working through examples, and persisting with help describe the core practice of process. As expressed in the student testimonials, explanations of math concepts should be given in smaller doses to enable students to more easily grasp complex information. These strategies imply that instructors of developmental and college-level math courses need to be cognizant of their students' background. Knowing where students are foundationally in their math skills is an essential step in assisting them. This confirms what Nolting stated in his interview with Boylan (2011): "Instructors who know their students' math background, math study skills level, and learning styles are in a better position to help students succeed in mathematics" (p. 22). Hence, process is a core practice that allows the Bobs and math faculty to ensure they meet the needs of students with various math abilities.

Demonstration. Another core practice, demonstration, consists of problem-solving strategies, additional examples, visual representations, and guiding questions. The findings of a study by Cafarella (2014) corroborate the significance of visual representations. Specifically, a few of the participants noted that "basic graphing paper has served as both an effective manipulative and visual for developmental math students" (p. 53). Students need to be assessed on their conceptual understanding and must be held accountable for their learning experiences. This can be achieved by the Bobs and math faculty through the core practice of demonstration.

Connection. Making students feel comfortable, providing individualized attention, and reducing power distances describe the core practice of connection. As mentioned in the student testimonials, building a rapport is salient to success. This supports what Shields (2005) stated about the learning environment:

> They [students] need instructors who can foster a supportive, nurturing environment and relate material to them in ways that teach them to not only learn the material, but to learn

> how to monitor their own learning, to think critically and strategically, and, most importantly, to appreciate the subject. (pp. 47-48)

Effective communication and encouragement by the Bobs and math faculty are ways in which they establish connection with the students. Hence, the core practice of connection minimizes students' anxiety of the subject, creating a positive and healthy environment that enhances learning.

Table 1

Attributes of the Core Practices

Interviews	Survey	Student Testimonials
Processing information– working through examples, listening for the problem, persisting with help Behavioral cues – gauging the social & emotional well-being	Processing information – explaining	Processing information – explanation of math concepts given in smaller, manageable sections
Demonstration – problem-solving strategies, additional examples, visual representations, guiding questions • assessment/benchmarking • student accountability	Demonstration – notetaking strategies, student accountability	Demonstration – guidance and repetition
Connection – making the student feel comfortable, building a rapport and commonality, connecting as humans/reducing power distances	Connection – communication, encouragement	Connection – individualized attention, establishing rapport, and encouragement

Chapter Summary

The findings from this study were based on the data collection and analysis. A description of the integrative elements of the reconceptualization of MathWorld's model was provided. Three key findings emerged from an examination of the results:

1. Cultivating content-specific skills is a core practice by which the Bobs and instructors guide the students to a better understanding of various math subjects. This core practice was described in the following ways: identifying content-specific skills, problem-solving representations, and math topics; assessing students; reinforcing student accountability;

promoting notetaking strategies; offering guidance and repetition; providing explanations in smaller, manageable sections; facilitating higher-order thinking skills; and learning from others.

2. Supporting life skills is a core practice by which the Bobs and instructors create an atmosphere of relatability and gauging the socioemotional well-being of the students. This core practice is characterized in the following ways: alleviating anxiety by using humor, discerning and working with various personalities, communicating with students on an even level, and providing encouragement and patience.
3. Providing holistic interventions is a core practice by which the Bobs and instructors discern the academic and socioemotional needs of the students and utilize appropriate interventions. This core practice is characterized in the following ways: listening intuitively, providing basic necessities, customizing student's academic situations, and providing individualized attention.

Chapter five, the final chapter, provides a discussion on the meaning of these findings and the implications. Additionally, the final chapter will provide conclusions and recommendations for further research based on the findings discovered through the data.

Discussion, Conclusions, and Recommendations

From the perspective of the interviewees, the purpose of this study was to identify MathWorld's core practices and link them into a conceptual model of success for developmental math students. This chapter restates the research questions for qualitative research with an interpretation of the findings.

The research was designed to discover from 11 math faculty and math support program specialists what they perceive as best practices in helping students understand math concepts, increasing student awareness of how math relates to their everyday living, and improving students' disposition towards math. The two research questions guiding this study were:

1. What is the conceptual model and the underlying core practices for the success of developmental math students?
2. How does usage of MathWorld support the development of math competencies and affective behaviors necessary for student success in developmental math courses?

Interpretation of the Findings

What is the conceptual model and the underlying core practices for the success of developmental math students? The integration of all three components core practices, cultivating content-specific skills, supporting life skills, and providing holistic interventions for student transformation, make up the *secret sauce* of MathWorld. This conceptual model of MathWorld is interactive in nature, because it requires the participation from students, as well as the Bobs and math faculty. While the Bobs and math faculty are in a unique position to guide students along their academic journey, the students are encouraged to practice what they are learning with self-sufficiency.

The *secret sauce* of MathWorld requires both participants (students and Bobs) to be engaged. For instance, although Bobs can provide assistance, students must also be self-starters and consistently take ownership of the learning process. Students are expected to be proactive in their academic experiences in order to achieve success. Additionally, although students can visit MathWorld, the Bobs must also be sufficiently trained in various strategies (teaching, learning, tutoring) in order to meet the students' needs. To reiterate, this interactive model suggests that the *secret sauce* is more than just teaching the math concepts. Bobs and math faculty need strong interpersonal skills to holistically address the students' needs. Also, students need to have a willingness to learn and overcome obstacles.

Cultivating content-specific skills is a vital core practice of MathWorld's conceptual model. In order to better assist developmental math students, the Bobs and math faculty must first identify the content-specific skills in which students are deficient. Assessing students' current conceptual understanding of math topics and problem-solving representation is essential, because this serves as valuable data as to how students process information.

From there, the Bobs and math faculty can demonstrate for the students some tutoring/teaching/learning techniques. Showing students how to take efficient notes, for example, is one of the workshops available in MathWorld. This confirms what Finney and Stoel (2010) captured in their interview with Phelps regarding supplemental instruction. Phelps described notetaking as part of her definition of supplemental instruction. Virtually all MathWorld staff attend various math classes periodically throughout the semester. Attending the classes allow the MathWorld staff to become familiar with the instructors' teaching styles, routines, and class expectations, and incorporate that information into their tutoring sessions with the students when they visit MathWorld. Students are expected to bring their notes from their math course to

MathWorld before receiving assistance. This requirement suggests that students must be held accountable in the learning experience.

Additionally, offering guidance and repetition is also an important technique that Bobs and math faculty use to scaffold student learning. Due to an ordinate amount of concrete and abstract topics in math, some students experience difficulty with these topics. Therefore, it is necessary for the Bobs and math faculty to provide explanations in smaller, manageable sections. As students progress through the developmental math course, they will undoubtedly encounter a variety of math problems that require higher-order thinking skills. Consequently, Bobs and math faculty demonstrate a range of problem-solving strategies that students may apply to problems. Also, learning from others (i.e., Bob/faculty to Bob/faculty, Bob/faculty to student, or student to student) is vital for enhancing content-specific skills. The implication here is the significance of connection: Effective communication must take place between the active participants in the learning exchange. This validates one of the implications from Cafarella's (2014) study: "Effective communication should be established between developmental math instructors and students as well as among developmental math instructors" (p. 35).

In this fashion, another essential core practice of MathWorld's conceptual model is supporting life skills. Connecting with students, especially by communicating with them on an even level, can alleviate math anxiety for students. For instance, it is quite common for Bobs and math faculty to demonstrate appropriate humor to diffuse the tension students oftentimes feel when processing math information. Providing encouragement and patience can also make students feel more at ease. Given the variety of personalities that are in the community college setting, it is imperative for all active participants (Bobs, math faculty, and students) to engage in proper interpersonal skills.

As follows, providing holistic interventions is the third critical core practice included in the conceptual model of MathWorld. With the purpose of determining the most effective ways to help students, the Bobs and math faculty process information from them by listening intuitively. For instance, if a student has special needs that require certain accommodations and/or modifications, the Bobs and math faculty provide individualized attention and demonstrate learning strategies that will enhance student learning. Such behaviors allow a connection between the active parties and, consequently, provide basic necessities for students.

How does usage of MathWorld support the development of math competencies and affective behaviors necessary for student success in developmental math courses? Usage of MathWorld supports student development of math competencies by cultivating students' hard skills and critical thinking skills. The following section describes these skills along with a discussion of how they relate to existing knowledge.

Hard skills. As defined in Chapter One, hard skills are "specific, teachable abilities that can be defined and measured, such as typing, writing, math, reading and ability to use software programs" (Investopedia, 2018, para. 1). In this study, math skills and technological skills were two identifiable categories of hard skills that are emphasized during student visits to MathWorld. Problem-solving representation, basic algebra, and basic arithmetic are specific types of math skills that students need to attain to ensure success in the subject. Additionally, some of the student testimonials mentioned specific examples of math topics in which they needed to understand, improve, and eventually become adept. These topics include operations, classifying numbers, word problems, equations, and formulas. It is suggested that a student's acquisition of these skills should be connected to real-world situations in order to reinforce the relevancy of math. This confirms what Cafarella (2014) and Galbraith and Jones (2006) found in their studies.

The participants in Cafarella's study emphasized the importance of incorporating "real-life applications [to] enhance student success" (p. 54). Galbraith and Jones, in their study, described how a developmental math instructor used a "checkbook balancing" activity with her students to connect basic math concepts to personal finances (p. 23). The ability to acquire math skills, in tandem with real-world applications, can help solidify for the students the relevancy and a better appreciation of the subject.

The ability to use various electronic devices and online programs describe the technological skills necessary for student success. As mentioned in Chapter One, a computer-assisted math program and an online learning management system platform corresponds to each math course offered at St. Philip's College. ALEKS, MyLabsPlus, Connect Math, and Hawkes are examples of the online learning management system platforms that students use in their courses. This confirms what scholars have said concerning the various methods of instruction: "lecture, individual learning modules, and computer-aided instruction" (Galbraith & Jones, 2006, p. 20). Regardless of the modalities, it is imperative for students to be proficient in using technology to ensure success. Students who attend MathWorld can receive assistance with their technology skills.

Critical thinking skills. Lipman (1987) defined critical thinking skills as "analyzing, judging, hypothesizing, explaining, and many other cognitive activities besides deciding and problem-solving" (p. 5). Critical thinking was another skill that was emphasized during student visits to MathWorld. This skill consists of the student's ability to analyze information and learn concepts from different points of view.

The findings of a report by McClenney (2007), Director of Community College Survey of Student Engagement (CCSSE) at the University of Texas at Austin, confirms the significance

of critical thinking skills. In her report, a survey was conducted to examine the college experiences of “academically underprepared students, students of color, first-generation students, adult learners, and part-time students” (p. 2). The results indicated that academically underprepared students “more frequently report that their colleges help them develop the skills and abilities they need to succeed, including…thinking critically and analytically, and solving numerical problems” (p. 3).

These observations by the participants in the study suggest that the ability to think mathematically is essential in preparing workers for jobs in this world economy. This ability to think mathematically is not limited to performing calculations. Additionally, it involves the capacity to observe patterns and become adept at solving various problems, which may involve unconventional methods.

Usage of MathWorld supports affective behaviors necessary for student success by supporting their soft skills, confidence-building skills, and emotional support skills. The following section describes these skills along with a discussion of how they relate to existing knowledge.

Soft skills. Soft skills, as defined by Robles (2012), consist of “character traits, attitudes, and behaviors—rather than technical aptitude or knowledge. Soft skills are the intangible, nontechnical, personality-specific skills that determine one’s strengths as a leader, facilitator, mediator, and negotiator” (p. 457). In this study, study skills and coping strategies were two identifiable categories of soft skills that are emphasized during student visits to MathWorld.

A student’s ability to study is vital to achieving a greater understanding of math. As validated by Zientek et al. (2014), study skills was one of the common themes that emerged as a critical factor to student success (p. 75). The student testimonials used in this study, in particular,

provided further insight on the illustration of this concept. Many students acknowledged that they not only needed to take initiative of their learning experiences, but they also should know what resources are available to them and how to use these resources in meaningful ways.

Although the phrase *stress management* was used as one of the emerging themes from the survey, stress management is a specific type of coping strategy. In this study, the participants agreed that students' ability to cope with challenging situations, within and outside the classroom, is an important skill that students must have in order to be successful. Participant P3, for example, asserted that the "ability to function under stress" is critical. A few students, in their testimonials, acknowledged the importance of practicing productive coping strategies when they encounter difficulties with math. In MathWorld, humor is one of the common expressions used by students, math faculty, and Bobs. This validates an observation made by Bonham and Boylan (2012): "They [students, faculty, and support staff] should be familiar with and employ strategies to help alleviate mathematics anxiety, build self-confidence, and maximize student learning in mathematics" (p. 15).

Confidence-building skills. Zulkosky (2009) defined self-efficacy/confidence as "a person's own judgment of capabilities to perform a certain activity in order to attain a certain outcome" (p. 95). Displaying a positive attitude and celebrating milestones describe the skill of confidence-building. In some of the testimonials in this study, students expressed a sense of pride with their improvements and achievements in math, in addition to facing their fear of the subject. This supports what Duranczyk and Higbee (2006) stated regarding the importance of student confidence in math: "Other affective variables, such as students' own confidence in their ability to learn mathematics, have also been shown to play a central role in mathematics learning in general" (p. 24). To ensure success in math, students must have the ability to recover after

making mistakes and learn from them. When students learn to persevere while working on any math problem, they are more likely to gain confidence in their ability to understand the subject matter.

Emotional support skills. As students enter MathWorld, the Bobs and math faculty gauge the students' socioemotional status by utilizing emotional support skills. These skills provide a sense of comfort and a welcoming environment for students who might need to maintain the proper emotional and mental posture for learning and working on math assignments. As noted by Durancyzk and Higbee (2006), "Noncognitive factors impact student performance and interest in mathematics" (p. 23). In alignment with this study, Burleson's (2003) definition of emotional support skills is appropriate. According to Burleson (2003), "specific lines of communicative behavior [are] enacted by one party with the intent of helping another cope effectively with emotional distress" (p. 552). As stated in Chapter Four, all of the participants in the interviews used positive words to describe MathWorld's environment and its impact on student success. Two of the most common, positive descriptors, *comfortable* and *welcoming,* were used. Several students remarked on how comfortable and welcomed they felt during their MathWorld experiences. The importance of such an environment supports a claim by Jackson (2013), who stated that community colleges are in a unique position to facilitate student success, particularly among minority students in STEM, "because of their emphasis on teaching, smaller student-to-teacher ratios, active learning in classrooms, lab experiences and positive learning environments" (p. 258).

The significance of the affective domain. A third research question emerged as a result of the study: What is the *secret sauce* of MathWorld? In the world of math, the focus tends to be on the concrete and abstract concepts of numbers, which suggests a substantial emphasis on the

cognitive domain. However, MathWorld is a unique program that not only incorporates the world of math, but it also provides holistic interventions that address the total person. This leads to a third key finding of this study: the *secret sauce* of MathWorld has a key ingredient, which is the emphasis on the affective domain; it is not just about the math.

In the context of this study, the affective domain consists of behavioral words that describe student emotion. This study confirms what many scholars have said about the importance of the affective domain in math. Bonham and Boylan (2012), for example, noted that the affective domain deserved attention in the study of math education, particularly in the field of developmental math:

> This [affective domain] is a rich area of information for educators designing developmental mathematics courses and one that should definitely not be ignored by anyone attempting to improve student performance in developmental mathematics. Students, faculty, and support staff need to understand the influence of affective factors on students' success and retention in developmental mathematics. (p. 15)

This observation was also made by Benken, Ramirez, Li, and Wetendorf (2015), who recognized the importance of studying the impact of affective behavior in math learning:

> Although affective factors have proven to be relevant to mathematics learning in general, the affective domain is often left out in efforts to increase students' performance in developmental mathematics. As a result, students who must take developmental mathematics courses are not necessarily developing positive math identities. (p. 16)

These key findings formed the basis for the reconceptualized model of MathWorld. The interactive model demonstrates that it is not just about the numbers. There is this balance of cognitive and affective influence that must be present in order for transformative learning to take place in situations where there are developmental needs. The *secret sauce* ingredients could essentially be the same for any remediation (academic or professional), because the model demonstrates that it takes more than just teaching the basics to move a person from point A to

point B. Additionally, it takes strong socio-interpersonal skills on the part of the tutor and a desire to succeed on the part of the learner.

Discussion of Relevant Theories

In approaching this research, I proposed four theoretical models as influencing conceptualization of this study: Graham and Weiner's (1996) Attribution Theory, Astin's (1999) Student Involvement Theory, Mezirow's (1991) Transformative Learning Theory, and McClelland's (1961) Theory of Needs. Referring back to the notion in Chapter Four that MathWorld's conceptual model is interactive in nature, any one or all of the three components of the model can serve the students, Bobs, and/or math faculty, depending on the student's needs. Although all four theories are relevant to this study, the data analysis revealed that they do not fully address the findings of the study. The following is a discussion of the connections and disparities of each theory to the research.

As aforementioned in Chapter Two, Weiner's (1996) Attribution Theory "describes how individuals interpret events and how their interpretation influences motivation for learning as well as future learning behaviors" (Demetriou & Schmitz-Sciborski, 2011, p. 6). This theory describes a confidence phenomenon that is evident both in research and in my lived experiences as a math educator. As shown in the results of the related literature and this study, students' perceptions about their abilities play a critical role in determining their success. Students who visit MathWorld are in a unique position to acquire a better mindset and experience with math over time as compared to their prior experiences. Although this theory connects well with the Supporting Life Skills element of MathWorld's reconceptualized model, it does not fully address the significance of a positive attitude. As explained in Chapter Four, the participants in this study convey the message that all students have the capacity to learn math concepts and increase their

confidence levels. However, they frequently encounter students who have a negative mindset towards math (e.g., *I hate math*). It is highly probable that many of these students are reliving their past experiences with math, and their attitude is such that they will never understand the subject. Nevertheless, fostering a positive attitude (e.g., *I can do it*) can increase student motivation to learn math.

Astin's (1999) Student Involvement Theory "refers to the amount of physical and psychological energy that the student devotes to the academic experience" (p. 518). Students' chances of success increase as their time and effort, in their academic studies, increase. Upon reviewing the related literature and results from this study, it is clear that student engagement is essential to their success. SPC math faculty and MathWorld staff, in their interactions with students, convey the message that active participation is necessary to acquiring a better understanding of math concepts. As reflected in the reconceptualized model of MathWorld, the Supporting Life Skills component connects well with Student Involvement Theory. Many of the participants in this study expressed that students must be held accountable and take an active role in their learning experiences. The participants also mentioned that students should be self-sufficient and learn how to use available resources. While it is clear from the study that student involvement is critical to student success, Student Involvement Theory does not sufficiently address how tutor/instructor involvement impacts student involvement. Student Involvement Theory, as its name suggests, is reasonably student-centered. However, student involvement is not the sole contributing factor to achieving student success. If tutors and instructors do not participate and get involved with the students, then there would be a minimal amount of influence to get the students involved. Hence, both participants (students and tutors/instructors) must be involved in the learning process.

Mezirow's (1991b) Transformative Learning Theory deals with "an enhanced level of awareness of the context of one's beliefs and feelings, a critique of one's assumptions, and particularly premises, and an assessment of alternative perspectives" (p. 161). When students are actively engaged in the learning process within and outside the classroom, their experiences can lead to an increased awareness and appreciation of math in their daily lives. It is evident, from the related literature and this study, that proper implementation of various teaching strategies with knowledge of various student learning styles can facilitate student success over time. As SPC math faculty and MathWorld staff work with students, they are adept at understanding students' learning styles. However, perseverance and consistent work habits on the students' part are necessary to ensure success. The math faculty and Bobs, as previously mentioned in Chapter Four, provide interventions (adaptation and customization) which lead to student transformation. Intuitive listening, for example, is a component of transformative learning. It helps students become amenable to adaptation and change, in addition to introducing them to a concept of a support system which they may have never experienced before. Although Transformative Learning Theory connects well with two components of MathWorld's conceptual model, Cultivating Content-Specific Skills and Supporting Life Skills, this theory does not clearly address the transformative learning experiences of the tutor/instructor. In fact, the theory does not explain how students may transform the tutor/instructors' learning. Many participants in this study shared how they increased their knowledge from each other as colleagues. Additionally, they indicated how their interactions with students impacted their strategies for tutoring and instruction. Therefore, growth (in attitude, behavior, and work habits), and knowledge application to various disciplines/situations, on the part of the tutors/instructors and students are mutual.

McClelland's (1961) Theory of Needs states that we all have a set of needs that are based on the need for achievement, affiliation, or power. This theory is compatible with the study because of the connection among the three problem areas: academic background, personal issues, and affective behavior. The student's academic background connects with the need for achievement as well as the Cultivating Content-Specific Skills component of the conceptual model. The student's personal issues connect with the need for affiliation, in addition to the Supporting Life Skills element of the conceptual model. The student's affective behavior, especially if it is negative, connects with the need for power, along with the Providing Holistic Interventions element of the conceptual model. Upon reviewing the related literature and the results of this study, it is apparent that administrators, instructors, and staff must be cognizant of the needs of students and use appropriate strategies to ensure their success. It is also evident from this study that providing an environment conducive to learning is critical to student success. To ensure an equitable opportunity in the pursuit of higher education, addressing these needs is critical for the population served at St. Philip's College.

However, the Theory of Needs, as it relates to this study, does not necessarily address the needs of the tutor/instructor. For instance, while there is evidence that the usage of MathWorld has an impact on student success, success does not come without challenges. Extensive review of all data sources revealed the existence of external challenges and internal challenges. External challenges, such as varying levels of student preparation and accountability, represent the obstacles that Bobs and math faculty face as students enter MathWorld. Internal challenges, resource-oriented in particular, represent the issues Bobs and math faculty encounter as hindrances to student success. For this study, these challenges represent the participants' needs. Ultimately, none of the theories (Attribution Theory, Student Involvement Theory,

Transformative Learning Theory, and Theory of Needs) is the holistic nature of what I discovered. A new theory that addresses the transformation through dynamic interconnectivity among tutors, instructors, and students is needed. It is evident from this study that the participation of the tutor/instructor and student is critical to student success in math.

Transformation through Dynamic Interconnectivity

As shown in Figure 6, the Transformation through Dynamic Interconnectivity Model is visually represented as three circles with connecting lines. Each circle in Figure 6 signifies the core practices used by the supporting role players in a given situation. The lines connecting each circle denotes the characteristics of these core practices, which will be introduced later in this chapter. The integration of these core practices, in addition to its characteristics, yield transformation.

Application of the TDI Model. The Transformation through Dynamic Interconnectivity (TDI) model is similar to the Reconceptualization of MathWorld's model (Figure 5) because it encompasses: (a) the same core practices (cultivating content-specific skills, supporting life skills, and providing holistic interventions), (b) the same categories of skills (hard, soft, critical thinking, confidence-building, and emotional support), and (c) the same characteristics of the core practices (processing information, demonstration, and connection). However, the integration of the aforementioned components creates the *secret sauce* of transformation through dynamic interconnectivity, which can be applied to a variety of subject areas, professional settings, and personal situations. The following sections provide an example of how the TDI Model can be utilized in the following settings: (a) subject area, (b) professional, and (c) personal. For each example, the supporting role players, in addition to the characteristics of each core practice, are identified.

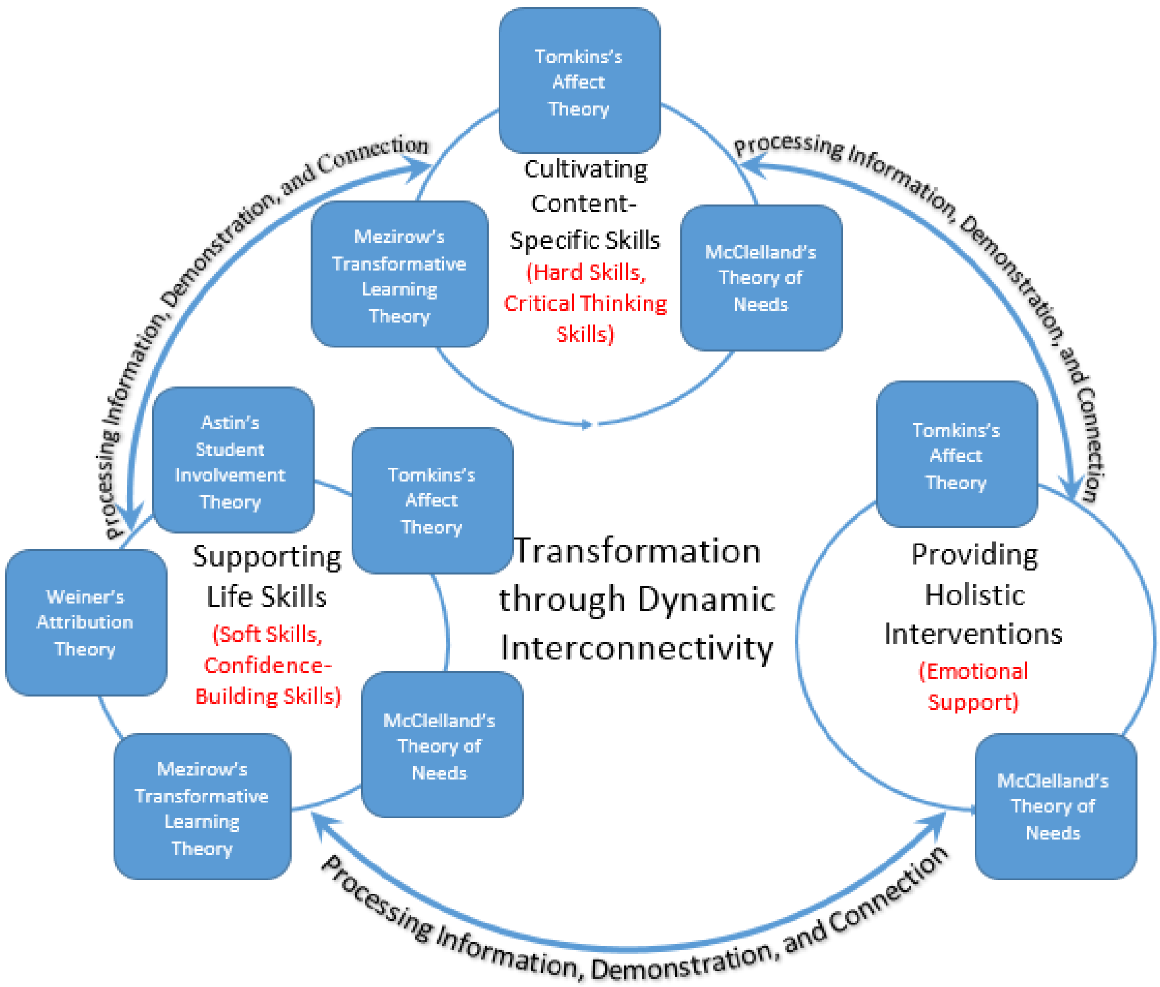

Figure 6. Transformation through dynamic interconnectivity model.

Example 1: Subject area. While this study specifically addressed developmental math, the core practices of the conceptual model are not limited to this subject area. To illustrate, developmental English will be used. The developmental English instructors, support specialists, and tutors are the supportive role players for students taking development English courses. They cultivate content-specific skills by assessing students' knowledge of hard skills (e.g., grammar usage, functions of words, and sentence structure) and critical thinking skills (e.g., analysis of written work). They also support life skills, for example, by modeling how to do an oral presentation based on the students' written work. Because students need to have command of the English language, it is expected that they also have the capacity to express their thoughts in a

logical, clear, and fluent manner. Some students need to muster the confidence needed to transfer what they are thinking into written form, and do so in such a way that it is clear and understandable to the reader. The emotional support also touches on accommodations and/or modifications for students with special needs. Given this, the supporting role players need to be aware and use appropriate strategies to facilitate students' needs.

Example 2: Professional. Although this study comprised a community college, the core practices of the conceptual model are not limited to an educational setting. To explain, professional development will be used. The supervisor, colleagues, and other content specialists are the supportive role players for the employees. They cultivate content-specific skills by assessing the employees' knowledge of hard skills specific to their field (e.g., use of technology, writing skills, and knowledge of content) and critical thinking would involve creating plans and programs that enhance the organization. The supportive role players also support life skills, for example, by modeling effective communication skills and time management. Employees, during their tenure in the organization, process a variety of information regarding their duties and responsibilities of their positions. For some employees, the significance of their status in the organization might become overwhelming and affect their confidence levels. Taking this into consideration, it is necessary for the supportive role players to utilize appropriate methods to guide the employees to success for the betterment of the organization.

Example 3: Personal. Whereas this study included lived experiences in a public location, the core practices of the conceptual model can also be practical in personal arenas. To elaborate, patients in a substance abuse facility will be used. The physicians, counselors, and other licensed professionals at the facility are the supportive role players for the patients. They cultivate content-specific skills by assessing the patients' knowledge of hard skills (e.g., adherence to

program rules and expectations) and critical thinking skills (e.g., develop and implement a personal development plan for recovery). They also support life skills, for example, by modeling strategies to counteract the urge of the substance with productive thoughts and behaviors. At some point during their time in the facility, patients are processing information, such as identifying the root causes of their addiction. Patients also may be fully cognizant of how their addiction has negatively impacted their lives and their spheres of influence (e.g., family, friends, coworkers). Given the emotional/psychological nuances of each patient, it is imperative for the supporting role players to use appropriate connections and interventions. This may include intuitively listening to the patients' expressions of guilt or shame, and providing a safe environment for patients so they feel more confident and free to discuss their issues. Hence, whether the circumstances involve subject areas, professional environments, or personal situations, the TDI model can be applicable to any context.

Discussion of Relevant Theories and the TDI Model. In a similar fashion as for the Reconceptualization of MathWorlds' Model, the four theories (Attribution Theory, Student Involvement Theory, Transformative Learning Theory, and Theory of Needs) do not fully explain the workings of the TDI Model. The following is a discussion of the connections and disparities of each theory to the TDI Model.

First, whereas Weiner's (1996) Attribution Theory connects well with the Supporting Life Skills element of the TDI Model, it does not fully address the significance of a positive attitude. It is highly probable that the supportive role players in a given context will encounter working with individuals who have developed a defeatist attitude resulting from negative past experiences. Second, although Astin's (1999) Student Involvement Theory can be reasonably linked with the Supporting Life Skills component of the TDI Model, it does not sufficiently

address how the supportive role player's involvement impacts recipient involvement. It is imperative for both participants (supportive role players and learners) to be involved in the work. Third, even though Mezirow's (1991b) Transformative Learning Theory is a relatively good fit for two components of the TDI Model, Cultivating Content-Specific Skills and Supporting Life Skills, this theory does not clearly address the transformative learning experiences of the supportive role player. In fact, the theory does not explain how the learners may transform the supportive role players' knowledge. Finally, while McClelland's (1961) Theory of Needs connects well with all three core practices (Cultivating Content-Specific Skills, Supporting Life Skills, and Providing Holistic Interventions), this theory does not necessarily address the needs of the supportive role player.

Therefore, none of the four theories (Attribution Theory, Student Involvement Theory, Transformative Learning Theory, and Theory of Needs) holistically encompasses the TDI Model. For this reason, I propose the need for a theory in which the TDI Model can be associated and addresses the transformation through dynamic interconnectivity among learners and role players in any given context.

As stated earlier, the review of the literature and the results of this study confirm the significance of the affective domain in developmental math. In the book *Approaches to Emotion*, Tomkins (1984) described the following nine innate affects: (a) interest or excitement, (b) enjoyment or joy, (c) surprise or startle, (d) distress or anguish, (e) fear or terror, (f) shame or humiliation, (g) contempt, (h) disgust, and (i) anger or rage (Tomkins, 1984, pp. 167-168). These nine affects encompass Tomkins's Affect Theory, which is applicable to this study. Tomkins (1984) explained the workings of these affects as a system:

> The affect system provides the primary blueprints for cognition, decision, and action. Humans are responsive to whatever circumstances activate the varieties of positive and

> negative affects. Some of these circumstances innately activate the affects. At the same time, the affect system is also capable of being instigated by learned stimuli and responses. The human being is thus urged by nature and by nurture to explore and to attempt to control the circumstances that evoke his positive and negative affective responses. It is the freedom of the affect system that makes it possible for the human being to begin to implement and to progress toward what he regards as an ideal state—one that, however else he may describe it, implicitly or explicitly entails the maximizing of positive affect and the minimizing of negative affect. (Tomkins, 1984, p. 167)

The premise of Tomkins's Affect Theory is that individuals are born with the capacity to respond to stimuli. This theory is relevant to the study, because virtually all nine affects have been demonstrated by students that visit MathWorld.

Students, for example, exhibit the *surprise/startle* affect when they finally reach a breakthrough of understanding a particular math concept after experiencing a substantive amount of time in confusion. As mentioned in Chapter Four, many of the testimonials described instances of students learning how to solve problems in various ways, as demonstrated by the Bobs and math faculty. This example indicates that the affect connects with critical thinking skills, which is part of the Cultivating Content-Specific Skills element of MathWorld's reconceptualized model.

In my lived experiences, I recall working with a student who had a traumatic brain injury. If she did not understand the required tasks during the group activities, then she displayed the *fear/terror* affect by pacing back and forth in the classroom. To help her develop more confidence, I stayed in close proximity with her, clarified any questions she had about the tasks, and assured her with encouraging words that she had the ability to complete the tasks. This example indicates that the affect links with confidence-building skills, which is part of the Supporting Life Skills element of MathWorld's reconceptualized model.

A third example of how Tomkins's Affect Theory applies to this study is in the case with Jim. As previously introduced in Chapter Four, Jim, a student with Autism, experienced

difficulties working in an evening developmental math course with 29 students and an adjunct faculty member whose primary mode of instruction was traditional lecture. Jim's progress, however, dramatically improved after the incorporation of MathWorld into his new math schedule: a daytime math course with less than 10 students, a full-time instructor, and a supplemental instructor (a Bob) for additional help. Jim fully thrived in this new environment and developed an interest in math. This example shows the *interest/excitement* affect ties with emotional support, which is part of the Providing Holistic Skills element of MathWorld's reconceptualized model.

The aforementioned examples illustrate that any of the nine innate affects could be connected to all three core practices and skills. These nonverbal cues by the students can provide essential clues for the Bobs and/or math instructors. In turn, the Bobs and math faculty can utilize appropriate strategies to come alongside the students. Therefore, the Bobs' and math faculty's ability to identify, discern, and correctly interpret the students' nonverbal communication of these affects is critical. In addition, it also suggests that the Bobs and math faculty make a conscientious effort to exhibit the characteristics of the core practices (process info, demonstrate, and connect) by utilizing suitable affects.

Ultimately, I have designed a seminal piece of work in which none of the theoretical framework originally outlined for the study comprehensively explains the model, either individually or in the aggregate. Students have a dynamic of issues that cannot be articulated by an individual existing theory, as demonstrated in Figure 6, the Transformation through Dynamic Interconnectivity Model, which is explained in the next section.

Conclusions

The following observations were made, and three key takeaways were drawn from this research: (a) discovery of the Transformation through Dynamic Interconnectivity model, (b) the lack of attention given in research and practice in meeting developmental math needs, and (c) the absence of theory explaining learner dynamics in developmental contexts.

A new model: Transformation through Dynamic Interconnectivity. One of the key conclusions of this study was that the originally conceived model (Figure 1) presented in Chapter 1, which was intended to illustrate the workings of MathWorld, was not an accurate representation.

Instead, the conceptual model of MathWorld is interactive in nature, because it requires the participation from students, as well as the Bobs and math faculty. The integration of all three components, cultivating content-specific skills, supporting life skills, and providing holistic interventions for student transformation, make up the *secret sauce* of MathWorld. While I expected to discover the *secret sauce*, I actually discovered that the *secret sauce* can apply to any situation that involves the development of students' educational skills and competencies while students had socioeconomic factors that impacted their learning.

The original conceptual model of MathWorld, as introduced in Chapter One, represents my hypothesis of this math support program before conducting the study. The "house" diagram (Figure *1*), courtesy of Renita Mitchell, illustrates a visual representation of the original conceptual model. As stated in Chapter One, developmental math classes provide a foundation for students to learn, understand, and master the math concepts necessary for college-level math courses; they are not solely the important elements that play a critical role in student success in college-level math courses. However, these classes do not serve as a starting point for students. The researcher proposes that students' prior knowledge of math, in addition to their personal and

professional experiences, serve as the foundation. For many students who enter college and enroll in developmental math courses, in particular, this foundation may not be steady or secure enough to sustain them through their college experience. Consequently, students' background knowledge of math can be characterized as a rocky road; the potholes in the road represent the students' gaps of knowledge. In this manner, a layer of concrete, which is symbolic of developmental math courses, must be applied to this foundation to provide more stability. Although developmental math courses have potential to fill in the necessary gaps to the students' knowledge base, these courses do not always provide maximum flexibility of time and space for customized attention in addressing study skills (such as becoming better problem solvers). MathWorld, however, is a math support program that provides pillars of support in tandem with the developmental education courses.

The original conceptual model was a way of organizing the types of skills (hard, soft, critical thinking, and confidence/self-efficacy) in which the Bobs and math faculty can assist students. After collecting and analyzing the data, however, I discovered that the original model needed adjusting. The reconceptualization of the MathWorld model is shown in Figure 2 of Chapter Four. In addition to the four skills from the original model, the reconceptualized model makes reference to emotional support, which emerged from the data analysis. MathWorld's reconceptualized model also places emphasis on the activities connected to these skills. Because the model is interactive in nature, it requires both participants (students and Bobs) to be engaged. For instance, although Bobs can provide assistance, students must also be self-starters and consistently take ownership of the learning process. Students are expected to be proactive in their academic experiences in order to achieve success. Additionally, although students can visit

MathWorld, the Bobs must also be sufficiently trained in various strategies (teaching, learning, tutoring) in order to meet the students' needs.

Lack of attention in research and practice to developmental math. A second key finding of this study is that it fills the gap in the literature, which was introduced in Chapter Two. As a result of a detailed database search, a scarce amount of qualitative studies exist that relate to this study. Although one of the studies mentioned developmental math, the focus was on peer tutoring at a public urban university. Additionally, while some of the studies addressed minority-serving institutions with emerging majority populations as participants, a four-year university was the common choice of setting for researchers to conduct these studies. Some of the remaining studies mentioned math, but it was under the umbrella of STEM (science, technology, engineering, math). Although there are plenty of quantitative studies, only four qualitative studies, including this one, explore the possibility that developmental math issues are not exclusively about math.

Table 2 displays a comparison of my study to Galbraith and Jones, Finney and Stoel, and Cafarella, with respect to the following areas: (a) the purpose of the study, (b) the method and setting, and (c) emerging theme/findings. The aforementioned first two areas were discussed in Chapter Two. A discussion of the emerging theme/findings among the related research follows.

In their findings, Galbraith and Jones (2006) identified the following activities that the instructor believed to be effective in the classroom: alternate methods of assessment, small groups, and real-world connections. Similarities and differences exist between Galbraith and

Jones' study and this study. While both studies are similar in that they highlighted the significance of real-world connections, Galbraith and Jones interviewed only one participant (a

math instructor), whereas I interviewed multiple participants who were both instructors and Bobs.

Jones' study and this study. While both studies are similar in that they highlighted the significance of real-world connections, Galbraith and Jones interviewed only one participant (a math instructor), whereas I interviewed multiple participants who were both instructors and Bobs.

Four years later, a case study by Finney and Stoel revealed the success of implementing supplemental instruction. In their interview with Phelps, as mentioned in Chapter Two, supplemental instruction was defined as:

> …cooperative learning outside and inside a class. A student who has taken the class and been successful is asked to sit through the class, listen to the lectures, be part of the class discussion, take notes, take the tests, and then model how to study outside of class. (Finney & Stoel, 2010, p. 38)

Similarities and differences exist between Finney and Stoel's study and this study. While both studies are similar in that they drew attention to the significance of notetaking, Finney and Stoel narrowed their focus on one specific strategy: supplemental instruction. This study identified a variety of best practices.

In 2014, the following themes emerged from Cafarella's study: communication, organization and structure, cooperative learning, and regular low stake assessments (p. 48). Similarities and differences exist between Cafarella's study and this study. Both studies were similar in that they stressed the importance of communication. Although Cafarella interviewed 0 participants (math instructors), I interviewed multiple participants who were both instructors and Bobs to achieve robust findings.

Table 2

Comparison of Related Research

	Galbraith & Jones (2006)	Finney & Stoel (2010)	Cafarella (2014)	Patterson (2018)—this study
Purpose of study	"we have introspectively examined research and personal experience related to teaching to identify elements essential to the art and science of teaching" (Galbraith & Jones, 2006, p. 21)	Explore the application and impact of supplemental instruction in developmental math courses at an urban community college	"the purpose was to gain an in-depth understanding of the best practices utilized by a group of developmental mathematics instructors at an urban community college" (Cafarella, 2014, p. 36).	The overarching purpose of this study is to develop a deeper understanding and explore the impact of participation in MathWorld on student success in developmental math courses, from the perspectives of math faculty and staff at a local community college.
Method / Setting	• Small rural CC • Interviews during one academic term • 1 participant: DM instructor	• Urban CC • One Interview 1 participant: DM instructor (Julie Phelps) who received the 2010 Virginia B. Smith Innovative Leadership Award	• Large urban CC • One pre-interview document and Interview per participant 20 participants: DM instructors who taught DM courses for 2 consecutive years (6 DM courses) and achieved at least 60% overall student passing rate	• Large urban CC • Interview 11 participants: 5 Bobs, 4 DE instructors, and 2 instructors/former Bobs (work with students who show up to MathWorld)
Emerging Theme(s) / Findings	• Alternative methods of assessment • Small groups • Real-world connections	Supplemental instruction	• Effective communication • Organizational skills • Frequent low stake assessments • Collaborative learning • Accelerated instruction • Instructor comfort level	• Cultivating content-specific skills • Supporting life skills • Providing holistic interventions

This study adds to the literature by revealing the impact of math support programs on the success of minority students attending a community college. Moreover, it also generated and promoted possible best practices for the necessary level of participation in developmental math courses to minimize struggle.

Absence of theory explaining learner dynamics in developmental contexts. As aforementioned in this chapter and shown in Figure 6, there are five theories to explain the dynamics in the core practices. However, this model of dynamic interconnectivity is not limited to its application in math. The model can apply to any educational, professional, or personal situation. Examples include on-the-job training, developmental reading, learning a second language, job rehabilitation for worker's compensation victims or disabled veterans, and re-entry programs for prisoners. Thus, the Transformation through Dynamic Interconnectivity Model creates a new way of thinking about establishing and maintaining productive learner dynamics in developmental contexts.

Recommendations

This study's key conclusions support the following recommendations for practitioners, policy makers, educators, and future researchers.

Practitioners and policy makers. The results of this study can be used as a learning tool for practitioners and policy makers. They are encouraged to replicate these core practices at other community colleges to ensure consistent and sustained success in math. It is recommended that college administrators, in particular, provide sufficient hours of availability for the student population. The results of this study, in addition to the literature that was presented in Chapter Two, confirmed the necessity for addressing the wide variety of student needs at minority-serving institutions. As shown in Appendix B, students who spent at least 50 hours in

MathWorld during the Spring 2017 Semester successfully completed the course at a rate of 88.5%. The successful completion rate during the Fall 2017 Semester, however, dropped to 71.6% for students who spent the same amount of time in MathWorld (Appendix C). As explained in Chapter Four, the decrease in the successful completion rate was due to limited hours of availability. Fortunately, this administrative decision to reduce MathWorld's hours of operation have since been changed, and the original hours were reinstated.

As previously mentioned, there were quantitative articles about STEM programs that emerged from the detailed database search. While STEM programs are not fundamentally created to improve math literacy, government officials have provided more funding to help students who have demonstrated exceptional skills in science, technology, engineering, and/or math. Ironically, the issue of math illiteracy is prevalent among students with socioeconomic factors that impact their learning, and there is little funding to assist these particular students. Therefore, it is recommended that practitioners and policy makers provide ways to generate more funding to provide a better educational future for the emerging majority population.

Educators. As there is a shifting of demographics in the United States, it is probable that there will be an increasing number of minority-serving institutions, as compared to the number of traditional colleges. Additionally, the change in the generation of students is to be considered. As more millennials enter college, educators must be more cognizant of the students' various learning styles and modalities, as compared to earlier generations, with their use of technology. Upon review of the literature, it is evident that proper implementation of various teaching strategies with knowledge of various student learning styles can facilitate student success over time. In order for this to occur, is recommended that math instructors, tutors, and other math

support staff collaborate with each other, share ideas based on their lived experiences, and participate in professional development opportunities to hone their craft.

Future researchers. As aforementioned, the study was conducted at one HBCU, in one city of the United States. Future researchers might consider replicating this study at other institutions, particularly those that are minority serving. These researchers may also find interest in determining correlations between quantitative data (such as number of student visits to a math support program) and each component of the new conceptual model of success for developmental math students. In future studies, researchers may supplement the study by creating a brief, open-ended questionnaire for recent graduates to complete. From there, they could check for trends in their responses and determine how MathWorld has affected the learning experiences for the students. Additionally, future researchers can explore the possible existence of a correlation between the diversity of the Bobs and their engagement styles with students. Also, throughout the United States, an action research study could be conducted at various minority-serving community colleges for further exploration. Moreover, since none of the four theories (Attribution Theory, Student Involvement Theory, Transformative Learning Theory, and Theory of Needs) fully encompassed this study, I recommend that future research explore the relevance of Tomkin's Affect theory in relation to developmental education students participating in supplemental instruction environments. Future research could also include a grounded theory study to explore a potential new theory that holistically addresses the transformation through dynamic interconnectivity among learners and supportive role players in any given context.

Finally, this study identified the behaviors of MathWorld staff and faculty that contribute to student success. It did not examine the thoughts and feelings behind these behaviors, because

it was beyond the scope of this study. Nevertheless, examining such thoughts and feelings could generate another rich qualitative study for future researchers.

Final Reflections

The researcher, throughout the course of this study, has discovered that the three supporting elements (cultivating content-specific skills, supporting life skills, and providing holistic interventions) of the new conceptual model of MathWorld are not limited to math per se. This model is transferable to other remedial or developmental education programs, such as English and reading. The *secret sauce* can be applied to everyone in all areas of life, whether personal, educational, or professional. To illustrate this point, I will describe my experiences as a PhD candidate.

My lived experiences as an educator and graduate student provided some background knowledge. However, I needed to acquire more insight on my topic of interest by way of scholarly research. The doctoral program at the University of the Incarnate Word provided me with this opportunity. My ability to read, write, and use the computer are a few of the hard skills. My ability to analyze the literature and the data I collected in the study represent the critical thinking skills. My ability to organize and manage my time are examples of the soft skills. My moments of creating rewards for met goals throughout the research process were ways in which I maintained my confidence. Prayer and meditation, in addition to seeking advice from family, friends, colleagues, and committee members, were ways in which I sustained emotional support. Throughout the dissertation process, in particular, my committee members provided the following necessary actions with respect to the TDI Model. To cultivate my skills as a PhD candidate, the committee members brought their expertise and suggestions. To support my life skills, they provided encouragement and patience. To provide holistic interventions, they listened

intently and remained flexible to my needs when I sought guidance on specific parts of my research (e.g., methodology).

Upon reflection, this academic experience has enlightened and empowered my role as an educator and researcher in the field of math education. It has changed my perceptions as a scholar, in that I learned how to view a topic of interest from multiple perspectives and at deeper levels to extract more meaning. Additionally, since I hold a strong belief in being a lifelong learner, this experience has increased my knowledge and wisdom in working with developmental math students. I understand that I play a critical role in their academic journey. It is always my desire to help developmental math students sharpen their math skills and increase their confidence in doing so.

For me, the key findings from this study confirmed my belief of MathWorld's significance to the student population at St. Philip's College. The affective domain, in particular, resonated deeply with me because of my lived experiences as an educator. For most students with whom I have worked, I discovered that I had to capture their heart (affective domain) before I could reach their mind (cognitive domain). When it comes to assisting students in developmental or college-level math courses, the emphasis on addressing the student holistically must not be overlooked.

The opportunity to share and describe the unique impact of MathWorld on student success is invaluable. It is my hope that stakeholders (students, educators, administrators) from other minority-serving institutions throughout the United States can experience the same.

References

Abraham, R. A., Slate, J. R., Saxon, D. P., & Barnes, W. (2014). Math readiness of Texas community college developmental education students: A multiyear statewide analysis. *The Community College Enterprise, 20*(2), 25-44.

Ahles, P. M., & Contento, J. M. (2006). Explaining helping behavior in a cooperative learning classroom setting using attribution theory. *Community College Journal of Research and Practice*, *30*(8), 609-626. Retrieved from https://naspa.tandfonline.com/doi/abs/10.1080/10668920500210191#.W1chdFVKhph

Aslanian, C. B. (2001). *Adult students today*. New York: College Board.

Astin, A. W. (1984). Student involvement: A developmental theory for higher education. *Journal of college student personnel*, *25*(4), 297-308.

Bailey, T. (2009). Challenge and opportunity: Rethinking the role and function of developmental education in community college. *New Directions for Community Colleges*, *2009*(145), 11–30.

Bailey, T., Jeong, D. W., & Cho, S.W. (2010). Referral, enrollment, and completion in developmental education sequences in community colleges. *Economics of Education Review*, *29*(2), 255–270.

Baxter, P., & Jack, S. (2008). Qualitative case study methodology: Study design and implementation for novice researchers. *The qualitative report*, *13*(4), 544-559.

Baxter Magolda, M. B. (2001). *Making their own way: Narratives for transforming higher education to promote self-development.* Sterling, VA: Stylus.

Benken, B. M., Ramirez, J., Li, X., & Wetendorf, S. (2015). Developmental mathematics success: Impact of students' knowledge and attitudes. *Journal of developmental education*, *38*(2), 14.

Bettinger, E. P., Boatman, A., & Long, B. T. (2013). Student supports: Developmental education and other academic programs. *The Future of Children, 23(1),* 93-115.

Boylan, H. R., & Bonham, B. S. (2007). 30 years of developmental education: A retrospective. *Journal of Developmental Education*, *30*(3), 2.

Bonham, B. S., & Boylan, H. R. (2011). Developmental mathematics: Challenges, promising practices, and recent initiatives. *Journal of Developmental Education, 34(3),* 2.

Boylan, H. R. (2011). Improving success in developmental mathematics: An interview with Paul Nolting. *Journal of Developmental Education*, *34*(3), 20.

Burleson, B. R. (2003). Emotional support skills. *Handbook of Communication and Social Interaction Skills*, 551-594.

Cafarella, B. V. (2014). Exploring best practices in developmental math. *Research & Teaching in Developmental Education, 30*(2), 35-64.

Charmaz, K. (2014). *Constructing grounded theory*. London: Sage.

Chaves, C. (2006). Involvement, development, and retention: Theoretical foundations and potential extensions for adult community college students. *Community College Review*, *34*(2), 139-152.

Corrigan, P., Markowitz, F. E., Watson, A., Rowan, D., & Kubiak, M. A. (2003). An attribution model of public discrimination towards persons with mental illness. *Journal of Health and Social Behavior*, 162-179.

Cortés-Suárez, G., & Sandiford, J. R. (2008). Causal attributions for success or failure of students in college algebra. *Community College Journal of Research and Practice*, *32*(4-6), 325-346. Retrieved from https://naspa.tandfonline.com/doi/full/10.1080/10668920701884414?scroll=top&needAccess=true#.W1ceMFVKhpg

Cranton, P. (2002). Teaching for transformation. *New Directions for Adult and Continuing Education*, (93), 63-72. Retrieved from http://www.cod.edu/people/faculty/liudejan/caha501/caha501/crantontft.pdf

Crawford, C., & Jervis, A. (2011). Community Colleges Today. *Contemporary Issues in Education Research*, *4*(8), 29–32.

Creswell, J. W. (2012). Collecting qualitative data. *Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research. Fourth ed.* Boston: Pearson.

Creswell, J. W. (2013). *Research design: Qualitative, quantitative, and mixed methods approaches*. Thousand Oaks: Sage.

Creswell, J. W., & Poth, C. N. (2017). *Qualitative inquiry and research design: Choosing among five approaches*. Thousand Oaks: Sage.

Crisp, G., & Nora, A. (2010). Hispanic student success: Factors influencing the persistence and transfer decisions of Latino community college students enrolled in developmental education. *Research in Higher Education*, *51*(2), 175-194.

Core Practice Consortium (2018). Core Practice. *Core Practice Consortium.* Retrieved from https://www.corepracticeconsortium.com/core-practice

Demetriou, C., & Schmitz-Sciborski, A. (2011). Integration, motivation, strengths and optimism: Retention theories past, present and future. In *Proceedings of the 7th National Symposium on student retention*, 300-312.

DeSilver, D. (2017, February). U.S. students' academic achievement still lags that of their peers in many other countries. *Pew Research Center*. Retrieved from http://www.pewresearch.org/fact-tank/2017/02/15/u-s-students-internationally-math-science/

Dougherty, K. J., Lahr, H., & Morest, V. S. (2017). Reforming the American community college: Promising changes and their challenges. CCRC Working Paper No. 98. *Community College Research Center, Teachers College, Columbia University*.

Duranczyk, I. M., & Higbee, J. L. (2006). Developmental mathematics in 4-year institutions: Denying access. *Journal of Developmental Education*, *30*(1), 22.

Fike, D. S., & Fike, R. (2008). Predictors of first-year student retention in the community college. *Community College Review*, *36*(2), 68-88.

Finney, J. E., & Stoel, C. F. (2010). Fostering student success: An interview with Julie Phelps Virginia B. Smith innovative leadership award recipient for 2010. *Change: The Magazine of Higher Learning*, *42*(4), 38-43.

Fong, C. J., Davis, C. W., Kim, Y., Kim, Y. W., Marriott, L., & Kim, S. (2017). Psychosocial factors and community college student success: A meta-analytic investigation. *Review of Educational Research*, *87*(2), 388-424.

Galbraith, M. W., & Jones, M. S. (2006). The art and science of teaching developmental mathematics: Building perspective through dialogue. *Journal of Developmental Education*, *30*(2), 20.

Gasman, M., Nguyen, T., & Conrad, C. F. (2015). Lives intertwined: A primer on the history and emergence of minority serving institutions. *Journal of Diversity in Higher Education, 8*(2), 120-138.

Givvin, K. B., Stigler, J. W., & Thompson, B. J. (2011). What community college developmental mathematics students understand about mathematics, Part II: The interviews. *The MathAMATYC Educator*, *2*(3), 4-18.

Glover, M. L., & Sussmane, J. B. (2002). Assessing pediatrics residents' mathematical skills for prescribing medication: a need for improved training. *Academic Medicine*, *77*(10), 1007-1010.

Graham, S., & Weiner, B. (1996). Theories and principles of motivation. *Handbook of Educational Psychology*, *4*, 63-84.

Gupta, S., Harris, D. E., Carrier, N. M., & Caron, P. (2006). Predictors of student success in entry-level undergraduate mathematics courses. *College Student Journal*, *40*(1).

Hancock, D. R., & Algozzine, B. (2016). *Doing case study research: A practical guide for beginning researchers*. New York: Teachers College Press.

Hard Skills (n.d.). Investopedia. In Investopedia. Retrieved from https://www.investopedia.com.

Jackson, D. L. (2013). A balancing act: Impacting and initiating the success of African American female community college transfer students in STEM into the HBCU environment. *The Journal of Negro Education*, *82*(3), 255-271, 356.

Karp, M. M., Hughes, K. L., & O'Gara, L. (2010). An exploration of Tinto's integration framework for community college students. *Journal of College Student Retention: Research, Theory & Practice*, *12*(1), 69–86.

Kitchenham, A. (2008). The evolution of John Mezirow's transformative learning theory. *Journal of Transformative Education*, *6*(2), 104-123.

Kuh, G. D., Cruce, T. M., Shoup, R., Kinzie, J., & Gonyea, R. M. (2008). Unmasking the effects of student engagement on first-year college grades and persistence. *The Journal of Higher Education*, *79*(5), 540-563.

Laden, B. V. (2004). Serving emerging majority students. *New Directions for Community Colleges*, *2004*(127), 5-19.

Lipman, M. (1987). Critical thinking: What can it be? *Analytic Teaching*, *8*(1), 5-12.

Lundberg, C. A. (2014). Peers and faculty as predictors of learning for community college students. *Community College Review*, *42*(2), 79–98.

Mathison, S. (1988). Why triangulate? *Educational Research Association, 17*(2), 13-17.

Maxwell, J. (2013). *Qualitative research design: An interactive approach*. Thousand Oaks, CA: Sage.

McCabe, R. H. (2000). *No one to waste: A report to public decision-makers and community college leaders*. Washington, DC: Community College Press.

McCabe, R. H., & Day Jr., P. R. (1998). *Developmental education: A twenty-first century social and economic imperative.* Mission Viejo, CA: League for Innovation in the Community College and The College Board.

McClelland, D. (1961). *The achieving society.* Princeton, NJ: Van Nostrand Company Inc.

McClenney, K. M. (2007). Research update: The community college survey of student

engagement. *Community College Review*, *35*(2), 137-146.

Merriam, S. B. (2002). Assessing and evaluating qualitative research. In. S. B. Merriam and Associates (Eds.), *Qualitative research in practice: Examples for discussion and Analysis* (18-33). San Francisco, CA: Jossey-Bass.

Merriam, S. B. & Associates (Ed.). (2002). *Qualitative research in practice: Examples for discussion and analysis*. San Francisco, CA: Jossey-Bass.

Mezirow, J. (1991b). Transformative theory and cultural context: A reply to Clarke and Wilson. *Adult Education Quarterly, 41*(3), 188-192.

Mezirow, J. (2008). An overview on transformative learning. In K. Illeris (Ed.), *Contemporary theories of learning: Learning theorists … in their own words* (pp. 90-105). New York, NY: Routledge. Retrieved from https://pdfs.semanticscholar.org/1085/b8aaeee9d65dccbe930dca5fe6034bbaeb4d.pdf#page=99

Miglietti, C. L., & Strange, C. C. (1998). Learning styles, classroom environment preferences, teaching, styles, and remedial course outcomes for underprepared adults at a two-year college. *Community College Review*, *26*(1), 1-19.

Moore, L. L., Grabsch, D. K., & Rotter, C. (2010). Using achievement motivation theory to explain student participation in a residential leadership learning community. *Journal of Leadership Education, 9*(2), 22-34.

National Research Council. (1989). *Everybody counts: A report to the nation on the future of mathematics education*. Washington, DC: National Academies Press.

Paraclete. (n.d.). In *Webster's New World College Dictionary* (5th ed.). Retrieved from http://www.yourdictionary.com/PARACLETE

Perin, D. (2004). Remediation beyond developmental education: The use of learning assistance centers to increase academic preparedness in community colleges. *Community College Journal of Research & Practice, 28(7)*, 559-582.

Pizzolato, J. E. (2005). Creating crossroads for self-authorship: Investigating the provocative moment. *Journal of College Student Development, 46*, 624-641.

Polya, G. (1945). *How to solve it.* Princeton, NJ: Princeton University Press.

Ponjuán, L., & Hernández, S. (2016). Untapped potential: improving Latino males academic success in community colleges. *Journal of Applied Research in the Community College, San Diego*, *23*(2), 1-20.

Robles, M. M. (2012). Executive perceptions of the top 10 soft skills needed in today's workplace. *Business Communication Quarterly*, *75*(4), 453-465.

Rose, S. L., & Pietri, C. E. (2002). Workers as research subjects: a vulnerable population. *Journal of Occupational and Environmental Medicine*, *44*(9), 801-805.

Saldaña, J. (2015). *The coding manual for qualitative researchers*. Los Angeles, CA: Sage.

Sergeyev, A., Alaraje, N., Kuhl, S., Hooker, J., Druschke, V., Kinney, M., & Highum, M. (2018). Revamping robotics education to meet 21st century workforce needs-years 1-2 progress reports. *Proceedings of the 2018 Conference for Industry and Education Collaboration.* Retrieved from http://www.indiana.edu/~ciec/Proceedings_2018/ETD/ETD%20406/ETD406_SereyevAlarajeKuhlHookerDruschkeKinneyHighum.pdf

Shields, D. J. (2005). Developmental education: Criticisms, benefits and survival strategies. *Research and Teaching in Developmental Education*, 43–51.

Siegle, D., Rubenstein, L. D. V., Pollard, E., & Romey, E. (2010). Exploring the relationship of college freshmen honors students' effort and ability attribution, interest, and implicit theory of intelligence with perceived ability. *Gifted Child Quarterly*, *54*(2), 92-101.

St. Philips College (2018). About Mathematics at SPC. Retrieved from https://www.alamo.edu/spc/math/

St. Philips College (2018). Fall 2016 Quick Facts. Retrieved from http://www.alamo.edu/uploadedFiles/SPC/Faculty_and_Staff/Departments_Non-Academic/Planning_and_Research/Files/Quick%20Facts%202016%20FinalFromLarryLopez.pdf

St. Philip's College (2018). Mission, Vision, and Values/Strategic Plan. Retrieved from http://www.alamo.edu/spc/mvv/

St. Philip's College ViewBook: A Point of Pride in the Community. (2017). Retrieved from https://www.alamo.edu/uploadedFiles/St_Philips_College/Library/Files/ViewBook.pdf

Stigler, J. W., Givvin, K. B., & Thompson, B. J. (2010). What community college developmental mathematics students understand about mathematics. *MathAMATYC Educator*, *1*(3), 4–16.

Strayhorn, T. L. (2010). When race and gender collide: Social and cultural capital's influence on the academic achievement of African American and Latino males. *Review of Higher Education, 33*(3), 307-332.

Tellis, W. M. (1997). Application of a case study methodology. *The qualitative report*, *3*(3), 1-19.

Terenzini, P. T., Rendon, L. I., Upcraft, M. L., Millar, S. B., Allison, K. W., Gregg, P. L., & Jalomo, R. (1994). The transition to college: Diverse students, diverse stories. *Research in higher education*, *35*(1), 57-73.

Texas Higher Education Coordinating Board. (2008). College for Texans Overview. Retrieved from http://www.thecb.state.tx.us/reports/PDF/1592.PDF?CFID=77533441&CFTCFTO=83769878

Thomas, G. (2015). *How to do your case study*. Thousand Oaks, CA: Sage.

Tomkins, S. (1984). Affect theory. In K. R. Scherer & P. Ekman (Eds.), *Approaches to emotion,* (pp. 163-195). Hillsdale, NJ: Erlbaum.

U. S. Department of Education (2012). Developing Hispanic-serving institutions Program, Title V, CFDA No. 84. 03IS; 84. 031C (2008). Retrieved from http://www2.ed.gov/programs/idueshsi/funding.html.

U. S. Department of Education (2012). White house initiative on historically black colleges and community colleges, Exec. Ord. 13256 9 (2002). Retrieved from http://www2. ed.gov/about/inits/list/whHBCU/edlite-index. html.

U.S. Department of Homeland Security (2018). Study in the States: What is community college? Retrieved from https://studyinthestates.dhs.gov/2012/03/what-is-community-college

Weiner, B. (1996). *Human motivation: Metaphors, theories, and research*. Thousand Oaks, CA: Sage.

Wild, L., & Ebbers, L. (2002). Rethinking student retention in community colleges. *Community College Journal of Research and Practice*, *26*(6), 503-519.

Wolf-Wendel, L., Ward, K., & Kinzie, J. (2009). A tangled web of terms: The overlap and unique contribution of involvement, engagement, and integration to understanding college student success. *Journal of College Student Development*, *50*(4), 407-428.

Yin, R. K. (2017). *Case study research and applications: Design and methods*. Thousand Oaks, CA: Sage.

Zhao, C. M., & Kuh, G. D. (2004). Adding value: Learning communities and student engagement. *Research in Higher Education*, *45*(2), 115-138.

Zientek, L. R., Schneider, C. L., & Onwuegbuzie, A. J. (2014). Placement and success: developmental mathematics instructors' perceptions about their students. *Community College Enterprise*, *20*(1), 66-82.

Zulkosky, K. (2009). Self-Efficacy: A Concept Analysis. *Nursing Forum, 44*(2), 93–102.

Appendices

Appendix A
Integrative Literature Review for Quantitative and Qualitative Studies

Name of Reference	Purpose of Study	Methodology	Key Results
Crisp, G., Nora, A., & Taggart, A. (2009). Student characteristics, pre-college, college, and environmental factors as predictors of majoring in and earning a STEM degree: An analysis of students attending a Hispanic serving institution. American Educational Research Journal, 46(4), 924-942.	The authors examined "the demographic, pre-college, environmental, and college factors that impact students' interest in and decision to earn a degree in STEM [science, technology, engineering, mathematics] among undergraduate students attending an HIS [Hispanic-serving institution]" (p. 926)	Quantitative study Participants: 1,925 students Predictors: demographic, environmental, and college variables Data analysis: Chi-square, *t* tests, logistic regression	Results indicated that Hispanic students were well represented among STEM majors, and students' decisions to declare a STEM major and earn a STEM degree were uniquely influenced by students' gender, ethnicity, SAT math score, and high school percentile. Earning a STEM degree was related to students' first-semester GPA and enrollment in mathematics and science "gatekeeper" courses. Findings indicate that HSIs may be an important point of access for students in STEM fields and may also provide opportunity for more equitable outcomes for Hispanic students. (p. 924)
Farmer, E., Hilton, A. A., & Reneau, F. H. (2016). Variables that contribute to retention and graduation of Black American females at an historically Black university. *Negro Educational Review, 67*(1-4), 133-148,169.	The purpose of this study was to determine whether select pre-college and college level variables have a relationship with retention and graduation of Black American females attending an Historically Black University. (p. 133)	Quantitative study "Data for this research came from an HBCU located in the southern region of the United States" (p. 138). Participants: 785 Black American females Data analysis: Descriptive and multivariate techniques	Results show that family income, hours attempted in year one in college, and hours earned in year one in college were predictors of retention. In addition, the results demonstrate that high school GPA, college GPA year one, and college GPA year four were predictors of graduation for this cohort of Black female students. (p. 133)

William, C. B. (2018). The higher education act and minority serving institutions: Towards a typology of title III and V funded programs. *Education Sciences, 8*(1), 33.	"The purpose of this study is to analyze MSI Title III and V programs based on project abstracts" (p. 1).	Quantitative study Data collected: "restricted-use data obtained from the U.S. Department of Education, NCES IPEDS, and the Office of Postsecondary Education" (p. 1) Data analysis: Content analysis	"Retention/persistence was among the most commonly sought outcomes for all categories of MSIs (65%)…. Course completion and transfer are more specific to two-year colleges…. It becomes clear through the project abstracts that most MSIs recognize they are institutions existing within communities that benefit from the college as much as the institution benefits from the community." (pp. 9-14)
Wang, X. (2013). Modeling entrance into STEM fields of study among students beginning at community colleges and four-year institutions. *Research in Higher Education, 54*(6), 664-692.	To understand what influences college students to enter majors in STEM fields, this study tests a theoretical model that examines factors shaping the decision to pursue STEM fields of study among students entering community colleges and four-year institutions using a nationally representative sample of high school graduates from 2004. (p. 665)	Quantitative study Data used for this study drew upon the first and second follow-up surveys of the Education Longitudinal Study of 2002 (ELS:2002), a national, longitudinal survey designed to study high school students' transition from secondary into postsecondary education. (p. 669) Data analysis: Multi-group structural equation modeling analysis	… while high school exposure to math and science courses appears to be a strong influence on four-year beginners' STEM interest, its impact on community college beginners' STEM interest, albeit being positive, is much smaller. In addition, college academic integration and financial aid receipt exhibit differential effects on STEM entrance, accruing more to four-year college students and less to those starting at community colleges. (p. 664)
Wolfe, B. A. (2018). Introductory geosciences at the two-year college: Factors that influence student transfer intent with geoscience degree aspirations. *Journal of*	The purpose of this study was to determine (a) who takes introductory geosciences courses at the 2YC [two-year colleges] and (b) what factors, if any, predict	This study used a quantitative research method design analyzing data collected from a pretransfer survey instrument measuring the academic	Sequential multiple regression findings revealed a number of factors that predict higher geoscience transfer intent, including age, high school math preparation, having taken an Earth science course in high

Geoscience Education, 66(1), 36-54. doi:http://dx.doi.org.uiwtx	2YC student intent to transfer to a 4YC with geoscience degree aspirations. (p. 37)	experiences and pretransfer behaviors of [708] 2YC students. (p. 41) Data analysis: Sequential multiple regression	school, the number of science courses taken at the 2YC, student– faculty interaction, and faculty and academic advisors discussing physical science careers. The results also demonstrated that field-based educational experiences have a significant role in increasing student intent to transfer pursuing geoscience degrees. Findings presented point to the need to develop practices focused on transfer student capital acquisition and supports the proposition that 2YCs can serve as an intervention point to broaden participation in the geosciences. (p. 36)
Flores, S. M., & Drake, T. A. (2014). Does English language learner (ELL) identification predict college remediation designation? A comparison by race and ethnicity, and ELL waiver status. *Review of Higher Education, 38*(1), 1-36.	This study addresses the gap in the research literature by examining the connection between students' ELL status and their being designated as needing remediation as it relates to race, ethnicity, and income level. That is, we explore whether ELL status is strongly associated with being designated as needing remedial coursework, or whether factors such as race/ethnicity, economic status, or academic preparation play a more significant role in that	Quantitative study The dataset includes student-level data collected from 1990 through 2008 and consist of administrative records from the state education agencies that oversee public K-12 schools (the Texas Education Agency) and postsecondary institutions (the Texas Higher Education Coordinating Board)…. Our sample includes all students who entered the first grade in 1995, graduated from high school in the spring of 2007, and entered	We found a few fundamental similarities across racial and ethnic groups who had been assigned ELL status, but the key story is that the factors that predict entry into remediation can differ distinctly by race and ethnicity. (p. 28)

	designation. (Flores & Drake, 2014, p. 4)	college in the fall of 2007…. We provide both a descriptive and a logistic regression analysis to answer our research questions. (Flores & Drake, pp. 10-15)	
LaSota, R. R., & Zumeta, W. (2016). What matters in increasing community college students' upward transfer to the baccalaureate degree: Findings from the beginning postsecondary study 2003-2009. *Research in Higher Education, 57*(2), 152-189.	This research uses the nationally representative Beginning Postsecondary Study: 2003–2009 to investigate the relative significance in upward transfer of individual and institutional factors for different groups of students, considering their state policy contexts of variable support for improved articulation and transfer between 2-year and baccalaureate-granting colleges. (p. 152)	Quantitative study We implemented multi-level logistic regression analysis to examine the influence of state articulation and transfer policies and community college characteristics on public 2-year college students' upward transfer probability after accounting for individual factors, focusing particularly on low-income and first generation students… The primary source is the Beginning Postsecondary Study (BPS) 2003–2009, which is nationally representative of first-time beginning college students in Autumn 2003…. The other sources of data are: (1) Integrated Postsecondary Education Data System (IPEDS) for all community college characteristics; (2) U.S. Bureau of Labor Statistics (BLS) for	Layered analyses of hierarchical generalized linear model population-average results found that a few community college characteristics and state transfer policy components (such as a state articulation policy, cooperative articulation agreements, transfer data reporting, etc.) demonstrated a statistically significant association with individual upward transfer probability within 6 years of community college entry. Student characteristics found to be influential and positive for increasing upward transfer probability included: having an intention for upward transfer at entry, attending primarily full-time, working between 1 and 19 h per week (not more or less), and declaring a transfer-oriented major in STEM (science, technology, engineering, or mathematics), Arts and Social/Behavioral Sciences, or Education. (p. 152)

		county-level unemployment rates where colleges are located11; (3) U.S. Bureau of Economic Analysis for 2003 per capita Gross State Product (GSP) as a measure of state wealth at the beginning of the time period; (4) Barron's Selectivity Index data from the National Center for Education Statistics (NCES) for nearest public-4 year institution for each public 2-year institution in the dataset; and (5) Education Commission of the States (ECS) for state policy data on articulation and transfer. (LaSota & Zumeta, 2016, pp. 159-162)	
Strayhorn, T. L. (2014). Making a way to success: Self-authorship and academic achievement of first-year African American students at historically black colleges. *Journal of College Student Development, 55*(2), 151-167.	This study was designed to advance our knowledge of HBCU students, self-authorship, and academic achievement by estimating the relationship between academic achievement in college, defined by first-year GPA, and self-authorship, as defined by Baxter Magolda (2001) and Pizzolato (2005), among African American first-year	Quantitative study This study employed a survey design to study the influence of self-authorship on academic achievement for African American first-year students at HBCUs…. The African American Student Success Questionnaire (AASSQ) was designed by the author for this study… The analytic sample	Findings reveal that self-authorship predicts first-year GPA above and beyond background characteristics and traditional measures of academic preparation for college (e.g., high school GPA, ACT/SAT); the final regression model accounts for approximately 58% of the variance in the dependent variable. (p. 151)

	students at HBCUs. (pp. 152-153)	consisted of the 140 students who completed the AASSQ and for whom first-year GPA was reported by the university's office of institutional research. (pp. 155-156) Data analysis: hierarchical linear regression techniques	
Wladis, C., Conway, K. M., & Hachey, A. C. (2015). The online STEM classroom-who succeeds? an exploration of the impact of ethnicity, gender, and non-traditional student characteristics in the community college context. *Community College Review, 43*(2), 142-164.	This study analyzes how ethnicity, gender, and non-traditional student characteristics relate to differential online versus face-to-face outcomes in science, technology, engineering, and mathematics (STEM) courses at community colleges. (Wladis, Conway, & Hachey, 2015, p. 142)	Quantitative study This study used a sample of 3,600 students in online and face-to-face courses matched by course, instructor, and semester from a large urban community college in the Northeast. Outcomes were measured using rates of successful course completion (with a "C-" or higher). Multilevel logistic regression and propensity score matching were utilized to control for unobserved heterogeneity between courses and for differences in student characteristics. (Wladis, Conway, & Hachey, 2015, p. 142)	With respect to successful course completion, older students did significantly better online, and women did significantly worse (although no worse than men) online, than would be expected based on their outcomes in comparable face-to-face courses. There was no significant interaction between the online medium and ethnicity, suggesting that though Black and Hispanic students may do worse on average in STEM courses than their White and Asian peers both online and face-to-face, this gap was not increased by the online environment. These findings suggest that both women and younger students in STEM courses may need extra support in the online environment. (Wladis, Conway, & Hachey, 2015, p. 142)
Bowman, N. A., & Seifert, T. A. (2011). Can college students accurately assess what	"This study expands the current literature with an examination of a particular form of	Quantitative study "Data from the Wabash National	The researchers found that "students were fairly inaccurate when reporting how their experiences with

affects their learning and development? *Journal of College Student Development, 52*(3), 270-290.	self-reported data, namely, students' reports of the degree to which a particular set of experiences influenced their development on a particular outcome" (p. 273).	Study of Liberal Arts Education (WNS) were used for this study" (p. 273) Participants: 3,081 students Data analysis: descriptive statistics, set of ordinary least squares multiple regression analyses (p. 277)	faculty and peers affected their own cognitive and personal development" (p. 270).
Strayhorn, T. L. (2010). When race and gender collide: Social and cultural capital's influence on the academic achievement of African American and Latino males. *Review of Higher Education, 33*(3), 307-332.	"The purpose of this study was to measure the influence of background traits, academic preparation for college, and sociocultural capital on academic achievement in college, as measured by college grade point average (GPA)" (p. 312).	Quantitative study Data for this study were drawn from the National Center for Education Statistics' (NCES) National Education Longitudinal Study (NELS:88/00) sponsored by the U.S. Department of Education…. the weighted analytic sample consisted of 171,936 African American males and 140,222 Latino males. (p. 313) Data analysis: descriptive statistics, hierarchical linear regression techniques, and significance tests (Strayhorn, 2010, pp. 314-315)	Findings suggest not only that sociocultural capital plays a role in determining a student's academic achievement in college but that this effect persists regardless of his pre-college experiences and preparation… Second, participation in pre-college outreach programs (e.g., Talent Search, Upward Bound) was associated with higher grades in college for both Black and Latino men…. Third, African American and Latino males who had college discussions with their parents also tended to earn higher grades in college. (Strayhorn, 2010, pp. 319-320)
Montague, J. R., & Hays, E. T. (2008). Predicting student success in a first-semester college biology course. *Florida*	In hopes of reducing the risks of wasted investment by students, professors and academic advisors, we've	Quantitative study Our analyses were based on quantitative data collected for 316 first-semester college	The study "revealed statistically significant correlations among SAT scores, GPA's, and performance on the comprehensive final exam

Scientist, 71(2), 105-114.	monitored our first-semester biology majors closely over the years, looking for accurate indicators of success. We want to use our finite academic resources most efficiently to maximize the educational opportunities and chances of success for all our biology majors. But do reliable indicators actually exist? Do we assess in vain? (p. 105)	biology majors (1993–2002)…. We collected part of our data using a query software program authorized by personnel in the Barry University Administrative Information System, and which partially limited our access to student records (we did not inspect individual transcripts or admission applications). (p. 107) Data analysis: correlation and linear progression programs (p. 108)	in their first biology course. Verbal SAT scores (but not Math SAT scores) and high school GPA were statistically significant though relatively weak predictors for final semester average for the introductory biology course required for all majors; 23% of the variation in final course average was explained by Verbal SAT and HS GPA, leaving 77% of that variation unexplained" (p. 105)
Bowman, N. A. (2012). Promoting sustained engagement with diversity: The reciprocal relationships between informal and formal college diversity experiences.	"This study explored the interrelationships among three types of diversity experiences: positive diversity interactions, diversity coursework, and negative diversity interactions" (p. 5)	Quantitative study I used data from the 2006 cohort of the Wabash National Study of Liberal Arts Education. Seventeen colleges and universities (11 liberal arts colleges, three research universities, and three regional universities) were included in the four-year longitudinal sample on the basis of their strong commitment to liberal arts education…. A total of 1,865 students participated in all three waves [of surveys], yielding an overall retest response rate of 44.5%.... I	Positive diversity interactions and openness to diversity in the freshman year are significant predictors of positive diversity interactions in the senior year in Block 1, whereas diversity coursework and negative diversity interactions are not significant. (p. 12)

		conducted hierarchical linear modeling (HLM) analyses to predict diversity experiences in the senior year of college. (Bowman, 2012, pp. 6-10)	
Nadal, K. L., Wong, Y., Griffin, K. E., Davidoff, K., & Sriken, J. (2014). The adverse impact of racial microaggressions on college students' self-esteem. *Journal of College Student Development, 55*(5), 461-474.	The study "examined the relationship between racial microaggressions and self-esteem" (p. 461)	Quantitative study Participants: "There were 161 females (71.6%) and 64 males (28.4%)" (p. 465) Data collected: responses from questionnaires and surveys Data analysis: ANOVA	Results indicate that racial microaggressions negatively predict a lower self-esteem, and that microaggressions that occur in educational and workplace environments are particularly harmful to self-esteem. Finally, findings reveal that individuals of various racial and ethnic minority groups experience racial microaggressions differently. (p. 461)
Bowman, N. A. (2013). How much diversity is enough? the curvilinear relationship between college diversity interactions and first-year student outcomes. *Research in Higher Education, 54*(8), 874-894.	"This study examined whether interpersonal interactions with diversity exhibit a positive, curvilinear relationship with several different first-year student outcomes (leadership skills, psychological well-being, intellectual engagement, and intercultural effectiveness)" (p. 878).	Quantitative study "The 2006–2009 Wabash National Study of Liberal Arts Education was used; all three cohorts from this large-scale dataset were included in the current study to ensure sufficient sample size for the conditional analyses" (p. 879) Participants: 8,615 first-year undergraduates at 49 colleges and universities (p. 874) Data analysis: hierarchical linear modeling analyses	The results indicate that rare or moderate diversity interactions are associated with virtually no growth (and sometimes even slight declines) in leadership skills, psychological well-being, and intellectual engagement, whereas very frequent diversity interactions are associated with considerable growth. The results are similar regardless of students' race, institutional characteristics, and whether the interactions are interracial or across multiple forms of difference. (p. 874)

Fifolt, M. (2015). Educating a diverse nation: Lessons from minority-serving institutions. *College and University, 91*(1), 58-62.	Fifolt reviews a book entitled *Educating a Diverse Nation: Lessons from Minority-serving Institutions* by Conrad and Gasman (2015).	n/a	Conrad and Gasman suggest that the problem with higher education in the United States is no longer one of access; rather, it is providing students with access to institutions that understand and value their experiences and recognize their unique challenges. (p. 62)
Sack, J., Quander, J., Redl, T., & Leveille, N. (2016). The community of practice among mathematics and mathematics education faculty members at an urban minority serving institution in the U.S. *Innovative Higher Education, 41*(2), 167-182.	Using narrative inquiry as a research method, four mathematics and mathematics education faculty members explored the integration of theoretical perspectives into their personal narratives as they developed a community of practice. (Sack, Quander, Redl, & Leveille, 2016, p. 167)	Qualitative study For this particular study the researchers themselves were the participants, and they brought their own individual perspectives to the group. Over time, they crosschecked the report collaboratively to triangulate and validate the data as they interacted and learned together. With respect to the use of words as data to support data interpretation, it is the nuances of the collaborative human experience that are of interest. (Sack, Quander, Redl, & Leveille, 2016, pp. 168-169)	The members of this community of practice have gained the respect of mathematicians in the mathematics department and of the University's administration through the curricular advances they have implemented and through their ability to bring in federal funds to a much greater extent than this institution has historically been awarded. (Sack, Quander, Redl, & Leveille, 2016, pp. 168-180)
Levin, J. S., Viggiano, T., López Damián, A. I., Morales Vazquez, E., & Wolf, J. (2017). Polymorphic students. *Community College Review, 45*(2), 119-143. Retrieved from	In an effort to break away from the stale classifications of community college students that stem from the hegemonic perspective of previous literature,	Qualitative study By utilizing Gee's identity theory and Grillo's theory of intersectionality, we analyze interviews with community	First, community college student identities are intricate and have changed with time; there are two different institutional views held by organizational members-the educational view and the managerial

http://eds.b.ebscohost.com/ehost/detail/detail?vid=6&sid=e31bc827-2d09-4a5d-becd-35f1cc69096f%40pdc-v-sessmgr04&bdata=JnNpdGU9ZWhvc3QtbGl2ZQ%3d%3d#AN=121710672&db=a9h	this work utilizes the perceptions of community college practitioners to demonstrate new ways of understanding the identities of community college students. (para. 1)	college practitioners from three different community colleges on the West coast of the United States to answer these questions: What identities (i.e., natural, institutional, and discursive) do faculty and administrators recognize in community college students? In what ways do community college faculty and administrators describe and conceptualize community college students? (para. 2)	view-which both shape the construction of student identities and play a prominent role in determining which students are disadvantaged. Second, organizational members constructed meanings of student achievement and value (i.e., attributes or outcomes of the ideal student, or what policy makers and institutions refer to as success) according to organizational priorities and perspectives. (para. 3)
Morales, E. E., Ambrose-roman, S., & Perez-Maldonado, R. (2016). Transmitting success: Comprehensive peer mentoring for at-risk students in developmental math. *Innovative Higher Education, 41*(2), 121-135	“This study presents and assesses a developmental math focused peer mentoring program at a public urban university” (p. 121).	Qualitative study “Over three semesters 45 mentees participated in the program” (p. 121) We conducted individual interviews and focus groups at the end of the semester in order to assess the degree to which, if any, the program had impacted participants’ sense of self-efficacy and degree of social integration and engagement within the University community. These interviews and focus groups were open ended and semi-structured. They were	Results include substantive increases in developmental pass rates as well as increases in self-efficacy and social integration. Other noteworthy findings include the significance of the peer mentors’ ability to translate and transmit academically effective behaviors to the mentees as well as ongoing program assessment and modification on the part of the program coordinators. (Morales, Ambroseroman, & Perez-Maldonado, 2016, p. 121)

		audiotaped, transcribed, reviewed, and analyzed. (Morales, Ambroseroman, & Perez-Maldonado, 2016, p. 121)	
D'Souza, M. J., Kroen, W. K., Stephens, C. B., & Kashmar, R. J. (2015). Strategies and initiatives that revitalize Wesley college STEM programs. *Journal of College Teaching & Learning (Online), 12*(3), 195-915.	In order to sustain the level of academic excellence and to continue to build student demographic diversity in its accessible robust Science and Mathematics (STEM) programs, the faculty sought federal and state funds to implement a coordinated program of curriculum enhancements and student support programs that will increase the number of students choosing STEM majors, increase their academic success, and improve retention. (p. 195)	Qualitative study A five-member Credo team came to campus for 3 days to conduct focus groups and interview more than 150 faculty, staff and students. Credo conducted an in-depth analysis of academic support services, student affairs, residence life, financial aid, student accounts, athletics, and other campus offices. (p. 196)	The observations of very low incoming freshman SAT scores coupled with resultant analyses of correlations observed between the final course grades in the first-year math, chemistry and biology courses, indicate that logical critical and creative thinking skills could be developed in wisely placed consequential STEM courses. This systematically-paced format should effectively prepare the students to catch up in the STEM track after inadequate high school preparation. (p. 203)
Jackson, D. L. (2013). A balancing act: Impacting and initiating the success of African American female community college transfer students in STEM into the HBCU environment. *The Journal of Negro Education, 82*(3), 255-271,356.	The study "seeks to understand the influences that facilitate success in their respective STEM [science, technology, engineering, mathematics] disciplines" (p. 256)	Qualitative study Data was collected by way of interviews and Photovoice, which allowed the students to capture their reactions and feelings of their college experiences. "Qualitative data analysis procedures were used to analyze the photos, photo descriptions,	"Findings indicate that their experiences at both the community college and HBCU assisted in their success as a STEM student" (p. 262)

		narratives and the interview transcripts" (p. 259). Participants: "seven African American community college female transfer students…enrolled at an HBCU in a STEM bachelor's degree program" (p. 256)	
Reyes, M. (2011). Unique challenges for women of color in STEM transferring from community colleges to universities. *Harvard Educational Review, 81*(2), 241-262,390.	The goal of this study was to identify the factors that assist women of color, particularly transfer students, in pursuing postsecondary degrees in STEM fields and to better understand the supportive services necessary to maximize their educational experience. (pp. 247-248)	Qualitative study Participants: "four women of color interviewees in undergraduate STEM disciplines that participated in Futurebound" (p. 248) Data collection: interviews Data analysis: thematic coding of interview transcripts	First, we need programs that target recruitment of women of color at the community college level with funding for first-year transition programs after transfer…. Second, students will benefit from programs and funding that target undergraduate research experiences for transitioning women of color…. Third, pedagogy workshops for STEM faculty should be implemented…. Finally, workshops for STEM faculty and staff to raise awareness about family and cultural responsibilities for transferring women of color would greatly inform efforts to develop academic success strategies for these students. (pp. 257-258)
Nuñez, A. (2011). Counterspaces and connections in college transitions: First-generation Latino students' perspectives on Chicano studies. *Journal of College Student Development, 52*(6), 639-655.	"This study explored how first-generation Latino sophomores in a public research university describe the influence of Chicano Studies classes on their college transition experiences" (p. 639).	Qualitative study "Thirty-seven first-generation Latino second-year students, including 26 women and 11 men, responded to this survey" (p. 644)	Students reported that taking Chicano Studies offered them opportunities to handle feelings of isolation, build awareness of community heritage, develop more meaningful student–faculty relationships, and understand perspectives of

		Data collection: questionnaires Data analysis: constant comparative method	people from different backgrounds. These processes enhanced their capacity to manage key developmental issues during their college transitions, including handling racism and forming a sense of community on campus. (p. 639)
Garcia, G. A., & Okhidoi, O. (2015). Culturally relevant practices that "serve" students at a Hispanic serving institution. *Innovative Higher Education, 40*(4), 345-357.	This study "examined culturally relevant practices at one HSI, including the ethnic studies curriculum and student support programs" (p. 345).	Qualitative study "The main source of data came from interviews and focus groups…. We also used two additional sources of data – documents and non-participant observations" (Garcia & Okhidoi, 2015, p. 348) Participants: 88 total (administrators, faculty members, student affairs staff, and students) (Garcia & Okhidoi, 2015, p. 348) Data analysis: open coding of interview transcripts	The data revealed two important themes about serving diverse students at a HSI: (1) the historical presence of culturally relevant curricula and programs and (2) the embedding of culturally relevant curricula and programs within the structures of the institution. (Garcia & Okhidoi, 2015, p. 349)
Schiller, M. (2003). Bridging the gap in rural special education: Paraeducators to teachers. *Rural Special Education Quarterly, 22*(1), 10-16.	The teacher education project described here is a collaborative effort among Central Arizona College, Pinal County school districts, and Prescott College, a private college that offers special education teacher certification	Qualitative study Narrative Participants: 65 paraeducators	It is difficult to ignore the challenges associated with the countrywide special education teacher shortage. Although some alternative certification programs have been developed at the university level, many require students to enter with a bachelor's degree and are less than user-friendly

	courses at the undergraduate level. The program was designed to be respectful of the "on the job learning" that many of the paraeducators had already undergone and their community college coursework in special education. The primary focus was to provide a quality, content-filled program in a user-friendly package (p. 11)		for rural communities. In a rural area, it is important to take advantage of the resources that are currently available. For this reason, community colleges can be the most reasonable place to begin for some prospective teachers; particularly those with little or no college coursework and those who might require some developmental courses. (p. 16)
Kater, S. T. (2017). Community college faculty conceptualizations of shared governance: Shared understandings of a sociopolitical reality. *Community College Review, 45*(3), 234-257.	"This study seeks to deepen understanding of faculty leaders' perceptions of the concept of shared governance" (p. 234).	Qualitative study "Qualitative analysis of interviews with 27 faculty from nine community colleges in five states was deconstructed to uncover common themes and understandings" (p. 234). Data analysis: transcription of interviews, in vivo coding	Themes of the importance of the faculty voice, trust and transparency, apathy and disengagement emerged. The findings support recent research which suggests that social and cultural aspects of soft governance are key variables in how faculty conceptualize shared governance (p. 234)
Palmer, R. T., Davis, R. J., & Maramba, D. C. (2010). Role of an HBCU in supporting academic success for underprepared black males. *Negro Educational Review*, *61*(1-4), 85-106,123-124.	The authors' purpose of the study was to "explore the contributions of HBCU's to the academic success of Black males. Specifically, the central question that guided this study was: What factors do academically	Qualitative study Using in-depth interview methods, we sought to explore the academic and social experiences of a specific group of students situated in a specific context…. the participants for this study were 11 Black	Although several themes emerged from this study, special attention was placed on the impact of an HBCU helping to facilitate Black male academic achievement. More specifically, participants in this study credited the university's racial composition, support from peers, faculty, and role

	underprepared Black males, who entered an HBCU through its remedial or developmental program and persisted to graduation, attribute to their success?" (pp. 87-88)	men who entered a public HBCU through participation in a university summer program and persisted to graduation. (p. 88) Data collection: in-depth interviews Data analysis: constant comparison, line by line coding of interview transcripts (p. 90)	models in helping to increase their propensity for learning and academic success. (p. 85)
Caroline Sotello, V. T. (2007). Pathways to the presidency: Biographical sketches of women of color firsts. *Harvard Educational Review, 77*(1), 1-38,127.	"This study contributes to the scant literature on the general topic of women of color in higher education administration because the women featured here are 'firsts'" (p. 2)	Qualitative study Participants: three female college/university presidents of color Data collection: in-depth interviews Data analysis: cross-case comparisons	Their [participants'] narratives provide insights on the importance of early educational and career success; the important role of interpersonal connections; their style of leadership, which built community out of difference; their responses to initial challenges in their role as president; their courage as they anticipate the future and do the unprecedented; what it means to be a first; and the role a positive individual and institutional match plays in their work lives. (p. 15)
Jett, C. C. (2010). Many are called, but few are chosen: The role of spirituality and religion in the educational outcomes of "chosen" African American male mathematics majors. *The Journal of Negro Education, 79*(3), 324-334,439.	Jett (2010) explored "the influences of spirituality and religion on the educational outcomes of four academically successful African American male graduate students in mathematics and	Qualitative study Multiple case study Participants: four African American males Data collection: structured interviews	Although the four African American men in the study are spiritually grounded, they do not share the same religious affiliations or denominations. They all, however, cited an internal connection or a personal relationship with a higher power (i.e., God), which guided to their academic

	mathematics education" (p. 324)		plans as mathematics majors and their plans with life in general. The participants acknowledged an internal spirit man as key to their lived experiences. Conclusively, my participants' spiritual connection was one of the driving forces behind their academic success with mathematics as a major in college and with their success as African American men in general. (Jett, 2010, p. 330).
Jensen, D. H., & Jetten, J. (2016). The importance of developing students' academic and professional identities in higher education. *Journal of College Student Development, 57*(8), 1027-1042.	"For this study we focused on students' experiences of their academic and professional identity formation. In particular, we were interested in how students experience their professional identity-building process" (p. 1038).	Qualitative study Participants: 26 Danish and 11 Australian university students (p. 1027) Data collection: in-depth interviews Data analysis: interpretive phenomenological analysis	This study revealed that being a university student is experienced as a complex change process characterized by gaining knowledge and self-development. The self-development process involves a parallel process of forming both an academic identity (i.e., feelings of belonging to the academic environment) and a professional identity (i.e., how I see myself in the future) that starts upon entering university. (p. 1037)

Appendix B
SPC Spring 2017 Math Course Completion Rates

SPC Spring 2017 Math Course Completion Rates
by Number of Hours in MathWorld

Hours	Enrollment	Completion	Completion Rate	Successful Completion	Successful Completion Rate
0 Hours	1238	1071	86.5%	881	71.2%
<1 Hour	293	246	84.0%	187	63.8%
1-9 Hours	451	403	89.4%	335	74.3%
10-24 Hours	245	217	88.6%	184	75.1%
25-49 Hours	136	125	91.9%	111	81.6%
50-99 Hours	96	90	93.8%	85	88.5%
100+ Hours	95	91	95.8%	83	87.4%
Errors	7	4	57.1%	3	42.9%
Grand Total	2561	2247	87.7%	1869	73.0%

Completion is any grade other than W; Successful Completion is a grade of A B or C.
Blank grades and Audits are excluded from the report.
Math0055 courses are excluded from the report.

MathWorldF17succ.egp .xlsx
Rj SPC IPRE 5/4/18

Appendix C
SPC Fall 2017 Math Course Completion Rates

SPC Fall 2017 Math Course Completion Rates
by Number of Hours in MathWorld

Hours	Enrollment	Completion	Completion Rate	Successful Completion	Successful Completion Rate
0 Hours	1166	1031	88.4%	868	74.4%
<1 Hour	320	276	86.3%	208	65.0%
1-9 Hours	485	423	87.2%	314	64.7%
10-24 Hours	382	342	89.5%	281	73.6%
25-49 Hours	199	181	91.0%	155	77.9%
50-99 Hours	88	82	93.2%	63	71.6%
100+ Hours	37	37	100.0%	36	97.3%
Grand Total	2677	2372	88.6%	1925	71.9%

Completion is any grade other than W; Successful Completion is a grade of A B or C.
Blank grades and Audits are excluded from the report.
Math0055 courses are excluded from the report.

MathWorldF17succ.egp .xlsx
Rj SPC IPRE 5/4/18

Appendix D
Subject Consent Form

SUBJECT CONSENT TO TAKE PART IN A STUDY OF IDENTIFYING CORE PRACTICES FOR SUCCESSFUL SUPPLEMENTAL INSTRUCTION OF COMMUNITY COLLEGE MATH STUDENTS

University of the Incarnate Word

Invitation to participate in a research study: Shannon A. Patterson, a graduate student at University of the Incarnate Word, invites you to take part of a research project that she will conduct in order to complete requirements for a doctorate degree in education with a concentration in mathematics education. She is supervised by Alfredo Ortiz, Ph.D. The project explores the impact of participation in MathWorld on student success in developmental math courses. The purpose of the study is to identify core practices that MathWorld uses to ensure a lasting, positive effect on student performance in math. We are asking you to participate because you are a faculty member of the mathematics department and/or serve as an academic program specialist in MathWorld.

Description of your involvement: If you agree to be part of the research study, it will involve the researcher inquiring into your experiences on these themes. You will be asked to participate in at least one short interview, initial interview, follow-up interview and/or focus group. Although we ask everyone in the group to respect everyone's privacy and confidentiality, and not to identify anyone in the group or repeat what is said during the group discussion, please remember that other participants in the group may accidentally repeat what was said.

These interviews will be conducted in different areas of St. Philip's College and/or other convenient locations nearby. You may decline to answer any of the interview questions if you so wish. Further, you may decide to withdraw from this study at any time without any negative consequences by advising the researcher. With your permission, the interview will be tape-recorded to facilitate collection of information and later transcribed for analysis. Shortly after the interview has been complete, the researcher will send you a copy of the transcript to give you an opportunity to confirm the accuracy of our conversation and to add or clarify any points that you wish.

Confidentiality: Should you desire, the information you provide can be treated confidentially. However, if you so desire, your name, quotations, etc. may be attributed to you in the research project. The researcher will revisit this agreement with you to determine whether you wish to remain confidential before your statements are published in the dissertation. Data collected during this study will be retained for five years in a combination-locked safe. Only researchers associated with this project will have access.

Risks and benefits: The researcher does not anticipate any risks to you participating in this study other than those encountered in day-to-day life.

Compensation: No compensation will be provided for participating in this study.

Contact Information: If you have any questions regarding this study, or would like additional information to assist you in reaching a decision about participation, please contact me at (210) 317-4716 or at shpatter@student.uiwtx.edu. You can also contact my supervisor, Dr. Alfredo Ortiz at (210) 829-3171 or alortiz1@uiwtx.edu.

The Institutional Review Board at University of the Incarnate Word will answer any questions about your rights as a research subject. Please feel free to contact the Office of Research and Graduate Studies at (210) 829-2759.

Statement of Consent: I have read the above information, and have received answers to any questions I asked. I consent to take part in the study.

Your Signature ___________________________________ Date _______________
Your Name (printed) ____
In addition to agreeing to participate, I also consent to having the interview tape-recorded.
Your Signature ___________________________________ Date _______________
Signature of person obtaining consent ____________________ Date ___________
Printed name of person obtaining consent _________________ Date ___________
This consent form will be kept by the researcher for at least five years beyond the end of the study.

Appendix E
IRB Approval: University of the Incarnate Word

UNIVERSITY OF THE INCARNATE WORD

December 13 2017

PI: Ms Shannon Patterson

Protocol title: Map of MathWorld: Identifying Core Practices for Successful Supplemental Instruction of Community College Math Students

Shannon:

Your request to conduct the study titled "Map of MathWorld: Identifying Core Practices for Successful Supplemental Instruction of Community College Math Students" was approved by Exempt review on 12/13/2017. Your IRB approval number is 17-12-002. Any written communication with potential subjects or subjects must be approved and include the IRB approval number.

Please keep in mind these additional IRB requirements:

- This approval will expire **one year** from 12/13/2017.
- Request for continuing review must be completed for projects extending past one year. Use the **IRB Continuing Review Request form**.
- Changes in protocol procedures must be approved by the IRB prior to implementation except when necessary to eliminate apparent immediate hazards to the subjects. Use the **IRB Amendment Request form**.
- Any unanticipated problems involving risks to subjects or others must be reported immediately.

Approved protocols are filed by their number. Please refer to this number when communicating about this protocol.

Approval may be suspended or terminated if there is evidence of a) noncompliance with federal regulations or university policy or b) any aberration from the current, approved protocol.

Congratulations and best wishes for successful completion of your research. If you need any assistance, please contact the UIW IRB representative for your college/school or the Office of Research Development.

Sincerely,

Ana Wandless-Hagendorf, PhD, CPRA

Ana Wandless Hagendorf, PhD, CPRA
Research Officer, Office of Research Development
University of the Incarnate Word
(210) 805-3036
wandless@uiwtx.edu

Appendix F
IRB Approval: St. Philip's College

ALAMO COLLEGES DISTRICT
St. Philip's College

Date: 22 November 2017

PI(s): Shannon Patterson

Dept.: Mathematics

Title: Map of MathWorld: Identifying Core Practices for Successful Supplemental Instruction of Community College Math Students

Re: IRB Approval

Dear Ms. Patterson:

In accordance with the College's review or research studies, your submission to perform research on the above titled project has been reviewed and approved. The only stipulation determined during this review is any additional or follow-up questions incorporated into the research will need to be submitted for IRB record.

Please contact George Johnson or Shanna Bradford with any questions.

Sincerely,

George Johnson
Institutional Review Board Chair
St. Philip's College