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INCREASING STEM PARTICIPATION AND STUDENT SUCCESS OF
DEVELOPMENTAL MATHEMATICS STUDENTS AT AN URBAN COMMUNITY
COLLEGE

A Dissertation Presented

by

VANESSA A. HILL

Submitted to the Graduate School of the
University of Massachusetts Amherst in partial fulfillment
of the requirements for the degree of

DOCTOR OF PHILOSOPHY

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College of Education

INCREASING STEM PARTICIPATION AND STUDENT SUCCESS OF
DEVELOPMENTAL MATHEMATICS STUDENTS AT AN URBAN COMMUNITY
COLLEGE

A Dissertation Presented

By

VANESSA A. HILL

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DEDICATION

This dissertation is dedicated to my amazing husband and children. Troy, Dante, and DeVaughn, you are truly my biggest supporters and protectors! I love you to no end, you continue to believe in me when I can't believe in myself.

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I must admit that writing this dissertation has been quite a roller coaster ride. I have so many people to thank, I need to start by thanking Lauren & Donna! There has never been anything that I have asked you to help me with that you didn't say yes. I couldn't have done this without your help, I love you more than you know. Not only you two, but all in the math department who have pitched in to help, agreeing to take part in my study, or just being overall supportive. And I cannot forget the ladies in the testing center for being a constant support.

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ABSTRACT

INCREASING STEM PARTICIPATION AND STUDENT SUCCESS OF
DEVELOPMENTAL MATHEMATICS STUDENTS AT AN URBAN COMMUNITY
COLLEGE

MAY 2018

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This mixed method, quantitative and qualitative, study explores the effects of a curriculum with an emphasis on scientific, technological, and engineering focused problems and careers on student success and interest in Science, Technology, Engineering, and Mathematics (STEM). The setting is an urban community college where in the spring of 2016, 71% of the students tested into developmental mathematics (STCC, 2017).

The course of study was Algebra one, a developmental, non-college credit bearing, mathematics course. Students had the option of two paths for the subsequent course, a terminal college level mathematics class, or a STEM pathway developmental algebra two course. Pass rates, pre/posttests, pre/post interest surveys, and subsequent math course were recorded and analyzed. Furthermore, implications and limitations of the study were examined with recommendations for future research presented. The findings were that there was an increase in both path rates, and STEM interest.

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CHAPTER 1

WITH ALL THINGS NOT BEING EQUAL

Education, then, beyond all other devices of human origin, is the great equalizer of the conditions of men -- the balance-wheel of the social machinery.

Horace Mann

If they get these math tools, then they will be in positions to demand access to the economic arrangements. These are the tools that are needed by people who are going to come to the table and act on their rights.

Bob Moses

It is indeed an essential task to educate our citizens, *all* of our citizens. This task, which sounds relatively simple and straightforward, is wrought with dysfunction. One disturbing aspect of this mission is that the type and quality of education a student receives is directly tied to their economic status and racial identity (Peske & Haycock, 2006). Unfortunately, our success rate with students of color and low-income students can be described as dismal at best.

Because the community college has an open admission process, the only requirements a student needs is a high school diploma or GED. Hence students enter with a wide array of abilities and preparedness. For those who test into developmental courses, it may take four or more semesters to reach college level classes, depending on the structure of the school (Bailey, Jeong & Cho, 2010). These developmental courses carry no college credit and are designed to prepare students for college level work. Incoming students take placement exams in both language arts (reading and writing) as well as mathematics before being allowed to register for courses.

It is important to emphasize the fact that the mission of the community college is to grant access to those who would otherwise not be afforded admission to higher education (Bragg, 2001). One of the strengths of the community college is having faculty

for whom their major role is to focus on the student body. And some faculty members have even balked at the idea of adding onto their already overloaded schedule, by closely mimicking the role of the university professor (Kelly-Kleese, 2004). Nonetheless, the argument can be made that who better to contribute to the body of knowledge than those on the front lines.

The community college is fertile ground on which to do research to contribute to the body of knowledge within a discipline, as well as to identify and research best practices within the teaching profession. In particular, there is a trend in higher education to minimize remediation at four-year colleges. When convenient, students needing remediation at a four-year institution are often referred to a local community college (Merisotis & Phipps, 2000). This puts an even stronger emphasis on understanding best practices to support student progress.

Unfortunately, a large number of students never make it through the developmental sequence to college level math. Consider a three-level developmental mathematical sequence. A student placed into the lowest level has a 17% chance of passing on to college level mathematics (Bailey, Jeong & Cho, 2010). This in turn prevents them from attaining their goals of attaining a certificate, an associate's degree, transferring to a four-year college, or gaining new skills to make them more marketable at their place of employment. It is worth noting those students who do successfully remediate, have the same success rate as their counterparts who did not remediate (Bettinger & Long, 2005).

Students often enter into the developmental math classes and find the same type of curriculum and delivery that they experienced in their K-12 academic career

(Desimone, Smith, Baker & Ueno, 2005). This is the same curriculum that did not work for them at the outset, a skill based, lecture driven classroom that emphasizes performance of algorithms over the contextualization of the mathematics (McMillan, Park & Lanning, 1997; Grubb, 2001).

According to a study conducted by Cavazos, Johnson and Sparrow (2010) student reactions to being assigned to these classes range from resentment in taking the same classes that they took in high school and middle school, to feelings of inadequacy in their ability to succeed. There is also a disinclination to take classes and learn materials that they do not feel are a part of their educational goals. The students are often bored and unmotivated and do not fulfill the requirements to move on.

I am operating under the assumption that there are effective methods in developing the necessary math skills among our students. There are curricula focuses that can be implemented to give students in developmental mathematics the support they need to be successful. I maintain that we are discounting some brilliant minds. It is my belief that given the right opportunity and situation that some of these developmental students can become the next generation of engineers, mathematicians, scientists, teachers, or whatever they desire to be in life.

If we look at the majority of the students who test into developmental education, often deemed “at risk”, it is apparent that they share certain demographic characteristics. They are frequently from under-represented minority groups, low socio-economic status, and first-generation college students (Engle & Tinto, 2008). In fact, students from these groups are far more likely to place into developmental education than their counterparts. It has been shown that each factor is shown to be a barrier to success, and habitually

students fall into several high-risk categories (Engel, 2007). In light of this population, and conjoined with the fact that at community colleges 10%, or more, of the students spend more than a year in remedial education, this represents a very troubling situation. Of course, this is only accounting for those who do persist, thus mathematics turns into an insurmountable obstacle that can alter or outright destroy the aspirations of the student (NCES, 2004). To further fuel the fire, nearly seventy-five percent of those students who begin in remediation classes never finish college level mathematics (Bahr, 2008).

The burden of remedial education promises to increase as more and more four-year institutions are opting out of remedial education, leaving it to the community colleges (Boulard, 2004). The population of a community college has a much higher percentage of these at-risk students than four-year colleges and universities. This point is illustrated by the fact that 53% of at-risk students attend community colleges compared to a rate of 35% for those not at risk (Engle & Tinto, 2008).

Under these circumstances, these students' failure to maneuver through the system, and attain educational goals, perpetuates inequities. The marginalized people of our society continue to be shut out of higher education; and the fallout of this trend can be felt throughout the country. Community colleges must therefore continue to fill the niche by providing opportunities to those who suffer disparities based on race, class and gender (Bahr, 2008).

Statement of the problem

Without question, our school systems continue to fail those that they are charged with educating. As a result, those most at-risk, those from low income and under-represented groups, continue to be under-served and ultimately blamed for their own

failure. Herbert Kohl has written extensively about a phenomenon where marginalized students refuse to participate in the process as a strategy in retaining the integrity of their identity (Kohl, 1994). It is understandable that a student would make a conscious effort to not accept blatant disregard of their ability.

Often times the system seems more bent on beating students into submission rather than educating and empowering them. Under these circumstances, we must acknowledge that there is quite a difference between failure and what Kohl calls “active not-learning” (Kohl, 1994). In the tradition of John Dewey this is the antithesis of what a school should be. Dewey had a firm belief that school was fluid with a mutuality that both students and teachers had a voice in the educational process, and topics should be relevant to student lives (Simpson & Stack, 2010).

One way to combat the adversarial role that can occur is to acknowledge that students are an integral partner of a positive educational experience and not view the process as something that is prescribed to them. This in no way dismisses that there are very positive educational settings as well as the fact that there are students who excel regardless of the setting (Cuban, 1989). The logical progression is to explore what has been effective and what can further be carried out on the part of educators and the educational system to elicit positive outcomes and build a partnership with the students. These constructs need to be explicitly identified and disseminated widely.

Unfortunately, this is not true in just one setting. There is plenty of criticizing going on where the secondary schools blame the primary grades. The post-secondary blames the secondary schools, the administrators blame the teachers, the teachers blame the parents, and it goes on and on (Zeidenberg, 2008). Regardless of what precipitated

the events, students are graduating and going to college woefully unprepared for the rigors of college level work (Bettinger & Long, 2009). Students are testing into developmental classes, with math being the biggest obstacle where 59% of students in community college need remediation nationally; there is a great need for this work to be addressed (Bailey, Jeong & Cho, 2010). It is even more critical when considering that low-income and minority students are most likely to attend a community college when pursuing post-secondary education (NCES, 2008).

It should be noted that there is not an abundance of literature about directly working with community college students on interventions in developmental mathematics. There are many studies on demographics, attrition, and student success. For instance, Bahr (2008) conducted a comparative analysis study to ascertain the level of success and failure of remedial mathematics at the community college level. What he found was that students who successfully remediate are nearly indistinguishable, in terms of math attainment in their college level math courses. Bahr also found that students are not likely to successfully remediate mathematics, and more work needs to be done to fully understand why some students successfully remediate while others do not. The National Center for Education Statistics, NCES, focuses a great deal of resources studying the demographic make-up as well as the student attrition rate of developmental mathematics students, statistics can be found in national databases to illustrate the grim reality of developmental students.

Yet, there is very little practical work being studied at the community college level. The goal of the community college is to be a teaching institution, which is one of its great strengths. But, without an ample body of research of best practices for this very

unique population, it is nearly impossible to determine effectiveness and reproducibility of any particular intervention based on the current literature. This in no way is an implication that this area is not relevant, as the idea of immediacy, or care, is very relevant to the experience of the community college student.

Another very important consideration in dealing with this under-represented and under-served population is the idea that access to pathways can change their socioeconomic status. Yet, most of these students have no direct exposure to the more well paid careers, many of which are within STEM fields (Melguizo & Wolniak, 2012). Most people who go into STEM fields have immediate role models, most especially family members, participating in those fields (Lent, Brown & Hackett, 2002). It has been shown that female students who have personal knowledge of women who are STEM experts have more of an affinity to choose those career pathways (Stout, Dasgupta, Hunsinger & McManus, 2011).

As a result of the lack of exposure to these lucrative careers for under-represented students, as well as, their desire to help their community and give back, they tend to pick non-STEM majors that they feel are more relevant to their communities (Bonous-Hammarth, 2000). These students, to a large extent, are not aware that the impact that they can have on their family and communities may be far more powerful and far-reaching by pursuing a STEM career (Melguizo & Wolniak, 2012). A career focused curriculum can be used as a bridge to introduced students to new possibilities, and has been shown to have a positive correlation in both classroom behavior and engagement (Bottge, 2001).

It has been well documented that the United States is falling behind in our technological advances in part because we do not have the STEM workforce necessary to continue to be a world leader (Kuenzi, 2008). This has not been lost on the highest level of our government, where President Obama announced initiatives that resulted in over a billion dollars in both financial and other support for STEM education, with a special emphasis on females and those from under-represented groups (Whitehouse, 2015).

With a burgeoning minority population of 13% African American and 17% Latino (the percentage of which both segments are increasing, with Latinos increasing at a higher rate) (U.S. Census Bureau, 2014), there exists this untapped pool of potential technologists that has not been recognized as a viable resource to resolve this shortage. Unfortunately, in the bigger picture, the percentages of minorities have remained unchanged in all levels of STEM education (Malone & Barabino, 2009). This is reflected in the fact that blacks hold 6% and Hispanics 7% of STEM jobs (Landivar, 2013). By acknowledging and pursuing this population we are actually addressing two issues within the STEM fields in this country.

Given the lack of a robust workforce in the STEM industries, coupled with the lack of diversity in STEM, a logical connection would be to incorporate this diverse population to help solve problems in innovative ways. There has been a big push to be inter-disciplinary to solve open problems. For example, if only biologists are working on a problem, they think like biologists, having similar trainings, and may not be able to come up with innovative approaches. But if scientists of other disciplines are brought together with their own unique perspectives, novel views are brought together thus creating a more powerful and innovative environment (Espinosa, 2011). The same is true

when thinking about the work of engineers. If all involved, working on a specific problem, are from very similar backgrounds and ethnicities, they tend to have the same approach. But, if you introduce diversity to the project, new ideas and perspectives challenge the status quo and unique designs and concepts can be developed (Scutt, Gilmartin, Sheppard & Brunhaver 2013; Bonous-Hammarth, 2000).

The state of mathematics remediation at the community college is both critical and dire. Currently, there is also a lack of research in this area as to viable ways to alleviate this problem. However, an approach within the tradition of Dewey can bring students and teachers together in a student focused environment. This focus is centered on students' needs and interest as the issues of mathematical remediation are addressed. Furthermore, the larger issues of the lack of STEM workforce can be addressed as students begin to situate themselves into these viable careers.

CHAPTER 2

CONCEPTUAL FRAMEWORKS

Core Theories

As these very complex and important issues are addressed empirically, the theories that will guide the study are threefold. In particular, theories related to equity in mathematics classrooms, how cultural practices and institutional norms reproduce inequities, and social identity theory will provide a wider context for understanding the work undertaken in this study.

Equity in Mathematics Classrooms

Equity. As discussed in the problem statement, a significant number of developmental students often share certain demographic markers. Engle & Tinto (2008) note that they are often from under-represented groups, low income, and first generation. Community Colleges play a major role in dealing with access to education as there would be far less students from these groups who had the opportunity to participate in higher education (Bragg, 2012). Robert Moses feels so strongly about equity in mathematical education, specifically math literacy, he has referred to it as the new civil rights issue (Moses & Cobb, 2001). The question then becomes, what does equity look like in the context of mathematical education? To attain equity in a classroom it takes a host of parties to come together to make it a priority. Students, teachers, family and community, administrators, all the way up to the policy makers have a responsibility to ensure we have equitable classroom experiences for *all* students. Regrettably, the disparities in mathematical achievement among minority and low-income students versus the rest of

the population is far reaching and unwavering (National Mathematics Advisory Panel, 2008).

One study conducted by Bartell et. al., explicitly designed to address equity, asked teachers to focus on individual students who are underperforming in their classes and ask specific questions related to that student in order to make a more personal connection with them. These exercises lead to the formation of a connection that the teachers had not previously experienced with the students. This led to a greater investment from the teacher by having a new sense of empathy for the student, and ultimately lead to higher student engagement and achievement from the students (Bartell, Meyer, Knott & Evitts, 2008). The students now had a pathway to getting what they needed, and were more inclined to use this new found standing. In essence the students are exposed to a new way of “doing” school. Just as the teachers see students in a new light, appreciating their uniqueness and abilities, students are more engaged and have higher achievement (Flores, 2007).

This new understanding of students’ culture and uniqueness that was addressed in context directly led to a more equitable environment in the classroom. It was no longer the norm that the content of the material is the main focus and that was all that was necessary to provide a quality education, to the more whole student focus that allowed for educating the whole child, and meeting them where they were instead of a preconceived notion of where and what they should be. By helping the student understand that not only the material is important, and why that is so, but that their personal agency is imperative, as education shouldn’t be something that is done to them, moves equity forward in the classroom (Gutstein, 2003).

Ostensibly, equity in mathematic classrooms shows as a culturally relevant pedagogy and context, that both empowers and challenges students in a way that they build self-efficacy and mathematical knowledge in a transformative way. In this sense mathematics becomes a sense-making tool, both for the world around them, as well as a foundation for a path towards academic and career goals. Supplementary, there is also an advantage to majority students when they study with those from under-represented groups, and are exposed to a more culturally inclusive curriculum. As they enter into their careers, they are better prepared to understand and address the issues that arise when dealing with a diverse population (Bonous-Hammarth, 2000). Ultimately, the challenge is to refrain from looking at persons from the under-represented groups as having limited potential.

Deficit Perspective. There is by no means a consensus when it comes to why some students are under-performing, nor what is possible for schools to provide in order to eliminate the disparity. Some teachers and researchers believe that the achievement gap is inherent when speaking of students from disadvantaged backgrounds (Harper, 2009, Anderson, 2007). Bensimon attributes this to what she refers to as the deficit perspective. This perspective extols that differences in achievement of under-represented versus majority students is to be expected, and is attributed to lack of preparation, initiative, and other cultural stereotypes (Bensimon, 2005). Furthermore, the mere presence of these students is enough of an indicator to bring down the potential achievement of the school setting (Greene & Forster, 2004). That is to say, supporters of this deficit perspective believe that the achievement gap should not be framed entirely as

an equity issue, but more a commentary on an unavoidable truth (Harper, 2009, Rothstein, 2011).

Indeed, most people do not see themselves as perpetuating a system of inequities. Because of this, much work needs to be done to have people who are advantaged to critically look at their identities, how those identities lead to their privilege, and how that privilege affects people from disadvantaged backgrounds. For it is not usually a conscious effort to not look critically at inequities, but more of a distorted view of what that entails (King, 1991). It is imperative that work be accomplished in order for local movements to gain traction. For without the larger system being open and accepting of a diverse population, as they successfully move on, the efforts of those supporting and empowering underrepresented students will have been in vain. For this study, I will focus on the things we do have control over in empowering our students and promoting parity.

I would like to avoid approaching inequities in mathematic success from strictly the deficit perspective, and instead of focusing strictly on at-risk students, move the focus to at-risk courses (Phelps & Evans, 2006). At risk courses are those classes in which students have a high rate of failure. Using this premise, the student is no longer being singled out as the problem, or as somehow inferior, but the accountability is put on the course. With this perspective in mind, much can be accomplished by examining curriculum and pedagogy, addressing deficiencies, and exposing students to novel ideas, and incorporating foundational supports to facilitate student growth. This is done through challenging the notion that entering students are damaged goods, and their failure

rest solely at their feet, and reframing that idea into what is inherently wrong with these courses that there is such a higher failure rate (Martin & Arendale, 1992).

There has been work done identifying specific course factors that can support student academic growth. One such factor has been the clear and explicit setting of goals for the course (Boylan & Saxon, 1999). By being very clear about what is happening in the class, the goals and necessary outcomes, and putting things in context, the students had higher performance (McCabe & Day, 1998). Furthermore, as referred to in the problem statement, students from under-represented groups continue to be under-served as they are not being honored as capable, agents of change, whose cultures should not only be acknowledged, but celebrated (Gutstein, 2003). In order for real change to come about, it is vital for faculty to have high expectations, and to encourage students to work cooperatively. It is also essential for faculty to be respectful of the students (Tinto, 1993). By honoring the uniqueness of cultures, and empowering students, there can be real change in power dynamics and combatting institutional racism.

Cultural practices and Institutions Reproduce Inequity

Reproduction. In a theory first proposed by Pierre Bourdieu, the theory of Reproduction, which is born out of habitus, speaks of the central role that schools have in maintaining, or reproducing socio-cultural inequities from one generation to the next (Bourdieu, 1973). Habitus, which can be defined as manifested cultural habits that inform the way ones' thoughts, actions and feelings are expressed (Bourdieu, 2005). Harker (1984) addresses the fact that this reproduction rewards those characteristics from the dominant culture and excludes those who do not hold the cultural capital to navigate the system. In essence those who are from the ruling class, who have a sense of entitlement,

are rewarded for understanding how to maneuver through the educational system, and reap the benefits of that system. Meanwhile, those who are not privy to that knowledge have the inequities manifested in a way that they cannot benefit.

This reproduction, adapted from Harker’s (1984) work (see Figure 1), contends that for true transformation to occur these students must be empowered to challenge the system and move ahead and into a position to alter the status quo. Ultimately, it is a question of equity; the only way for true transformation to occur is moving students from the lower cycle to the top. The only way for true transformation to occur is if our under-represented students are enabled in a way that they understand that there is another level of schooling, to develop the cultural capital of the dominant group, and ultimately challenge that access.

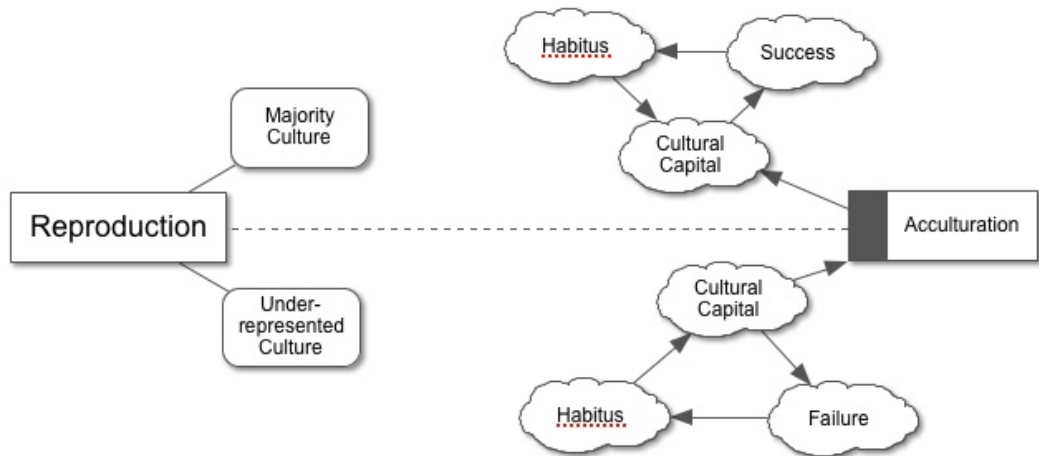


Figure 1: Harker theory of Reproduction

Reproduction can be reflected in comments that may not be seen as inflammatory from the perspective of the teacher/professor. Comments such as “Yes, there is engineering ... but you should pick a major you are more likely and able to graduate in.” or “Really? Wow! I didn’t think you would be able to answer a question like that!” both of which were aimed at African American students (McGee & Martin, 2011).

In order for change/growth/learning to occur the classroom culture must be a place where the social capital of all is respected and incorporated into the learning process (Gutierrez, 2002). Students do not enter into the classroom as blank slates. They come in with ideas and intelligences that can and should be incorporated and honored to further the learning process. The social capital is part of that community, and incorporates such ideas such as partnership, mutual respect and trustworthiness (Anderson, 2008). The antithesis of this is the generational replication of socio-cultural inequities (Harker, 1984).

Opening access, and making the educational process transparent and cooperative, not only values the student but helps them to understand the dominant culture, and, more importantly, can empower them to challenge deficit constructions thus allowing real, lasting change and growth (Aschaffenburg & Maas, 1997). This catalyst may be just the necessary step for future success of the student.

Cultural Capital. An integral part in the reproductive cycle, and challenging reproduction in the classroom is that marginalized students build cultural capital, as their experiences are validated, voices heard, and are exposed to how the educational system functions (Monkman, Ronald & Théràmène, 2005). Cultural capital can be defined as the disposition, goods and properties that work together to reproduce social norms (Bourdieu,

2001). For although the goal of education purports to be an opportunity to level the playing field, and despite tremendous efforts, unequal power relations continue to be reproduced generationally (Skrla, Schuerich, Johnson & Koschoreck, 2001). It can even be argued that the mere idea of challenging the legitimacy of the academic institutions is discordant as the dominant culture and educators fiercely defend the legitimacy of current academic institutions although they continue to fail so many (Pajak & Green, 2003).

Arguably, the very essence of power dynamics in the classroom between teachers and students can either be a reproduction of social inequities, or can be transformative in nature (Davison, 2004). Therefore, an integral part of changing and challenging these patterns is understanding the hidden pathways and language to which students who identify with the dominant culture are already privy (Aschaffenburg & Maas, 1997). That capital ranges from understanding the student service (support and financial services offered) to academic programs (majors, internships, and career options). Building that cultural capital, thus gaining access to the knowledge that allows one to navigate the larger system is imperative for student success. Yet, if one is in the midst of the situation, it is often not even evident that such advantage exists.

Remarkably, this is true whether one is from the dominant culture or if one is not privy to that advantage, it still may not be evident that cultural capital exists (Stanton-Salazar, 1997). However, the repercussions are all too real, as those from disadvantaged backgrounds continue to be alienated from the system, and those who are advantaged to begin with, and who successfully navigate are upheld as evidence of a productive and successful structure (Bourdieu, 2001).

Thus, not having this capital, leads consequentially to facing often-insurmountable obstacles and is viewed as a sense of inadequacy and lack of individual fortitude, rather than addressing the fact that these students have no power to change anything in the first place, for that responsibility lies with those in power to ensure access to all (Anderson, 2007). As we address the community college, most especially in urban and rural areas, this building of cultural capital is imperative if the goal is to provide a gateway for upper social and economic mobility.

To this end, it is of great importance that students of under-represented groups have a model, or agent, to guide them through the socialization process of academia (Museus & Quaye, 2009). This agent is most often a faculty or staff member who explicitly addresses what steps/pathways are available to students and what the cultural norms of academia are (Stanton-Salazar, 1997). During this process, the culture of the student must also be acknowledged and honored, as so it is not seen as merely an attempt to transform them into the norms of the dominant culture, but as a pathway to greater access (Stanton-Salazar, 1997). This idea of cultural capital, is not necessarily a conscious construct, as both majority and under-represented students are very comfortable with their own cultures. The benefit comes with the actual culture in power. With that, social capital is also a critical piece to this argument.

Social Capital. Social Capital speaks to the ability of certain individuals to garner benefits by merely being a member of a specific social organization or group (Portes, 2000). Bourdieu (2001) formalizes this as an affiliation in the group that entitles the member recognition or acceptance by association. Whether one possesses social capital is dependent on the situation/arena in which they find themselves. When students

hold similar cultures and knowledge as those in power, they necessarily are at an advantage over those who do not (Nasir, Hand & Taylor, 2008). Therefore, explicitly exploring and incorporating the culture and experiences of those students who come from backgrounds that do not hold power allows them to build social capital in a novel environment. Without such change, the inequities continue to be reproduced.

But, this evolution does not happen by chance. The classroom culture, including interactions and respectfulness, amongst students and faculty, are critical in empowering those from historically under-represented groups to assume the role of, or be comfortable in, challenging the status quo, and demand opportunities based on their hard work and merit. Yet, the emphasis on reproducing cultural norms of the dominant culture is so ingrained that students are not getting what they need and the system, including teachers cannot see themselves as part of the problem (Pajak & Green, 2003). Thus, by building and honoring the social capital of all parties becomes a necessary progression in combating the reproduction of inequities within the classroom. With a socially and culturally supportive learning environment, the students can incorporate and or build on their identity both educationally and more long range, in terms of a career.

Social Identity Theory

An equally important construct is based off of social identity theory. This theory assesses how a person defines members of a group, while also defining how they fit into the social environment (Ashforth & Mael, 1989). This is instinctive in that one classifies oneself in a particular category or categories (Stets & Burke, 2000). It also addresses how one comes to identify with a particular group (Stets & Burke, 2000). To this end, I am most interested in exploring how students from under-represented groups can become

one with an unfamiliar, at times conflicting, identity, to reveal possibilities for their own goals and dreams. By identifying with a group the individual is more likely to take on the norms of that group (Ethier & Deaux, 1994), thus allowing themselves to be more fully engaged in the culture, increasing the chances for success.

Agency/Developing a Student Identity

One of the core features, that of human agency is at the heart of the learning process. Agency has grown from and is connected to Bourdieu's theory of habitus and reproduction, although Bourdieu never made that connection explicitly (Nash, 1999). Although several models of agency have been proposed, a fluid and dynamic model seems to best fit.

Emirbayer and Mische (1998) propose a model of agency that is temporal and threefold, and that reproduces as well as transforms constructions, whether organizational or situational. The first dimension is iterative. This process looks at past patterns and behaviors as a way of reacting to present interactions. It can be thought of as somewhat habitual, and serves to give stability, and sustain the existing state. They term the next dimension as projective. Here the person imagines different pathways or projections. These are based off of, in part, their wishes and dreams for the future, as well as their fears. Lastly, there is the practical-evaluative element. Here the individual makes judgements about these alternate pathways. They evaluate the soundness as well as possible repercussions and or rewards. These three components are fluid and dynamic, with one occupying more focus than another at particular times.

Not unlike the theory of agency proposed by Emirbayer and Mische, Bandura relates this to the classroom environment. Under the tenets of social cognitive theory,

Bandura (2001) asserts that learning occurs as a result of the stages of complex interactions between behavior, environment and agency. The first stage is intentionality. In this stage, a learner is devising a plan, either alone or in conjunction with other learners to solve a problem. Next is forethought, as a learner is carrying out actions they continue to think about how their actions are going to play out as things develop. There is a constant shift to stay on their directed target as things come about that may be offsetting their original plan of action. Next is self-reactiveness. In essence, it is not enough to make a plan, watch it unfold to see how it may turn out, but self-regulation and motivation is key to accomplishment. Lastly is self-reflecting (Bandura, 2001).

If students are not afforded the opportunity to develop meaningful and thoughtful ideas related to mathematical concepts, they tend to try to recall static manipulations to answer questions and have a very difficult time attaching meaning to the problems (Smith, diSessa & Roschelle, 1994). The majority of the time that American students spend in the classroom is devoted to listening to the teacher or working independently on a task (whether seatwork or quizzes/exams), yet this has not been shown to foster a deep understanding of mathematics (Desimone, Smith, Baker & Ueno, 2005). Yet, this type of interaction does not foster the student developing the required skills to develop their identity as a student, a vital stakeholder in their education. By acknowledging the intellectual process that students must work through for their own cognitive development, while engaging with mathematics in a more communal way (through discussions with peers and teachers) and by introducing real-world problems, courses can be structured to support the progression.

STEM Identity. In particular, for this focus, it is imperative for a person to see themselves as having the potential to pursue a STEM career (Lam, Srivatsan, Doverspike, Vesalo & Mawasha, 2005). Students from underrepresented groups who do not develop this as part of their identity are much less likely to persevere in a setting where they feel as if they are the other and are often times the only one from their particular background (Walton & Cohen, 2007). For being the only, or the other, is not merely about one's skin tone, or native tongue, but of all the experiences that come along with it, both good and bad, overt and subtle (Malone & Barabino, 2009).

For minority students to develop a positive STEM identity it is important that a collaborative and support environment be in place. This environment allows them to develop this new identity without discrediting their racial/ethnic identity, thus honoring their social capital (Hurtado, Newman, Tran & Chang, 2010). It is important to be recognized and accepted in the community one is identifying with (Malone & Barabino, 2009). This leads to the idea that work needs to be done on the macro level as well as the micro level so that as these students advance there is a place where they can continue their growth in an environment that is conducive to their success and that they are given the opportunity to contribute to the academy. A critical piece that contributes to the development of this STEM identity is the attitude with which the student comes into the educational setting.

A large number of students enter into community colleges not having a clear idea as to their goals, or even knowing what careers are available (Aycaster, 2001, Scott-Clayton, 2011). By introducing a STEM focused curriculum and exposing the students to viable careers, educational inequities in our system can be addressed. Consequently, this

exposure may potentially open the pipeline to this slighted population who have largely been excluded from more lucrative occupations, all the while addressing a national need.

This is not to say that students from under-represented groups have not been successful in STEM, despite the environment they find themselves in. Some manage to succeed, even excel, despite the constant barrage of negative stereotypes challenging their ability. They not only do not succumb to this threat, but consciously chose to devote little to no energy to combat it, they merely embrace their racial/ethnic identity and give the negative energy no power in their lives (McGee & Martin, 2011).

But, for the majority, it must be acknowledged that stereotype threat is a large part of the process as students take on an atypical identity (Steele & Aronson, 1995). This can be thought of as an identity, or characteristic, which is not typically assigned to a specific group. There is a real fear of doing or saying something that will have a negative impact on the way one's culture, ethnicity or gender is perceived. The fear is to be a contributor to reinforcing negative stereotypes. This has been shown to be true even when people with similar abilities are given a difficult task. A study carried out by Steele and Aronson (1995) found that given students with similar math abilities, women and African Americans performed lower on the most difficult of tasks and doubted their abilities instead of realizing it was merely a difficult task (Steele, Spencer & Aronson, 2002). The phenomenon becomes not only a source of doubt about one's belonging and ability, but also a self-fulfilling prophecy that has a direct effect on intellectual performance and achievement (Scutt, et. al, 2013, Steele & Aronson, 1995).

Dasgupta (2011) offers a new theory, the stereotype inoculation model, as a way to address the discontinuity that students from underrepresented groups experience in

areas where they are not typically represented. She contends that although research has shown that in-group representation can be a strong draw for women and minorities to venture into fields of study, the scarcity of like individuals in STEM careers, in particular, cannot be denied. Yet, there are factors that can affect underrepresented student's feelings of belonging and grit in challenging academic environments. In particular, how the students are received by experts within the field, and how they are received/treated by their peers.

If underrepresented students are greeted, welcomed, valued, and encouraged by these experts, the idea of "token" or "only" will be diminished, and the student can strengthen their identity into the group. This also serves to dispel stereotypes of this population with other ethnic majority members within the community. For negative stereotypes, even those of the subtlest form can have a deep and demoralizing effect on a student's self-efficacy. This is also true of peer affiliation. Students pick up on social cues of both belonging and expectations. If the underrepresented student feels that they are the "token" from their cohort, or are not accepted, that pressure can have a negative psychological and academic effect.

There needs to be a reconciliation of the student's identity as a member of the STEM community and the innate identity of being a person from a group that is not typically expected to be a member of this group. Thus, the ability to work through difficulties, be resilient when suffering setbacks, and retain a positive identity is critical. Notably, the strongest indicator for students from ethnic minority backgrounds to persevere and achieve academically, is to have a strong and positive racial/ethnic identity as they take on new and difficult tasks (Byrd & Chavous, 2009). Yet, in relation to that,

those that feel that their racial identity is being disrespected have less engagement in the academic process (Aronson, 2002). The combination of students having a strong personal identity and creating an environment that is respectful of that identity is critical to the learning process (Gutstein, 2003).

But many educators dismiss this aspect of the learning environment, that of acknowledging and understanding cultural norms of their population. This leads to the notion of “color-blindness” where teachers believe that all students should be treated the same, that race, class, and ethnicity should not be acknowledged. This is also true of the curriculum, and pedagogy that overwhelmingly reflects the dominant culture (Nieto, 1993). Yet, this view of color-blindness is actually a detriment to students from under-represented groups, who need to be acknowledge for the total of who they are and their experiences and can hinder their educational experience (Byrd & Chavous, 2009). In essence it is used to discount any idea that institutionalized racism exists and put the onus back on the students, holding them solely accountable for their own failure (Gallagher, 2003).

Choosing a STEM Identity

Recognizing that there is a complex relationship in building vocational identity, in both honoring the student and their personal experiences, as well as the contributing environment, Lent, Brown and Hackett (1994, 2002) developed Social Cognitive Career Theory which is anchored to a large extent in Bandura’s work with Social Cognitive Theory. In particular, this theory focuses on the three constructs that contribute to student choice in pursuit of academic majors. The first, self-efficacy, is defined as belief in personal capabilities of performance. The authors view this as a dynamic interaction of

indirect knowledge, personal accomplishments, social, personal and biological states. Included in this category is students internalized perceptions based on race, class, gender, and ethnicity.

The second is outcome expectations, the belief in specific consequences resulting in actions taken. An example would be a student studying for their exams expect to perform well. Yet, it does not have to necessarily be a tangible result, being absorbed, engaged and taking pride in one's work while involved in the activity are also a part of this paradigm. The third construct is personal goals, the anticipated result of a students' decisions and work. These goals serve as an instrument to keep students motivated and focused to get through the task at hand, keeping focused on the end result.

In addition to these constructs, external influences are also crucial, in terms of environment, support, acceptance, etc. Lent, Brown, and Hackett (1994; 2002) propose that by identifying these important constructs in a students' development, specific interventions can be introduced to scaffold their progress into viable careers, that the student may not have felt confident in pursuing without support.

Building on this work, Wang (2013) offers a model for adapting a STEM persona. Wang specifically looked at community colleges as well as four-year schools and how students enter into STEM fields using Social Cognitive Career Theory (SCCT). She explicitly acknowledges that women, and under-represented minorities are more likely to enter post-secondary education at a community college, and that it is imperative to look at community colleges and research best practice to find out how to best facilitate their progression into STEM. In the model, she starts with what students are entering with, which are their learning experiences and self-efficacy as they enter the community

college. Those factors play directly into their beliefs about their readiness and their interest in pursuing certain majors. The final link is to their STEM choice, which can be linked further to the colleges support and outside personal circumstances (Figure 2).

At the onset, she hypothesizes that self-efficacy, in particular about one's beliefs of their mathematical ability, has a large effect on a student choosing a STEM career. This self-efficacy is developed in middle and high school. Also, the learning that students experienced in high school, in relationship to college readiness and exposure is also a contributing factor. If a student was never exposed to higher levels of mathematics and science classes, or STEM careers through schooling or personal relationships, there is no way for that to be of interest, or a goal. Wang found that there are long lasting effects relating high school learning, in terms of math and science, and STEM interest and persistence.

Wang also ascertained that once enrolled in college, postsecondary factors begin to play into student choices and interest. With contextual supports, students can either be steered toward or away from certain fields of study. One of the major factors in support is remediation. With students testing into developmental education, it creates yet another barrier to exposure. The final piece, which I refer to as personal circumstances, refers to demographic information of the students: race, SES, gender, expectations based off of educational background.

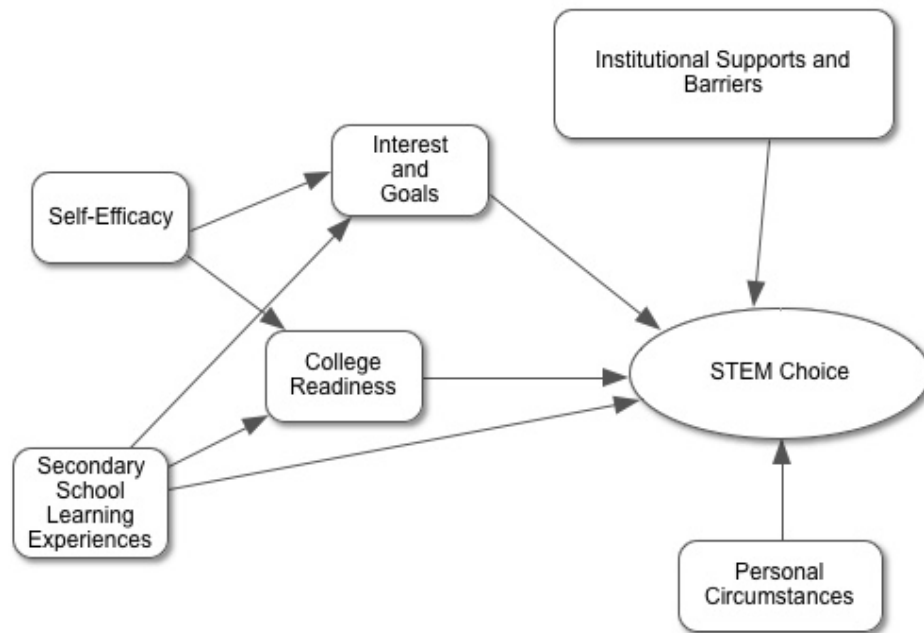


Figure 2: Wang's conceptual model

According to Wang, STEM interest, and attitudes are the biggest predictor of students entering a STEM pathway. A clear and directed exposure to STEM areas, as well as more math and science courses, is imperative in widening the STEM pipeline. Consequently, remediation has proven to be a barrier to STEM entrance. Therefore, the introduction to STEM in remedial courses would reach a segment of the population that are not represented in STEM, and can build efficacy as student's interest grows. Unfortunately, for those who had STEM aspirations, the number of courses that are necessary has proven overwhelming to the point that students desert their goals. The question remains how do math attitudes play into this building of identity, and what exactly is being examined when discussing attitudes.

Attitudes. Eagly and Chaiken (2007) define attitude as the process of evaluation, which refers to a persons' tendency to feel either favorably or unfavorably towards something or someone. This may be either conscious or unconscious, and may invoke reactions ranging from feelings or emotions to behaviors. These attitudes are formed through a multitude of avenues. They range from simple exposure, to classical (reflexive) or operational (based on consequences) conditioning, through social learning (Baumeister, 2014). For this analysis, math attitudes are of interest, therefore the focus is shifted to what are the forces that drive math attitudes, and can negative attitudes be addressed and changed.

The sources of those negative attitudes have been examined in terms of gender-stereotypes as well as parental attitudes. One study found that girls as young as five years old are negatively affected by this doctrine. Yet, the authors went on to find that when the mother strongly rejects gender stereotypes, even when girls were exposed to negative gender attitudes about girls' ability to perform math, girls performed equally well (Tomasetto, Alparone, & Cadinu, 2011). Yet, the problem lies deeper than projecting on a student, what their perceived math abilities are. It can also be examined in the sense of parents and teachers own math anxieties (Gunderson, Ramirez, Levine & Beilock, 2012). Parents who do not feel they have the ability to understand or help their children with math, and teachers who question their own teaching ability with respect to mathematics may impart their attitudes onto the students.

Di Martino and Zan (2010) developed a model based off of their qualitative study of 1,496 students from kindergarten through high school. They administered, collected and analyzed open-ended essays. There were also 146 teachers from the various grade

levels that were administered a questionnaire. Their use of grounded theory in the development of their model yield three factors that contributed to the students attitudes of mathematics. Emotional proclivity (especially in relationship with teachers), perception of what mathematics is, and efficacy in mathematical ability.

Di Martino and Zan (2010) propose using their model as a tool in addressing negative attitudes on these multiple levels to support student growth. They found that both for teachers and students alike, if the student has a negative attitude, it is practically beyond their control to make adjustments. By acknowledging the different dimensions, and addressing them, both individually and collectively, can shift attitudes. In particular, the researchers propose a more thoughtful, problem solving approach can address the multiple dimensions of attitude. These findings were consistent with the work of Hannula (2002) who came up with a similar model, and found these attitudes to be fluid in his study, and that situated mathematics, with support, had a profound effect on a students' attitude about mathematics.

The complexities that contribute to learning in the classroom are profound. The dynamics are further complicated by the realization that one dimension can directly affect several others. Yet, by carefully examining how factors play upon one another, and play out in the classroom, a more focused and deliberate approach can be established to ensure a positive and productive learning environment for all students. The next step is to use this information and examine critically what has been carried out, what has been found to be effective, being mindful of the conceptual frameworks that have shown to be important in the learning process.

CHAPTER 3

WHAT HAVE WE LEARNED, WHAT ELSE IS NEEDED?

With the establishment of the core theories, that addressed equity, cultural and institutional norms, and identity the next step is to progress into examining what studies have been undertaken to address these areas. In particular, studies that address a career-focus, STEM identity, contextual, and problem-based curriculums.

Career focus and student success

A students' attachment to a strong, career-focused program has shown to be a great advantage in student success and retention. A case study carried out by Nitecki (2011) examined two such programs at an urban community college that, like so many, struggled with student success and retention (NCES, 2008). The Fairview Community College, FCC, has a large (44,000 full and part time as well as noncredit) diverse student body with 44% African American, 25% White and 6% Hispanic students. In this study, the programs examined were paralegal and early childhood. Nitecki found that the college wide graduation rate was 12.5% and students who left after unsuccessfully taking classes was 35.0%. She then compared that to the early childhood, which had a 51.3% graduation rate and 3.9% departure rate, and paralegal with a 32.2% graduation rate and 10.2% departure rate. These programs had the highest retention and graduation rates at the college.

The researcher collected a wide variety of data that included: document analysis, faculty and student interviews, and observations. Some of the major findings of the study were that the program itself mattered. Although these two programs were very different in terms of structure, focus, and level of difficulty (with paralegal being seen as

somewhat more rigorous) there were common themes that emerged from both series. One collective thread to these programs was the emphasis on the practical. The emphasis on students understanding how the material relates to their field was always a focus. There was also a strong sense of community, described as a “culture of family” in the study. Small class sizes and the natural cohort that results from the career focus contributed to this atmosphere. Although a limitation of the study was the limited number of students (200 in paralegal and 350 in early childhood), and there are questions about generalizability.

Investigating these themes on a grander scale, a comprehensive, longitudinal study undertaken by Castellano, Stone III, Stringfield, Farley-Ripple, Overman, and Hussain (2007) carried out an investigation that measured the effect of school reform geared toward at-risk students using a career-focused curriculum. This study, funded by a US Department of Education grant, followed three programs starting in middle school, through high school that were undergoing reform directed at reducing the dropout rate, and bolstering student achievement. There were also control schools for each of the study schools that shared similar demographics. In particular, the researchers hypothesized that career and technical education (CTE) would improve engagement, retention, and transition to an increased level of success for these at-risk students beyond high school.

The sample was made up of three cohorts, 7th, 9th, and 11th graders with between 150 and 200 students in each cohort both experimental and control at the onset. The findings, although mixed, indicated that in terms of achievement, students in CTE courses had lower dropout rates, and were more likely to identify and follow the career

path in post-secondary education. Students in both the control and experimental group were equally likely to need remediation if they attended a community college, with the majority testing into developmental education.

The introduction of specific careers focused curricula has been shown to be beneficial in interest, retention, and achievement in varying degrees. For this study, the specific examination of STEM focus in a mathematics classroom is of interest.

Therefore, given the promising results of career focus in various courses/programs, the question arises of the applicability of this concept in the specific context of STEM focused curriculum and mathematic achievement.

Integrated STEM curriculum and mathematical achievement

In the examination of what a STEM focused curriculum entails, it is important to examine what has been carried out in the arena of STEM curriculum and its effect on student mathematical achievement. Several studies have been carried out addressing this area. Judson and Sawaada (2000) examined the research question “Does the integration of mathematics into a science class have a positive effect on student performance in their mathematics class?” with the hypotheses being that students in the integrated class would perform better than the students in the control group.

This study was carried out at a junior high school in Phoenix, AZ. It involved a mathematics teacher and science teacher. These teachers were recruited from the school, and attended training workshops to prepare for the integrated curriculum. The math teacher had two statistics classes, the science teacher had three science classes, one of which was a class that had both of these individuals as teachers. There were 53 students in the study, 26 in the control and 27 in the experiment. It should be noted that the math

teacher did not incorporate any technology or integrate any science concepts into her class. It was strictly carried out in the science classroom with the integration of the mathematical concepts.

Of the two math classes, 54% of the control scored a D or F on a unit test that was integrated with the science concepts, which was true for only 4% of the integrated students. A Chi-square test was performed for a value of 16.92 and $p < 0.005$. The three science classes were also examined to see if there was any difference in the achievement of the integrated versus the control, and none was found.

The small number of students involved may be considered a weakness to this study is, although statistical significance was proven. A considerable strength was that there did not seem to be an unreasonable burden on the science teacher to incorporate the mathematics into his course. This study is replicable, and if the results are reinforced could be distributed and incorporated on a larger scale.

In line with this recommendation, a meta-analysis carried out by Becker and Park (2011) examined empirical studies to investigate the effectiveness of integrative approaches within STEM education on student achievement. They identified four areas of interest: Identify the effect a STEM integrative approach has on student achievement, ascertain how the integrative approach differs among grade levels in terms of student success, to identify which combination of an integrative approach showed the most gain in student achievement, and to identify which STEM subject had the most improved student achievement using integration.

Data was collected from twenty-eight studies from primary authors. All of the studies selected were integrative STEM education, and had empirical data provided that

examined students' achievement. The individual studies ranged from approximately twenty to over one thousand participants. The grade levels represented were from elementary through college. Effect sizes were calculated using means and standard of deviation.

The findings in this study were mixed. Researchers found that the effect sizes ranged from 3.27 to -0.61 and for the most part the traditional curriculum groups outperformed the integrative approach groups. Unfortunately, there was not a specific breakdown of the studies, and the differences attributed to the types of interventions. It was stated that the great positive effect in regards to the integrative group was amongst elementary school children.

The combination of integrating science and technology showed the strongest positive effect in student achievement, but there were seven different ways the integration took place, thus the numbers for each combination were small. Math-science integration had the most studies with ten, but the results were not substantial, there were seven studies that showed a less than a 0.2 effect size. The individual subject with the greatest gain in student achievement when using an integrative approach was technology. Notably, one of the few positive results of the study, with respect to the integrative model, found that students with exposure to integrative approaches perform better academically in their STEM courses overall.

Yet, there were limitations to the study. There are few empirical studies on the effects on the integration of a STEM focused curriculum on student learning. This is not a reflection of the researchers as such literature is scarce. This small sample size was exacerbated when the studies were further broken down into grade levels, and types of

integration. Also, the researchers were not explicit on their final numbers when examining the data. Tables were present, but exact numbers were not presented. The recommendation was that this area needs to be more thoroughly studied, to draw stronger conclusions. In addition, there is little information on the students in this study nor how directly applicable the results are to under-served versus majority students. Opportunities for integrative approaches in STEM subjects should be presented to administrators and teachers as a way to motivate interest in, and learning of STEM fields.

On a major scale, a study by Satchwell and Loepp (2002) investigated a research team funded by a National Science Foundation (NSF) federal grant. The goal was to develop and test an integrated, standards-based mathematics, science and technology (IMaST) curriculum, for the 7th grade. Researchers from Illinois State University and practitioners came together to develop and implement the curricula. There were eight research questions that deal with curriculum development and fidelity to effectiveness of the curriculum, support for widespread adaptation, and student achievement. The question of interest for this review is “Is student achievement affected by integrated curricula?”

To answer this question the Third International Mathematics and Science Study (TIMSS) exam was administered to students in both a traditional (the control) and the IMaST in both mathematics and science. The hypotheses were that students in the IMaST will perform better on problem solving and processes than the students in the traditional classrooms. This study was carried out over six schools, each school receiving both treatments. The number of students involved was 293 in the intervention, and 246 in the control.

For the mathematics portion, there was no statistical significance in the two groups $p > 0.05$. However, for the science portion of the exam, the intervention class performed better on the process portion with a difference of 0.78, and the traditional classes performed better on the *knowing* (repeating facts) portion with a difference of 0.56 the associated $p < 0.001$. The results show that the integrative model still promotes student success while meeting standards. One of the strengths of this study was the comprehensiveness, with such a large sample size. A recommendation for future research is to look at long-term progress comparing students in the integrated versus the traditional classes. As well as to determine if there is a correlation between the integrated classrooms and the students' affinity towards mathematics. A possibility in determining a difference in affinity is to survey the students in both control and experimental classes.

It is important not to focus so much on creating interest that students are not retaining their mathematical knowledge, or are lacking the ability to apply that knowledge in different areas when appropriate. To this end, an investigation carried out by Burghardt, Lauckhardt, Kennedy, Hecht and McHugh (2015) investigated a practical model of mathematical and science integration used to increase understanding and transference of concepts between the two disciplines. This study emerged from an NSF granted, *Mathematics, Science, and Technology Project (MSTP)*.

The researchers investigated several research questions. Do students who are in the math infused lessons: a) have measureable gains in knowledge, reasoning and applications in their science course, b) have measurable gains in their mathematics class, c) have greater gains than those students in standard science classes. Lastly, are these infused lessons effective for those who were under-performing. The hypotheses being the

mathematics-infused science classes will positively impact both their science and mathematical understanding.

Administrators were recruited from across New York State. The target population of the study was eighth-grade science classes where teachers taught six math integrated lessons throughout the school year. Teachers and administrators were asked to commit to carrying out the lessons strictly as prescribed, reporting demographic and achievement data of the students.

There were a total of eight middle schools, with twenty-two teachers, who participated in the study. At each school the teachers were assigned to either the infusion or control class. For all of the classes a pre-and post-test were administered and analyzed by the researchers. They used this to analyze gain scores, and content knowledge. There were also classroom observations and surveys to ensure the fidelity of the study. The researchers used t-tests to analyze difference in scores for students from both groups, the intervention and control. This occurred both to ascertain gain scores as well as to identify any differences between the groups. Analysis of covariance was conducted to identify differences between groups on the pre-test.

Students in both group had gains with respect to pre/posttests. Yet, the gain for the intervention group was twice that of the control group at 16.4% to 8.7%. The intervention group had 5.5 times the growth in reasoning. After ANOVA was carried out to control for confounding variables, the researchers found the gain of the intervention class was significant with effect size 0.23 and $p < 0.001$.

Although the researchers were diligent in trying to ensure the lessons were carried out as prescribed, they found that there was some variability in how the lessons were

conducted. Furthermore, teachers own ability and experience factored in to how the lessons were executed. Another weakness to the study was that the control classes were not all the same. Because of the Regent system in New York State, the associated math class could have been Algebra or Pre-Algebra concepts. This was a confounding variable that was not accounted for. The recommendation for future research includes expanding on the mathematical concepts that lend themselves to science, and, investigating which grades levels would benefit the most from such integrative approaches. Another recommendation would be to examine the impact of the teacher on such integrative approaches.

In summary, research related to integrating STEM curriculum has had mixed results. There have been promising gains, but there is also a lack of consistency in what data is collected and analyzed. There is also a lack of explicit information as far as what was being measured, and confounding variables that were not accounted for. Although, it has shown promise in terms of contextualizing the math to make it more relevant, thus bolstering student achievement. Although examining an integrated curriculum on mathematic achievement is an important aspect, there is also a question of how students' overall opinions and views of mathematics may be affected.

Integrated STEM curriculum and math attitudes

Although achievement is one component in measuring the effects of a STEM focused curriculum, it is also important to understand the students' attitude toward the material, and whether there is a positive correlation. An enquiry by Elliott, Oty, McArthur and Clark (2001) was designed to gauge the effects of an integrated algebra and science course had on students' attitude towards mathematics, as well as their

problem solving and critical thinking skills. This investigation was carried out at Southeastern Oklahoma State University in eight classes. Four of the classes were integrated, called 'Algebra for the Sciences', and the other four were traditional college algebra classes. In the integrated classes, students were introduced to mathematical concepts in the context of scientific disciplines. For example, a unit on logarithms was taught by a physicist in context of sound waves.

This study ran for two semesters. During the first semester, there were two sections of college algebra in the course catalogue with a cap of 50 for each section. On the first day of classes, the faculty randomly assigned the students to two sub-sections (using a random number generator), half the class continued on in a traditional college algebra class, while the others were in algebra for the sciences. In all the classes, the faculty referred to the classes only as college algebra so as not to emphasize any differences. The subsequent semester the algebra for the sciences classes were advertised in the course catalogue.

The total beginning sample size resulted in 211 students 118 in college algebra and 93 in algebra for the sciences. After attrition, there were 143 students, 75 in college algebra and 68 in algebra for the sciences. Demographic information was collected on all students in the study. The attributes recorded were: age, gender, major, and ACT scores.

To consistently measure problem-solving skills common final exams were given. The questions were categorized and a common scale was developed to ensure equivalent grading. Critical thinking skills were measured using the Watson-Glaser Critical Thinking Appraisal (WGCTA). This is a considered a benchmark for other test of similar nature. Independent t-test were used to test for differences in critical thinking between the

control and intervention classes. Lastly, to measure students' attitudes towards mathematics, a Likert scale was administered at the end of the semester. Chi-square tests were conducted for statements to ascertain differences between the classes.

The researchers first looked to see if there was a difference in the randomly assigning students versus those who self-selected, and there was none. Nor did they find any significant differences in problem solving skills between the groups. Critical thinking skills were higher in the algebra for sciences classes, but with a small significance at only significant to 0.10. The most significance occurred when examining the attitude survey's. Students in the algebra for science vs traditional class, strongly agreed that the course improved their attitude towards math 48% to 26% with $p < 0.05$. They also found the course to be more interesting 62% to 20% $p < 0.005$, and more practical 68% to 24% $p < 0.005$. Mathematical achievement and critical skills were not sacrificed, yet interest was greatly increased.

A strength of the study is that it is ongoing, researchers continue to track subsequent math courses to surmise if this intervention had an effect on the academic trajectory of the student. This study suggests that one way to improve student mathematical achievement is to improve attitudes toward the subject. Although research has been conducted to affirm this idea, research in the post-secondary level is lacking, which is another strength of the study. Hurley (2001) performed an intensive review of 31 studies published from 1935-1997. These studies covered students from Kindergarten through undergraduate students, and covered science and mathematics integration. What she found was a lack of consistency on how integration was defined and carried

out, and an inconsistency of how achievement was defined. Furthermore, social aspect, including attitudes, were mostly reported on an anecdotal level.

Teacher attitudes and student achievement

The teacher is an integral part of the learning experience. In both their content knowledge, as well as the culture established in the classroom. It is important to explore the effect of teachers who create a caring environment within the classroom. This would consist of a teacher's commitment to upholding a level of rigor, all the while holding expectations that the students can succeed, and that they care about their success. Nell Noddings has worked extensively with the idea of care. Even students have rather expressive ideas of what it means to have a caring teacher. They have been identified as providing both academic and interpersonal support in an individualized way to their students (Bartell, Meyer, Knott & Evitts, 2008).

This can be a somewhat tricky idea to embrace. There are, without a doubt, teachers who express emotional support and affinity for students, yet are not demanding the rigor that is necessary for students to excel. When we address the concepts of care, it is imperative that both pieces are present. A teacher who shows disdain or lack of respect to their students is not present enough to draw out the full potential of the students' ability. Conversely, if the emotional support is there, but not the deep understanding of the material being taught, along with a high academic standard, the students are again at a major disadvantage (Jansen & Bartell, 2013).

The teacher is a key part of the equation as we examine the class. In particular, how the teachers feel about their students, can affect student performance. Albert Mehrabian first proposed the idea of immediacy. He created this principle based on his

idea that “people are drawn toward persons and things they like, evaluate highly, and prefer; and they avoid or move away from things they dislike, evaluate negatively, or do not prefer” (Mehrabian, 1971, p.1). This is a weighty idea as examined in the context of teaching. The idea of immediacy can be described as both verbal and nonverbal cues that lead to a perception of attachment between people (Richmond, Gorham & McCroskey, 1987). According to Christophel (1990) students who view their teachers with this type of immediacy view the course as well as the teacher with a more positive attitude. And even more importantly immediate teachers have a positive effect on student learning outcomes. As a result of this mutual deference, the social capital of the student is honored with a positive shared learning experience.

Although it can be argued that the connection with the teacher and the student can't be directly attributed to student success, it can be said that it is a direct consequence of that positive relationship (Witt, Wheelless & Allen, 2004). As students feel more comfortable and valued in the class, motivation and level of engagement increases, concurrently their stress level decreases and ultimately leads to better success in the class (Rocca, 2009).

A study carried out by Klem and Connell (2004) examined this type of environment created by the teacher and the impact of the relationships between teacher and student on student success. In this longitudinal study students were surveyed from six elementary, and three middle schools in one urban school district. The sample size was over 4,200 participants. These surveys measured teacher's support from both the teachers' as well as the students' perspective. The survey used was the Research Assessment Package for School™ (RAPS). There were several versions: elementary

students, secondary students, teachers and parents. Students were also categorized as optimal or at risk based upon their attendance records and reading or math scores. Some of the findings of the study were that both the students and teachers felt like the support of the teacher is important to student engagement. Elementary students who felt supported by their teacher were 89% more likely to report being engaged. For middle school students, the level of engagement overall was much lower than elementary students. Notably, negative effects of uncaring teachers were much more pronounced in elementary school students. Students identified fairness, consistency, and high expectations as being motivating factors. Most important at the middle school level students were 68% more likely to be disengaged if they feel their teacher does not care about them. The higher the level of engagement was associated with increased attendance and test scores.

This relationship was also examined in an investigation by Brewster and Bowen (2004). The focus of the study was Latino middle and high school students, who were at risk of failing. In particular, students' perception of the role of the teacher as a support. The data was collected in the form of surveys from 633 Latino students throughout the United States that had been identified by school officials as at risk of failing. These surveys were a subset of a larger study of 5,016 students using the School Success Profile (SSP) survey. This is a peer-reviewed instrument that evaluates students' perceptions of their school, area in which they live, family, and themselves.

The independent variables for this study were parental support and teacher support, with the dependent variables being problematic behaviors of the student (anything from being tardy, or absent to suspensions) and student's perceptions on the

meaningfulness of school. To gauge meaning, students responded on a three point Likert scale how strongly they felt about statements like, “I look forward to going to school”. There were six items for students to respond to about how much support and emphasis they receive from their parents as it pertains to school. And, seven items questioning teacher support. All items were analyzed and to ensure reliability Cronbach’s alpha was calculated.

The researchers found that teacher support was the most meaningful in having positive effect on problematic behaviors and school meaningfulness. As students view of teachers being supportive the problematic behaviors decreased at an effect size of $-.233$, and meaningfulness increased to $.313$. This study showed that for these students, teacher support had more influence than even parent support with at-risk Latino students.

By leveraging social capital in a way that values the student, positive gains can be made. This was true for the at-risk Latino students, but arguably this can be extended to other groups, which would be a recommendation for future research. The researchers found that having adequate and proper student support in the schools is invaluable. This support should come from not only teachers, but social workers and other support staff. A limitation of the study was the ethnicity of the participants was not addressed, nor the native language, which could affect behaviors and school meaningfulness. Another important area is to critically examine what supports academically that are necessary for students to be successful. Students who are at-risk to fail, often need remediation to address gaps in knowledge. Therefore, the next question to address is the value of remediation to determine if it is yet another obstacle for the at-risk student.

Efficacy of mathematical remediation

Bahr (2008) carried out a study to critically examine remedial mathematics at community colleges by evaluating the success or failure of students who pass through the remedial system. The hypothesis being that students who successfully remediate are indistinguishable from students who do not require remediation in credential attainment and transfer. For this study, data was collected from the entire California community college system, fall of 1995. First-time freshmen were identified with a sample size of 202,484. This longitudinal study was carried out over six years, which lead through the spring of 2001. After adjustments for discrepancies in the data, a final cohort of 85,894 students were analyzed. Demographic data was collected on the students concerning sex, race, SES and age.

This study examined the student's entry into the math sequence (developmental or college level), and tracked the academic attainment. The two categories that constituted this attainment were 1 – associate degree or certificate, 2 – transfer to a four-year institution. Of these umbrella categories, five sub-categories were disaggregated. 1 – no credentials or transfer, 2 – certificate only, 3 – degree, 4 – transfer without credentials, 5 – transfer with credentials. The data was analyzed using multinomial logistic regression to find variations in the probability of the five outcomes.

The most notable finding of this study is that of completion rates of college level course. The data showed that those that placed directly into college level mathematics and students who first had to complete a remedial course had similar outcomes in their likelihood to gain credentials with 78.23% to 81.11%.

Although this study shows that those who successfully remediate have as good a chance as those who do not remediate to gain credentials, there is still quite a large

disparity in those who do not successfully remediate. It is recommended that future studies focus on successful interventions of remediation to close that gap, and to examine which groups benefits the most.

Drilling further into this data set, Bahr (2010) looked at demographic information of race/ethnicity with respect to efficacy in remediation of developmental coursework. There were five independent variables for this subsequent analysis. Math deficiency, English deficiency, student grade in first math class, student's goals, and student's enrollment pattern. The dependent variables were passing a college level math class, and the efficacy of remedial courses with respect to racial groups.

The researcher uses logistical regressions to analyze patterns in and efficacy of remediation. Frequency distributions between those who successfully remediate mathematics within six years with $N=63,147$ were calculated and Chi-square tests were also conducted to ascertain statistical significance at $p<0.001$. As noted in his earlier study, students who successfully remediate have the same probability to attain credentials as those who place in college level, the chances of successful remediation amongst racial differences had quite different results. One finding is that a fourth of white and Asian students successfully remediate and pass a college level math class. Yet this is only true for one-ninth of Black and one-fifth of Hispanic students.

A limitation of this study, which leads to future research is to identify specific interventions that have been shown to be successful, or a hindrance for students within the classroom. Bahr proposes that more research be carried out on specific interventions to support students who need multiple levels of remediation. He suggests an integrated approach, including advising and early interventions to ensure minorities in particular

have the necessary scaffolding to be successful, as well as identify those who would benefit the most from those practices.

In order to ascertain validity, Bettinger and Long (2009) researched the questions of who should be in developmental education and questioned whether there was any real benefit from remediation. In this longitudinal study first time, full-time, freshman in Ohio public colleges in fall of 1998 were studied. In particular, those who were either at a four-year college or indicated they were transferring to a four-year school. The sample size was over 28,000 and the students were tracked over six years. The focus of this study was those students that place, or should have placed, in remedial education.

Because of the lack of consistency used to determine which students need remediation, the researchers constructed a model to normalize this category. They identified a series of variables and used regressions to control for confounding variables. They tested their model against known data and found that their model was statistically significant to the 99% level.

The results indicated that students who need and receive remediation were 12% less likely to drop and the likelihood to graduate increased 11%. Just focusing on math remediation graduation increased to 1.5% and persistence increased 13.9%. Overall, the researchers found that remediation positively effects outcomes. Additionally, with students who were interested in majoring in a field that is math related, remediation increased percentage of degree completion, and interest overall.

One drawback of this study was that the type of remediation was not examined, therefore there is no way of identifying which type, if any, had a more positive effect than others. Additional research should be focused on what constitutes effective remediation.

It also leads to the question of what factors effect persistence at the community college level. Commuter schools have the unique position in that students are coming to campus just for classes, and then leaving for jobs, family obligations, etc. It is much more difficult to build a sense of community with these students, and keep them invested in coming to campus when the face difficulty.

The community college student and persistence

In the quest to identify how programs support persistence, Tinto (1997) used a mixed method approach to examine a program at Seattle Central Community College. In this study students who were in learning communities, referred to as Coordinated Studies Program (CSP), were compared to students in traditional classes. The CSP students shared several courses together, and the faculty who taught those courses were present for each class, whether they were teaching it or not. The research questions were does this CSP program make a difference? and if so how? There were questionnaires distributed at the beginning and end of the quarter, and interviews were conducted to assess the students' perspective of their experience. This was true of both those in the CSP classes and in the control.

At the beginning of the fall semester, 517 questionnaires were usable, 210 from CSP, and 307 from the control group. At the end of the quarter there were 287 responses, 121 CSP, 166 control. Ultimately the sample was reduced to only those who responded to both survey's which left a total of 121 in CSP and 166 control. Quantitative analysis was conducted to ensure statistical significance of outcomes, and regression models employed to ascertain change over time within variables. For the qualitative analysis, purposeful sampling was used based off of the work of Bogdan and Biklen (1992).

The biggest gain for the CSP students was in course involvement 3.05 to 2.46 on a 4-point scale. And perceived academic gain of 2.68 to 2.46. The CSP students overall had greater affinity for the college in general and school related activities. When examining persistence students from the CSP made major strides comparatively with the control group. Of the 121 in the CSP examined, 83.8% returned the spring semester, and 66.7% returned the following fall. The control, which consisted of 166 students, 80.9% returned for the spring, but only 52% returned the following fall semester. The researchers then went further to identifying how confounding variables may contribute to these results. In particular, they looked at G.P.A., number of study hours per week, perception' of faculty, and involvement with peers. Participation in CSP was still by far the greatest factor in persistence.

In examining the qualitative data several themes emerged from the data. One of the major themes was related to building a peer network inside of the class that by virtue of multiple interactions, led to a supportive academic and social network outside of the classroom. Students interacted with people of different ages, backgrounds, and ethnicities in a way that they felt helped them grow. A drawback of this learning community is that involving all instructors in all the classes, can be cost prohibitive to a lot of schools. Yet, the tenants of involving students and creating a community within the class is replicable.

Deil-Amen (2011) also examined Tinto's model of social and academic integration at two-year schools conducted in a mid-western city. She conducted a series of 238 interviews (with faculty, staff and students), surveys, and observations. These

were carried out at fourteen two-year schools, seven public and seven private. A purposeful sample was drawn to ensure demographic variability.

The findings were consistent with Tinto's findings in the previous study. A major theme was that social and academic integration was key for students to feel connected, and thus persist. Students viewed the relationships with peers as a support system, not necessarily as a friendship for outside of school. The building of relationships with their peers served several important purposes. One was a way to help navigate the system. Unlike four year schools, it is more difficult for students to navigate the system as far as questions about advising or financial aid. By building relationships with faculty, staff and peers, they found a way to navigate the system.

This was also true when having difficulty in the class. Peers and a close relationship with faculty helped students to persevere, by forming formal and informal study sessions. In particular minority and non-traditional students have a great deal of self-doubt when entering college, and having a sense of belonging, and feeling that their peers and professors cared was a common theme, with approximately 75% of students mentioning this. Unfortunately, even when instructors made efforts to engage students individually, not all students felt comfortable responding. This was made worse when the researcher looked at the large number of adjunct faculty who taught classes, and their inaccessibility outside of class. This further emphasized the importance of in class support, as well as peer support to help students navigate not only the academics, but also pertinent information necessary to stay enrolled.

It should be noted that upon careful consideration of best practices and lessons learned, and given the unique demands of community college students Terenzini &

Pascarella (1991) assert that with over one-third of college students attending community college and less than 5% of the 2600 studies examined directly dealing with community colleges, much work is to be done (Pascarella, 1997). Townsend, Donaldson and Wilson (2004) found similar results when they examined 2,321 articles in five higher education journals from 1990-2003 with only 187, which is merely 8% of the total number of articles, examining or mentioning community college. Of those 161, or 6.9% of the total, were empirical studies involving community college. Therefore, the majority of the studies examined for this literature review involved K-12 education.

Which in no way diminishes the importance of carrying out research at the community college, which is an integral part of post-secondary education. It is a haven for those who either do not have access to, or the means to attend four-year colleges. But, even more importantly, it serves as an entry point to higher education to those who are the most disenfranchised in our society. It is not only a task to support these students, but it is imperative to ensure a foundation is in place to buoy their progress. Therefore, it is imperative to find ways to help the most at-risk students successfully remediate and attain their desired credentials. One way of doing this is to incorporate supports into the classroom to not only help remediation, but to expose them to pathways that will help with engagement and retention to ensure they receive their desired credentials.

Purpose Statement

The purpose of this mixed-methods study is to determine if teaching a STEM focused versus a traditional curriculum increases the affinity for pursuing a STEM pathway, and has a positive effect in pass rates, for algebra one (a remedial, non-college

level, mathematics class) in students at an urban community college. Additionally, teacher practices and attitudes are examined to ascertain their effects on students.

Research Question

1. How, if at all, does the incorporation of a STEM career focus into the curriculum of a remedial Algebra 1 class at an urban community college:
 - a. Stimulate an interest into STEM?
 - b. Have an effect the pass rate?
 - c. Have an effect on the selection of the subsequent mathematics class?
2. How does a teacher action research and a STEM empowerment curricula:
 - a. Affect teacher practices?
 - b. Impact teachers' perceptions of their influence on their students?
 - c. Impact teacher's perceptions of their students?
 - d. Impact students' perception of their teacher?
 - e. Impact students' perception of the course?

CHAPTER 4

RESEARCH DESIGN AND METHODOLOGY

Setting

The setting is at an urban community college where I am a full-time faculty member in the department of mathematics. Springfield Technical Community College, STCC, has been designated as a Hispanic Serving Institution with 28% of the students identifying as Hispanic, 16% African American, 49% White, 6% other minorities. Furthermore 67% of full-time students received PELL Grants. Of those students 79% African American, 75% Hispanic and 69% white students test into developmental mathematics. Also, worthy of noting is that female students outnumber male students at a rate of 57% to 43% (STCC, IR, 2016).

Springfield is a city of 32 square miles and a total population of 153,703 people (U.S. Census Bureau, 2017). It is known as the city of homes for its Victorian mansions and numerous small homes, which were first constructed for factory workers. The population of Springfield has been pretty stagnant; however, the racial composition of the city is continually changing. In 2004, it was found that less than 70% of Springfield residents spoke English as their primary language, with nearly 24% of that population speaking Spanish. Springfield also has notable populations of Asian, Russian, and Ethiopian nationalities as well as other groups. The racial make-up of the city is approximately 56% white, 27% Latino, and 21% black with the balance made up of mixed race and other racial groups (Pioneer Valley Planning Commission, 2014).

Springfield is a city that has been over-run with financial and crime problems in the last few years. In 2004, the Massachusetts General Court created the Finance

Control Board (FCB) to take over fiscal responsibilities of the city. The FCB authorized a \$ 52 million loan to resolve the escalating financial crisis. The local city government has also been marred by corruption on all levels which has resulted in an FBI investigation that has brought many charges and convictions within the ranks of elected officials and supervisors throughout the system. In addition, the violent crime rate in the city is staggering. The violent crime rate was 19.2 per 1,000 people, this is approximately double that of other cities of comparable size (U.S. Census, 2000).

Poverty is an extremely serious problem in the city. The median household income for Springfield is \$35,742 and 20.7% families is headed by a single parent, (U.S. Economic Development Association, 2015) compared to \$68,563 at the state level and \$53,889 at the national level (U.S. Census, 2016). This is very clearly illustrated in the fact that more than a third of children in Springfield live in households with incomes below the Federal poverty line. It should also be noted that over 75% of the students in the public-school system qualify for free or reduced price lunch (Springfield Public Schools, 2017). Researchers have found that students living below the poverty level have a much harder time excelling academically than their more financially secure counterparts (Burney & Bielke, 2008).

In examining the education system in the city, it should be noted that MCAS scores have notably improved. Unfortunately, they remain between 10 and 20 points below the Massachusetts average. Besides the inordinately high percentage of low-income students we also have a school system where teachers have not had a contract for over two years and many very qualified teachers have resigned. Less than 80% of

teachers in the public schools are actually licensed in their academic area. In comparison, the state average is 94.4% (Massachusetts Department of Education, 2015).

The result of the children being “under-educated” in the K-12 system is seen in the adult population where only 17.8% of Springfield adults (over the age of 25) have a bachelor’s degree compared to approximately 41.2% of the state adult population, and 30.3% of the US population (U. S. Census, 2016). This is also reflected in the fact that the workforce in Springfield is concentrated in the service and sales occupations, such as medical assistants and receptionists. Very few have the educational background to hold a professional or management position. This also plays out in the community college where approximately two-thirds of all math courses offered are developmental, and nearly half of all English classes offered are developmental (including English as a Second Language, ESL).

Springfield Technical Community College (STCC)

STCC was founded in 1967 on the historic site of the Springfield Armory, which is famous for development of the Springfield rifle as well as other manufacturing innovations. It also was the site where Shay’s Rebellion was fought. The rebellion was an attempt to take over the arsenal and has been credited with being a catalyst for the signing of the United States Constitution. STCC is one of the largest community colleges in the state serving more than 8,000 students during the academic year and having more than 38,000 graduates since its inception. Furthermore, the college has agreements with several colleges including: University of Massachusetts, Amherst, Rensselaer Polytechnic Institute, Springfield College, Western New England University and more so

that the students can either take classes simultaneously at these colleges, or transfer after their associates' degree into the school as a junior to finish their bachelor degrees.

STCC has some other very unique programs in that it is the only community college in the country to have established its own technology park. It also has developed the Springfield Enterprise Center which is an incubator and accelerator for start-up companies. These companies are formed from both the STCC students through entrepreneurial programs, as well as the general city population who is invested in getting their idea off the ground, but is in need of a solid support system to get them going. This innovative attitude is reflected in their mission statement:

Springfield Technical Community College is a nationally recognized pace-setting leader in technology education and instructional innovation. With its myriad of degree and certificate programs in technologies, health sciences, business and engineering, the institution is the most comprehensive community college in New England. A highly-qualified faculty and advanced academic and technological facilities provide an exceptional learning environment. The college is committed to comprehensive institutional assessment and effectiveness. The philosophy and process of continuous quality improvement serve as the underlying foundation of all college programs and services. Springfield Technical Community College has a strong and recognized commitment to the economic development of the Pioneer Valley, Massachusetts, and the nation.

In alignment with the mission statement the college offers 40 Associate degree programs in the areas of: Arts, Humanities and Social Sciences, Business and Information Technologies, Engineering, Health, Math, Science and Liberal Arts. They also offer 25 certificate programs in such areas as Pharmacy Technician, Medical Billing and coding Specialist, Wastewater and Water Technicians, Commercial Driver License Training, Interior Design, as well as a host of Informational Technology (IT) classes.

The students at the college, for the most part, seem to grasp the idea that this is an incredible opportunity for them. A great deal of the population does not have anyone else in their family who have attended college and at times the pressure put on them by their parents can be overwhelming. The student body also has some very unique challenges that most four-year college students never face. The vast majority of students at the very least have a job, and typically they have jobs, and children and families depending on them. I view them with such a deep sense of respect as I watch them juggle all the priorities in their life so that they can attain their degree.

In response to this very diverse and stressed population, the school seems to be bending over backward to retain as many students as possible. There is a very active club system here ranging from chess club to the Gay Lesbian Bisexual Transgender Alliance (GLBTA). The disabilities office has been nationally acknowledged for their innovative work and the ESL program encompasses everything from reading and writing to teaching math courses in Spanish. Furthermore, there are counselors available to anyone without needing a referral to talk about all aspects of students, staff or faculty's life. I believe Deborah Meier in particular would applaud the efforts focused on small class sizes and personal connections with the students (Meier, 2000). The stronger the connection between students and faculty/staff translates into increased possibility that students will complete their programs and in turn raise their future prospects.

As was earlier noted a large percent of the population of Springfield falls below the poverty line. Statistically this translates to a large percentage of students enrolled at STCC fall below the poverty line. Between welfare reform, immigration reform and anti-affirmative action initiatives funding is at times scarce for the students. Additionally,

state education public school budgets are continually being cut, which makes it exceedingly difficult to remain progressive in funding innovative programs. There is also great pressure to maintain and increase enrollment as well as look for outside grants to fund essential programs. Kozol, 2012, would see this as just another way to maintain and increase the divide between the haves and the have not's. Public community colleges do not typically have large endowments as an insurance policy to maintain essential programming needs and academic services.

Overall, I believe that STCC is committed to providing a quality, inclusive environment for its student body as well as its staff and faculty. Diversity is an issue that is continually addressed throughout the college system. The goal seems to be to engage and educate each and every member of the community so that they may attain a quality education, while at the same time giving extra support to those students who need to fill in the gaps before they are ready to engage in college level material.

Participants

The course that the study took place in was Algebra 1 (developmental mathematics, non-college level). There were three classes that the intervention was carried out in and five classes used as a control. Faculty for the intervention classes were recruited individually, and selected based on their willingness to follow through on every aspect of the intervention. The full study was explained, along with assignments and data collection. There were interviews conducted to ensure the scope of the project was understood, and that there was a commitment to follow every aspect of the protocol. Faculty for the control were recruited on a strictly voluntary basis. An email was sent out to every faculty member (both full and part time) who was teaching Algebra 1 during the

spring 2016 semester, explaining the study and asking if they would commit to giving the pre/posttest, pre/post survey's, as well as share their final grades for the course. Initially the study called for three control and three intervention classes. But, upon reflection with my committee members and critical friends (faculty, doctoral students, and those who have recently completed their doctorate), a larger group was used for the control, to ensure an adequate sample size. Ultimately a total of six faculty members committed to these resolutions, of those six, one faculty member failed to follow through with the post/test and survey's so those students are not included in the study, with the exception of the pre/survey's as they were anonymous and could not be isolated out of the total.

The number of students in the intervention classes totaled 63. There were 104 students in the control classes. For each of the students, demographic information was collected: age, gender, placement scores and race. This study was quasi-experimental in that students were not randomly selected for the classes. There was no indication on the master schedule that the intervention classes would be any different than other Algebra 1 classes. Nor, was there any advertising that any study was to be conducted whatsoever. The students self-selected and were not informed of any differences until the classes convened.

The tenants of teacher action research (TAR) were employed for part of the study. TAR puts the teacher in the role of researcher, studying their own practice, examining learning process and adjusting curriculum design (Feldman & Capobianco, 2000). The outcome is a mutually beneficial relationship, where the students become stakeholders in the process, and the investigator is immediately informed on their practices, and can adjust accordingly. Students were explicitly told the reason for the experiment, and what

we are hoping to gain, and classroom conversations revisited the goals throughout the semester.

The benefit of this approach was that all aspects of the class could be reported on and analyzed. This method allows for insight into context-based knowledge that could not be garnered strictly from a quantitative lens (Flyvbjerg, 2006). Thus, this genre allows for an in-depth analysis examining the interactions, attitudes, and the atmosphere of the classes. The obvious drawback is that as the researcher and teacher, it is extremely important to make sure that data is collected and analyzed in a way that retains validity and accuracy and not what I want them to be. To ensure validity, the use of other professors, student feedback, my advisor and committee, as well as critical friends (which consisted of graduate students and professionals who have received their doctoral degrees) were imperative, along with the artifacts that were collected. Furthermore, interviews and focus groups were conducted.

Variables and Hypotheses

The purpose of this study was to ascertain the effects of a STEM focused curriculum on students' achievement, retention, and attitudes towards STEM. The independent variable is the STEM focused curriculum. There are three dependent variables for this study: pass rates, STEM interest, and subsequent course selection. The hypothesis is that explicit exposure to STEM careers/pathways will lead to a higher pass rate in the course and a greater affinity towards STEM. The confounding variables to be examined are race, gender, and course placement.

Data Collection

Control and Intervention Classes

Surveys

The surveys that were administered to the students was the peer reviewed S-STEM Student Attitudes toward STEM™ survey that was designed and tested from North Carolina State University (Friday Inst., 2012). Cronbach's alpha was used to show internal reliability of the instrument, with question items ranging from 0.89 to 0.92. This survey was designed to examine students' attitudes toward mathematics, science, technology, engineering and knowledge of STEM careers.

The survey consists of a total of 49 questions. The first 37 questions ask students to respond on a five point Likert scale ranging from strongly disagree to strongly agree about their personal feelings towards STEM and 21st Century Learning. Eight of those questions are pertaining to math, an example of a math question is "Math has been my worst subject". There are nine science questions, nine engineering and technology questions, and eleven 21st Century Learning questions. 21st Century Learning is defined as the confidence and communication skills, directed at both collaborative and independent learning (Jerald, 2009, Friday Inst., 2012). For sample one question reads "I am confident I can include others' perspectives when making decisions".

As stated above, the surveys were scored on a five-point Likert scale. Some of the questions were worded positively, while others were worded negatively. For the final analysis, the negatively worded questions were adjusted to ensure the data was consistent, as outlined by the authors of the study. Ultimately a five on the scale was the strongest possible positive result, and a one was the strongest negatively viewed outcome.

The last twelve questions are under the category "Your Future". For each of the twelve subject areas, a brief definition of what is involved in the discipline, and sample

careers are provided. The categories are: physics, biology and zoology, veterinary work, mathematics, medicine, earth science, computer science, medical science, chemistry, energy, and engineering. For example, the medical science category is defined as researching human disease and searching for solutions to health problems. Some of the careers listed are Laboratory Technician, Epidemiologist, and Biomedical engineer. There was a four-point Likert scale for these questions. The choices are: not at all interested, not so interested, interested, and very interested. The same survey was given at the beginning and end of the semester. That was true of both the control and intervention classes.

Pre/Post Test

In both the control and intervention classes, the exact same exam was administered both at the beginning and end of the semester. This is a twenty-five-question test that covers all of the course competencies of the algebra one course. This exam was a department exam, that is still in use. Thus, the exam is not presented in the appendix. This test is administered, at the beginning of the semester, usually the first class, for all the developmental classes. If students score an 80 or above on the exam, they are given the option of moving up to a higher-level math class, thus shortening their developmental sequence. These scores were used to record student's progress, as well as to gauge if there was a difference in the level of preparedness of the students upon entrance to the classes.

Subsequent Math Class

The ensuing math classes were tracked for each student in the eight classes. Students may take a college level, terminal mathematics class after this course. The

options are liberal arts math, specifically statistics or math for a modern society. But, if students are interested in STEM fields they must go on to take algebra two, another developmental mathematics class, to be qualified for a college level STEM Pathway math course. In essence, extending their developmental sequence. A frequency table, exclusively including the number of students who passed, was conducted looking at the percentage of students who choose either the terminal or the pathway course, from the control versus the intervention classes.

Focus Groups

There were two focus groups conducted during the fall semester of 2016. The students were emailed and asked if they would consider participating in the focus groups. They were told that there was no obligation to participate, that their identity would be confidential, and a ten dollar Dunkin' Donuts gift card would be provided for their participation. At the beginning of the focus group, informed consent sheets (appendix E) were distributed, and at the conclusion of the focus group gift cards were distributed.

One group was with students in the control classes, with five student participants. The other was with six students of the intervention classes. The focus group questions were:

1. What were your overall feelings about your Algebra 1 class from last semester?
2. Do you think it prepared you for your next course?
3. Do you think there are enough resources to help you be successful?
4. Do you feel your teacher was invested in your learning?
5. Do you think your algebra one class had any effect on the subsequent course you took?

6. Did it make you think about career pathways or majors?
7. What would you like to see different/changed?
8. Anything else that you would like to share?

The one exception to the questions was a sub-question was added for the Intervention group for question one. They were asked their feeling about the STEM focus to their algebra class.

Intervention Classes

Letter of Introduction and Informed Consent. At the start of the semester, the students were given a handout (appendix A) that explained the supplementary goal of the course, which was to increase exposure to and participation in STEM. This letter defined what STEM is, expressed that the assignments would have a career focus, but the content/mathematical concepts would be the same as all Algebra 1 classes. There were also two copies of the informed consent form (appendix B), one for the student to keep and one to sign and return. If a student chose to opt out they were given the opportunity to be transferred to a standard Algebra 1 class with no penalty. There was also an informed consent for the faculty participating in the study (appendix C). It should be noted that no students chose to opt out and switch sections out of the intervention classes.

Intervention course design

Career Assignment. One major assignment of the intervention class was the career activity that each of the students researched. This assignment had two purposes. The first was to introduce students to careers that they may have no prior knowledge (Appendix E). This activity had the added benefit of reinforcing students written and oral communication skills that are a necessity as they enter the workforce (Scutt, Gilmartin,

Sheppard & Brunhaver, 2013). It was also chosen as a way to develop agency, and develop both student and STEM identity. The assignment requires the students to research a particular career outside of class. This career was randomly assigned to them (we pulled careers out of a paper bag). They then wrote a brief description of what the job entails, the level of mathematics and the level of education (associates, bachelor's masters, doctorate) needed to be qualified for the position. They also reported on the average salary of the position, and regional job availability.

The goal of this assignment was to introduce students to career options in STEM disciplines. In order to keep students on track and be able to find the requested information, the following websites were proposed as resources. These websites were selected for both ease of use, and completeness. The goal was to have them be able to find the information without searching multiple websites.

Mini-Assessments

To further examine the students understanding of the mathematical concepts that we study, five mini-assessments (Appendix F) were distributed in all of the intervention classes. The purpose of these assignments was to look at mathematical principles in a contextual way, and foster students' communication and mathematical reasoning skills, leading to student success. One such assignments follows:

- An urban planner has 6 weeks and \$500,000 to revitalize a park that was destroyed during the tornado for the grand opening and ribbon cutting ceremony. She has narrowed it down to two bids: Company A says it will take 5 weeks and they charge \$220,000 for labor, \$275,000 in materials. Company B says it will

take 6 weeks, with \$180,000 in labor and \$300,000 in materials. Which company do you think she should go with and why?

Panel

One panel was held that all students in the intervention classes attended. This panel consisted of graduate students from under-represented groups in STEM. The rationale for the panels was to develop a STEM identity by being able to engage with students of color in STEM who can share their path and experiences in pursuit of their graduate degree. There were three graduate students in various phases of their academic career. One student was in her first year of graduate school, one was in her fourth year, and the last had just successfully defended her dissertation. The panel served dual purposes: first, students would hear about the prospective paths that each participant traversed to get to the point where they are in their academic careers. Secondly, students would be able to ask questions of the panelist to gain a better insight into what it takes to get to the point the panelist are within their career, as well as make a personal connection. The questions for the panelist follow:

1. Please briefly introduce yourselves, what program are you in, which year, and your research topic.
2. What was the hardest part of getting to where you are now, how did you persevere?
3. What advice would you give to someone just starting out?
4. Have you ever suffered from imposter syndrome, and if so how did you deal with it?

5. Did you have support from your family/friends?
6. Did you feel as if you were prepared for graduate school?
7. What made you interested in the topic/area that you are studying?

After the panel, students were given a short questionnaire asking for their feedback. The first question was “How do you feel about the panel (what did you like, what didn’t you like)?” The second question was “Do you have any questions that were not answered?”. This data was collected, recorded and coded, and analyzed in conjunction with the other qualitative data.

A second panel was scheduled to take place that included professionals from under-represented groups who are working in STEM fields. Unfortunately, because of weather issues, it had to be canceled and was not able to be re-scheduled. The goal of this panel was to further expose the students to people of color who have successfully entered the world of STEM. And, to have the panelist encourage them to pursue a STEM pathway, furthering reinforcing the tone set in the classroom.

Teacher Reflections

During the course of the semester, the teachers of the intervention classes kept reflective journals on a bi-weekly basis. The journals were incorporated to gauge how faculty were viewing their students, and to capture any noteworthy moments in the classroom. It also was a way to gauge the idea of care from the faculty perspective. The guiding probes for the journals were:

1. Any significant incidents
2. Classroom happenings/atmosphere
3. Challenges/Issues/Positive Events

4. Teachers' personal reflections (interpretations of events)
5. Teachers feelings

Furthermore, at the end of the semester a debriefing meeting was held with all instructors of the intervention classes, and those results were also recorded and coded, along with the journals. The interview protocol for the debriefing follows.

Teacher Interviews – end of semester (Adopted from Bonner, 2006)

1. What did you learn from the action research project?
 - a. about teaching math?
 - b. about your students?
 - c. about yourself?
 - d. about the process?
2. What did your students gain?
3. What was frustrating to you in the process?
4. What was exciting?
5. What would you do differently next time?
6. Would you do an action research project again?
7. What would you say to a teacher considering taking on an action research?

Researcher Personal Profile

I am an African-American wife and mother of two sons. I am also a math professor at Springfield Technical Community College, and have been there for eleven years. Although I teach all levels of mathematics, the majority of my time is spent teaching developmental mathematics classes. In those classes I find a disproportionate number of low-income, African-American and Latino students, who often do not make it

through the course. Those at greatest risk are men of color. I see these young men and cannot help but think of my own sons, and what it will take to give them the foundation they need for success. I firmly believe that these students' failure is not a direct result of ability, but more a result of the failure of the system.

The courses that under-prepared students are forced to take, which are not for college credit, are often viewed as demeaning as well as major obstacles in receiving a degree or certificate. I often encounter students who feel that the process is too overwhelming to even try. If they don't feel they can be successful, they often disappear never to be seen again. I find myself being an advisor, counselor, and cheerleader encouraging students to go through the process because in the end it will be worth it. I often get frustrated at how we tend to talk *at* the students, in much the same way they were talked at in their high school career, but somehow now they are going to be engaged, understand perfectly and progress through their college career.

The subject I am interested in is not commonly considered inflammatory in general, but I am aware that some people may have a problem with devoting resources to this particular population. There are also some of my colleagues who would take offense at the questioning of how their classes could/should be run. Therefore, I am very aware of the audience as I share my findings.

Profiles of additional participating faculty

The other two faculty carrying out the intervention classes were both white women who are veteran teachers. One has been at the college for 22 years and the other for 28 years. They have both been involved in numerous initiatives at the college, and are strong supporters of increased student success and creating an equitable classroom.

In particular, both professors, as well as myself, were an integral part of the Achieving the Dream initiative. This national initiative, driven by the Lumina Foundation is aimed at increasing student success at community colleges. STCC is now in its' ninth year of association, although not actively pursuing new initiatives.

Data Analysis

Upon completion of the semester, for the quantitative analysis, several methods were employed. Both Excel™ and Stata™ were used for the data analysis. These particular software programs were chosen because the researchers who created the survey used in this study, recommended Excel for survey analysis, and used Stata to analyze the regression models to validate their instrument. Furthermore, I consulted with the Institute for Social Science Research (ISSR) at University of Massachusetts, Amherst, and they also recommended the Stata software. Correlations, and regression with analysis of covariance (ANOVA) were carried out to ascertain the strength of the relationships between gender and ethnicity with pass rates and course selection. There was also an analysis of pre/posttest gain scores, and course completion versus dropout rate.

For the qualitative analysis, the data was coded using schemes from Bogdan & Biklen (1997). Coding categories were proposed under several categories, which I adapted into my original coding categories: setting/context – how one sees themselves as a participant in a developmental class at an urban community college. The second is situation - how ones sees themselves in their roles as teacher and student. Next is subject perspective - the shared rules and norms within the classroom. The fourth area is subject ways of thinking - how do teachers view students and students view teachers, as well as views about the material being covered. Following that is processes - how students and

teachers attitudes and views change over time, in relation to the course and interpersonal relationships.

The sixth category is activity – class attendance and participation of the students, including small group collaboration and whole class activities. The seventh category is event – activities that occur in the subjects lives that effect classroom setting. This is followed by strategies – techniques used to manage task, such as homework, and test taking. The final category is relationship and social structure – this consists of social and formal cultural relationships.

Interviews, feedback from the panel, focus group records and journals were typed and numbered to begin the analysis process. Next was the process of thoroughly reading through the data twice, as prescribed by Bogdan & Biklin (1997) in order to grasp the totality of the documents. During these readings preliminary categories were noted, that fell under the categories noted above. All of the typed data was then entered into Nvivo™ and coded on the sentence level. Nvivo™ is a qualitative computer software program that enables researchers to organize, code and analyze data. It allows for the data to be sorted and coded under multiple categories, as the researchers identifies them. From those preliminary codes, other themes emerged, and the categories were refined.

For instance, after the initial sorting, and while refining the codes the word more surfaced multiple times students as well as the professors alluded to wanting more contextualized problems, and that developed into one of the new categories. After several iterations, the following themes were identified: Math in context, the more the better. This developed from several different categories, mainly subject perspective, subject ways of thinking, and activity codes. Next was increasing interest increases success and

motivation. The categories this came out of were activity and subjects' way of thinking. Then the theme of frustrations surfaced, both on the faculty and student side. I found this setting/context, events, strategies, and processes. The next category addressed how teachers and students are equally important. This was most evident in relationship and social structure, subject perspective, setting/context and situation. Lastly, the frequency of contact between teachers and students was identified. This was evident in subject ways of thinking, strategies, and relationship and social structure.

Finally, the results were then triangulated. From this original coding, based on interviews, journals, and focus groups, the data was sorted into themes, and re-examined, reviewed and deliberated with faculty to substantiate validity. This process was iterative in that it started with informal check-ins during the semester. After the conclusion of the semester, interviews were held to get feedback and the journals were collected for analysis. Lastly, after the initial findings were analyzed, they were given to the faculty participants to get feedback as to whether they thought an accurate depiction of the occurrences, and that the themes were authentic.

CHAPTER 5
DATA PRESENTATION

Table 1 reflects the racial make-up at the beginning of the semester before any withdrawals. There is a greater percentage of minorities in these developmental classes than in the college as a whole. Blacks and Hispanics collectively make up 44% of the college population, and for these classes they made up 64% of the intervention and 69% of the control classes. The college had approximately 8,550 students during the 2015-16 academic year (Springfield Technical Community College, 2017). In contrast, the white students make up 49% of the college, but only 35% and 29% respectively for the intervention and control classes. This trend of higher minority representation in developmental education, is college wide, as noted earlier when discussing the setting.

Table 1: Racial profile of students

	Total	Black	Latino	Caucasian
Intervention	63	27 %	37 %	35 %
Control	104	34 %	35 %	29 %
College	8,550	16 %	28 %	49 %

In order to gather data from the students, in response to the research questions based on STEM interest and goals, the S-STEM students' attitudes toward STEM survey was administered at both the beginning and end of the semester. The survey results are reported in two sections. The first section is about attitudes towards four areas of STEM: math, science, engineering and technology, and 21st century skills. Table 2, shows the mean of the categories that addressed each of the four areas of math, science, engineering and technology, and 21st century skills that were from the pre-survey. The responses for each question consisted of a five point Likert scale. The choices were: Strongly

Disagree, Disagree, Neither Agree nor Disagree, Agree, or Strongly Agree. The aggregate of the categories is reported, as the authors of the survey state that it is not significant on the question, but on the categorical level. It should be noted that there are more students in the control STEM attitudes survey than reported above. This anomaly is because of the collection of the sixth control class pre-survey's but the faculty from that course submitted no other information, and those students were excluded from any further data. However, because of the anonymity of the survey's and how they were collected (the surveys were deposited in a mail slot), those surveys could not be identified and removed.

Table 2: STEM Attitudes – Pre-Survey

STEM Attitudes	Intervention (n=49)	Control (n=119)
Math	2.798	2.993
Science	3.215	3.162
Engineering & Technology	3.206	3.250
21 st Century Skills	4.224	4.060

Frequency charts were also constructed to illustrate the distribution of the selections. Chart 1 shows the four attitudes that were surveyed. On the x-axis, the horizontal axis each section represents the four areas of STEM measured. The first interval is math followed by science, engineering and technology and finally 21st century skills on a five point Likert scale. The first set of bars in each category would correlate to the most negative attitude and the fifth bar in the category correlates to the strongest affinity. On the y-axis, the vertical axis, the values were tabulated with the amount of responses for each question in a category. For example, the highest value attained was for the 21st century learning category. There are eleven questions in that section, with

one hundred nineteen respondents in the control group which lead to 782 responses of four on the Likert scale. The math category had eight questions, and both the science and the engineering and technology categories contained nine questions each.

The distributions for math, show a more normal distribution in the intervention group than the control class. The control group has a higher propensity on the onset, as the majority choose three or four in their attitude towards math. The science category mimic each other in terms of shape, this is also true for engineering and technology as well as 21st century learning. It should be noted there were no 1's marked on the survey in the intervention group in the 21st century learning category, and only two ones scored in the control group. The intervention group had two responses of two on the Likert scale while the control had twenty responses of two. This by far was the most positively favored category on the survey.

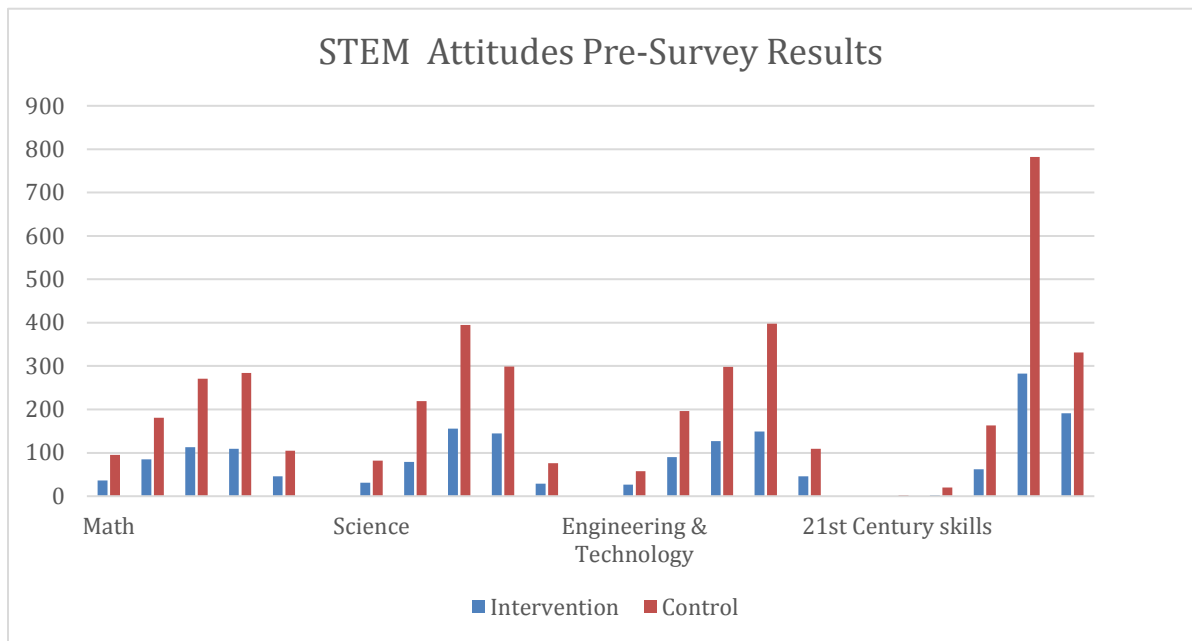


Chart 1: Distributions of the affinity for the four areas of STEM, pre-survey

At the end of the semester, the same protocol was carried out with the administration of the post-test, which was the same instrument as the pre-test. Students were given the surveys to fill out as they waited for their exams to be graded, and turned them in when they received their scores. There was quite a large mortality in the post-survey's. Students did not show up at assigned times to take their exams, thus some were administered at a different time, and faculty did not redistribute them. There was also the problem with students not wanting to complete the survey, and if they chose not to there was no penalty, or reward, if they did complete the survey. Yet, because of this, it can be argued that the populations were more equivalent in comparison.

Table 3: STEM Attitudes Post-Survey

STEM Attitudes	Intervention (n=31)	Control (n=33)
Math	3.246	2.966
Science	3.244	3.162
Engineering & Technology	3.333	3.071
21 st Century Skills	4.243	3.893

Because of this mortality, the actual numbers can be compared for the post survey. The math questions are more normally distributed for the intervention class than the control group. Although the mean is higher, there are more people in the control with a four rating than the intervention. The science distribution mimic each other as does the engineering and technology. Although the intervention mean is higher on both. Lastly the 21st century skills remain high for both groups, but again with and two people choose two compared to fifteen who choose two in the control group. Also, the control scored more fours while the intervention scored more five's.

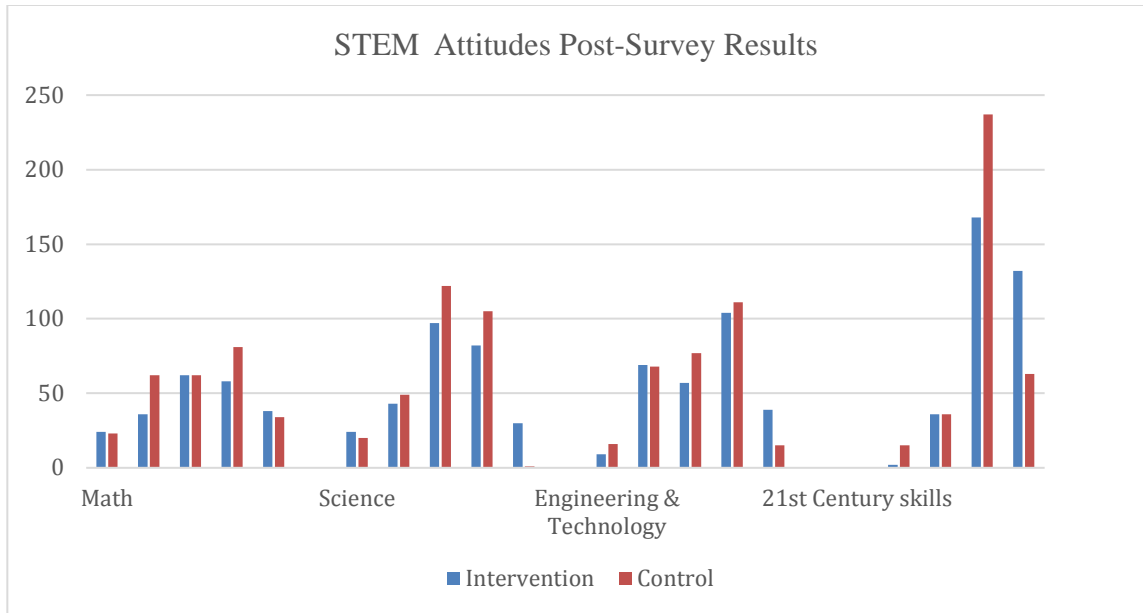


Chart 2: Distributions of the affinity for the four areas of STEM, post-survey

Regarding the S-STEM students' attitudes toward STEM survey, the pre-survey showed little difference in the intervention versus the control classes (Table 4). The control was roughly two/tenths higher for math, less than one/tenth lower for science, relatively even for engineering and technology, and the intervention was nearly two/tenths higher for 21st century skills. When looking at these same categories at the post survey, there was a more substantive difference in some areas. The least change was in Science, with the change of affinity between the groups merely three/hundredths. The control group, had no change in the mean score for science attitudes. It remained at 3.162. The intervention class increased 0.029 from 3.215 to 3.246. The greatest change was in the math attitudes. The students in the control had a slight decrease in math attitudes with a mean dropping from 2.993 to 2.966. By contrast the students in the intervention increased from 2.798 to 3.246 on their math attitude scale.

Upon examination of 21st century learning skills, the intervention class remained relatively steady with 4.224 pre, and 4.243 post. The students in the control class, had a

slight decrease with 4.060 pre, and 3.893 post. Engineering and Technology had the second largest difference with the intervention rising from 3.206 to 3.333, and the control falling from 3.250 to 3.071.

Table 4: STEM attitude comparisons

Difference in Survey Results Intervention mean minus the Control mean	Beginning of Semester	End of Semester	Semester Change
Math	- 0.195	0.28	0.475
Science	0.053	0.082	0.029
Engineering & Technology	- 0.044	0.262	0.306
21 st Century Skills	0.164	0.35	0.186

The next grouping of questions from the STEM survey described in some detail what the named career field entailed and gave specific examples of careers in each of the fields. Students were then asked to indicate, on a four point Likert scale their interest. The choices were: not at all interested, not so interested, interested, very interested. Table 5 shows the mean responses for both the intervention and control classes at the beginning of the semester, table 6 contains the end of semester results.

Table 5: Future Career Interest-Pre-Survey

Your Future	Intervention (n=49)	Control (n=119)	Difference of means - Intervention minus Control
Physics	1.959	1.723	0.236
Environmental Work	2.224	1.891	0.333
Biology and Zoology	2.429	1.958	0.471
Veterinary Work	2.286	1.832	0.454
Mathematics	1.857	1.756	0.101
Medicine	2.633	2.210	0.423
Earth Science	2.163	1.790	0.373
Computer Science	2.204	1.815	0.389
Medical Science	2.510	2.109	0.401
Chemistry	1.980	1.731	0.249
Energy	2.061	1.866	0.195
Engineering	2.061	1.916	0.145

Table 6: Future Career Interest-Post-Survey

Your Future	Intervention (n=31)	Control (n=33)	Difference of means - Intervention minus Control
Physics	2.129	1.970	0.159
Environmental Work	2.387	2.000	0.387
Biology and Zoology	2.516	2.061	0.455
Veterinary Work	2.258	1.727	0.531
Mathematics	2.323	1.848	0.475
Medicine	2.839	2.273	0.566
Earth Science	2.419	1.848	0.571
Computer Science	2.226	2.121	0.105
Medical Science	2.581	2.091	0.49
Chemistry	2.258	1.879	0.379
Energy	2.323	2.000	0.323
Engineering	2.323	2.091	0.232

For the beginning of the semester, the largest differences were in biology and zoology, veterinary work, and medical science. The intervention classes had higher means on interest in all categories. The mathematics was relatively low in both groups with 1.857 intervention and 1.756 control. The two other lowest means were in physics and chemistry. For the post survey, the largest gain for the intervention was in math careers, the mean went up nearly a half a point. Conversely, the control group had less than a tenth increase in mathematics. Veterinary work went down in both groups, and medical science decreased in the control group. Table 7 illustrates the change from the post-survey less the pre-survey for the twelve categories.

Table 7: Change in means for pre and post survey

Post minus Pre	Intervention	Control
Physics	0.17	0.247
Environmental Work	0.163	0.109
Biology and Zoology	0.087	0.103
Veterinary Work	-0.028	-0.105
Mathematics	0.466	0.092
Medicine	0.206	0.063
Earth Science	0.256	0.058
Computer Science	0.022	0.306
Medical Science	0.071	-0.018
Chemistry	0.278	0.148
Energy	0.262	0.134
Engineering	0.262	0.175

The intervention class also had roughly quarter point increase of mean in earth science, chemistry, engineering and engineering. Notably, during the course of the semester, all of these topics were touched upon within the contextualization of the math class. The largest gain for the control group was in computer science at 0.306 and physics, at 0.247.

After looking at STEM interest, the subsequent course selection, and pass rates were also a part of the research questions. Of the students who finished the course (with a letter grade of A, B, C, D or F) students pass rate and subsequent math class was tracked. Table 8 illustrates the pass rates (defined as a C or better) and subsequent class. The students from the intervention class passed at a rate of 69% versus 49% for the control classes. For the subsequent math course, Algebra 2 or terminal college level course, the intervention class had nearly twice as many (percentage wise) students continue on a possible STEM pathway with 29% to 15%.

Table 8: Pass rates and subsequent STEM Pathway course

Students who Finished the course	Pass rate	STEM follow up rate
Intervention	69%	29%
Control	49%	15%
All Algebra 1 students	64%	

A Chi-square test was run to determine if the difference in the pass rates was due to chance, or if it is significant (Table 9). In this case, the probability is $0.0299 < .05$ so we must not reject the idea that the higher pass rates in the intervention is merely chance.

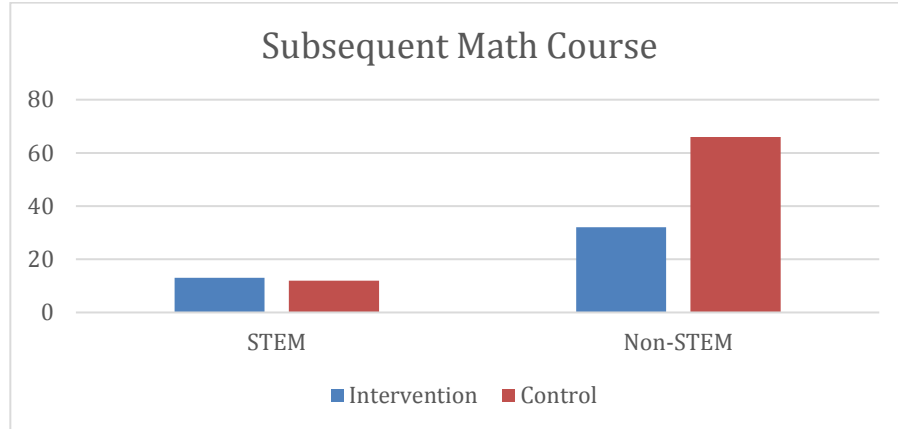
Table 9: Chi-square test

	pass	fail	total
Intervention	31	14	45
Control	38	40	78

Chi-square = 4.714, p-value = 0.0299

Chart 3 shows the frequency distribution of those students who went into the second level of developmental math, which would have them eligible to take STEM courses, versus those who did not. The frequency of the STEM group is nearly identical between the intervention and control (thirteen versus twelve respectively), but there is a significant difference in those who did not take the STEM class. The intervention class had thirty-two students who took a terminal non-STEM math course while the control class had sixty-six. As a result, the percentage of students from the intervention class who took the STEM follow up class is nearly doubled (29% versus 15%.)

Chart 3: Subsequent math course selection



Along with pass rates, persistence rates of both those control and intervention, and algebra one students as a whole, were calculated. Table 10 represents outcome information, addressing those who withdrew, and showing pass rates of those who began the course versus those who completed the whole course, and received a final grade.

Table 10: Enrollment and breakdown of outcomes

	Started	Withdrew	Finished	% Finished	Passed	Pass rate (of finishers)	Pass rate (of starters)
Intervention	63	18	45	71%	31	69%	49%
Control	104	26	78	75%	38	49%	37%
All Alg 1	553	81	472	85%	304	64%	55%

After recording, calculating and the initial inspection and analysis of the data, it was important to determine if there was statistical significance, as well as determine the strength of such effects of the relationships between the variables. There were multiple aspects of each student, demographic and otherwise, that were collected, that could be examined to try and understanding confounding factors.

To this end, initial correlations were run to gauge if there was an association between factors. Table 11 looks at gain scores, gender, age, placement (whether arithmetic, which is a developmental class preceding algebra one, or directly into algebra one), and whether the student passed or not. The strongest correlations, although not remarkable, related gain scores and pass rates, and placement with pass rates. There was also a stronger correlation with males and higher placement rates. Yet, a slight negative association with males and in terms of gain scores as well as pass rates. The intervention class had negative correlations in every aspect except for pass rates.

Table 11: Correlations measures

	Gain	Gender	Age	Placement	Pass
Gain	1.0000				
Gender	-0.0634	1.0000			
Age	0.1764	0.0186	1.0000		
Placement	0.0613	0.2402	0.1407	1.0000	
Pass	0.2505	-0.0059	0.0995	0.2846	1.0000
Intervention	-0.0239	-0.1271	-0.0130	-0.1481	0.1015

In table 12, students pass rates were correlated with regards to race (white, black, and Hispanic), whether student was in the intervention versus the control classes, and they were also correlated amongst the different variables. The most significant correlation was that black and Hispanic students performed significantly worse compared to white students (both at -0.5107). This unfortunately is reflective of the pattern overall, and despite the intervention this data suggests that much more has to be done to diminish this achievement gap. There was a positive correlation with the intervention and pass rate, albeit small, as well as for white students and the pass rate as well as the intervention. After viewing the correlations, the next step was to see if there was statistical significance with the data.

Table 12: Correlations race and intervention

	Pass	Intervention	White	Black	Hispanic
Pass	1.0000				
Intervention	0.1015	1.0000			
White	0.1684	0.1116	1.0000		
Black	-0.1438	-0.1645	-0.5107	1.0000	
Hispanic	0.0031	0.0664	-0.5107	-0.4545	1.0000

Both linear and logistical regressions were run to determine if there was a statistically significant effect on the pass rate involving the following factors: control group, race, age and gender. The first is the multiple linear regression (Table 13). The only factor that was statistically significant was placement. If this is the students second semester of developmental education, they have less of a chance to pass (although they have successfully passed the previous course with a C or better). There is also a negative association with being in the control and males passed at a lower rate than females. When we examine race, Whites performed the best, followed by Hispanics, and lastly Blacks.

Table 13: Multiple Linear Regressions

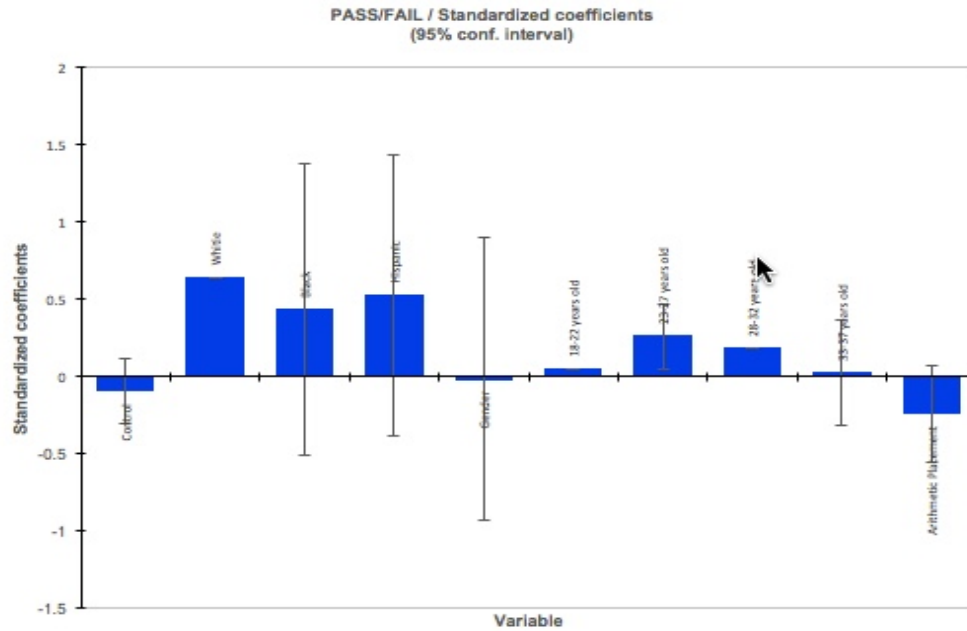
Source	Value	Standard error	t	Pr > t
Intercept	0.300	0.504	0.595	0.553
Control	-0.089	0.098	-0.901	0.370
White	0.610	0.453	1.345	0.182
Black	0.429	0.452	0.947	0.346
Hispanic	0.523	0.455	1.150	0.254
Gender	-0.015	0.099	-0.148	0.883
18-22 years old	0.046	0.167	0.277	0.783
23-27 years old	0.312	0.190	1.644	0.104
28-32 years old	0.321	0.232	1.385	0.170
33-37 years old	0.105	0.478	0.219	0.827
Arithmetic Placement	-0.243	0.109	-2.239	0.028

The data was then standardized, by taking the values minus the mean and divided that by the standard error, to a 95% confidence interval and examined (Table 14) and the standardized effect size is show in Figure 3. As far as the age of the student, the youngest and older the student, the less chance that the student will pass the course. The logistical regressions supported the findings of the multivariable linear regressions, still without statistical significance outside of placement. Each bar represents a confounding variable being measured to determine effect size on the independent variable, which was pass rate. Those coefficients that are above the axis have a positive coefficient, or a positive effect on pass rates. Those beneath the axis have negative coefficients, or a negative effect on pass rates. The further the distance from the axis, the stronger the effect.

Table 14: Standardized multiple linear regression

Source	Value	Standard error	t	Pr > t
Control	-0.094	0.104	-0.901	0.370
White	0.639	0.475	1.345	0.182
Black	0.433	0.457	0.947	0.346
Hispanic	0.528	0.460	1.150	0.254
Gender	-0.015	0.105	-0.148	0.883
18-22 years old	0.048	0.173	0.277	0.783
23-27 years old	0.259	0.158	1.644	0.104
28-32 years old	0.182	0.131	1.385	0.170
33-37 years old	0.023	0.106	0.219	0.827
Arithmetic Placement	-0.241	0.108	-2.239	0.028

Figure 3: Standardized coefficients of linear regression model



Next was the logistical analysis, which showed similar findings, the only fact that was statistically significant was placement. The standardized data can be found in Table 15. Blacks and Hispanics have a negative coefficient compared to whites, and it is more evident that younger and older students fair the poorest in terms of passing.

Table 15: Standardized logistical regression

Source	Value	Standard error	Chi-Square	Pr > Chi ²
Control	0.000	0.000		
Intervention	0.123	0.141	0.760	0.383
Black	-0.257	0.155	2.729	0.099
Hispanic	-0.156	0.161	0.941	0.332
Gender	0.062	0.145	0.182	0.670
18-22 years old	0.000	0.000		
23-27 years old	0.315	0.165	3.644	0.056
28-32 years old	0.276	0.230	1.441	0.230
33-37 years old	-0.072	0.137	0.273	0.602
Algebra 1	0.388	0.176	4.852	0.028

From the quantitative data, several of the research questions were addressed (see question Q1a, Q1b, Q1c below). Yet, there was variability in the data, and not always statistically significant, which is why the qualitative data that was collected and analyzed is critical to answering the research questions.

Qualitative Findings

From the qualitative data collected (teacher journals, focus groups, individual interviews, and panel feedback) a thorough analysis was conducted and the following themes developed. In the interest of clarity, themes will be addressed, and the research questions will be referenced by number:

Q1a: How, if at all, does a STEM empowerment curriculum stimulate interest into STEM?

Q1b: How, if at all, does a STEM empowerment curriculum effect pass rates?

Q1c: How, if at all, does a STEM empowerment curriculum effect subsequent course selection?

Q2a: How, if at all, does teacher action research and a STEM empowerment curriculum affect teacher practices?

Q2b: How, if at all, does teacher action research and a STEM empowerment curriculum impact teachers perceptions of their influence on their students?

Q2c: How, if at all, does teacher action research and a STEM empowerment curriculum impact teachers' perceptions of their students?

Q2d: How, if at all, does teacher action research and a STEM empowerment curriculum impact students' perceptions of their teachers?

Q2e: How, if at all, does teacher action research and a STEM empowerment curriculum impact students' perceptions of the course?

Math in context increases interest – more is better (Q1a)

There was increased interest in math, and engineering and technology with the students of the intervention class. The discourse in the classroom was intentionally explicit about why the math was important, the applications, and the careers for which it can open doors. During the exit interviews the professors discussed the design of the course, and how purposely talking to the students about careers and their future was fruitful as Professor M states “It opened up conversation in the classroom and everything else. I might have said a few things when I was doing a problem in the past, but this was different.”

Professor A follows “Yeah, I think I thought more consciously too, like yeah, you see this and what class were we talking about a concept, and keep linking it back to careers and classes they might need to take. I was definitely more conscious of trying to make those connections than I think I have in the past.” This exposure to different careers and putting the math in context was well received. Professor A journaled “They seem to appreciate the dialogues we have had about careers and equity issues.” As the students were reminded that there is not much diversity in the STEM fields, in terms of gender, race, and ethnicities.

This was not only true of the instructors, but was reflected in student feedback from the intervention classes. In the focus group with students from the intervention class Tiffany states “I think it was helpful, when people are going into college for something, I feel like it’s a basic thing and people don’t expand their search into broader

subjects, so when we had the assignment, it was like hey this is good money, it made me think about things.” While Carlos added “I know what I want to study, but I think it was good to give people ideas.” Professor A added in her journal “the students seemed genuinely excited about the study. They liked the fact that I was introducing them to careers that they had no knowledge of and that I believed that they could attain.”

In conjunction with the positive feedback, a theme that emerged from the analysis of journals, teacher interviews, panel feedback, and focus groups was that not only was interest increased, but there was an overall feeling of not enough was incorporated. Sam stated in the focus group “yeah, that was cool, but I wish we had gotten more of it. If they made the career thing, make it more of a project thing, where they really read and presented I think that would be good.” This sentiment was echoed by Carlos and Yadi, who “definitely” agreed. In the exit interview Professor K stated “I thought the career activity was probably one of the bests ones for them. One of the most eye opening for them, it opened up conversations in the classroom.” There were so many fields and jobs, that they had never heard of, and that the contextualized problems were more interesting, and engaging. All involved (teachers and students) repeatedly stated that they learned about things they had never heard of before.

While undertaking course design, there was a deliberate attempt to not over-tax the faculty involved in the intervention. All the while, ensuring that the research questions of the course were thoroughly examined. As the projects were designed, and vetted through both the faculty teaching the classes and other STEM faculty, there was concern that the mini-assessments might be too time-consuming, and have a negative effect on completing the material. It quickly became obvious, during the implementation

of the intervention, that this was not a concern, and that there should have been more problems incorporated, as the students and faculty, felt they were a great asset to the class, and to greater understanding of the material.

One problem in particular had Professor M very excited as she stated in the exit interview:

“Even that Cab problem I have never done that first of all. I was amazed at that. I was amazed before we even started graphing and we did this cab problem and they knew right away. They knew it. I was amazed at how many people were involved and knew it.”

For reference the following is the cab problem:

A taxi company charges a base charge of \$2.50 and an additional \$0.50 per mile.

- a. Express the cost, C , of the taxi in the number of miles, m , that a person may travel.
- b. Complete the table, use at least four values:

m	C

- c. Choose an appropriate equation. scale for the axes, and graph this
- d. What does the slope of the line tell you? What about the y-intercept?
- e. You live 13 miles away and have \$10, do you have enough to get home?

This enthusiasm was also present in her journaling as she wrote “Loved the career part of the class. I think more exposure and more problems would have helped one of my students asked were we going to do more.” she went on to write “They seem to like the word problems, now I wish we had more of them.” And during the exit interview Professor K stated “I would have a few more projects for the homework that correlated with the applied. I would do more word problems.”

The faculty in this study were constantly reminded as they journaled and had check-in's that what they were doing was much bigger than teaching a math class. "I'm glad we're doing this, it helps me keep things in perspective". In the day to day life of a teacher, it can sometimes become rote. By constantly revisiting "why" the faculty became much more conscious and deliberate in their actions to incorporate STEM. The added benefit of introducing STEM pathways was also rejuvenating. During a check in Professor M states "Wow, I think I am learning more than my students, I never heard of some of these careers, and how cool is it that some of these jobs, with just an associate's (degree) pay so well."

Increase interest, increase success and motivation (Q1b, Q1c)

The pass rate was significantly higher for students in the intervention class. Sam, a student in the intervention class stated in his focus group "Yeah, it was a good class, my teacher was great, I never did algebra when I was in school, now I know I can handle math." An interesting byproduct of the structure of the class was the students mentally positioning themselves in novel situations. There were incidents reported in the classroom where students talked about seeing themselves in the STEM jobs in which the math was situated. Professor A journaled "Melissa was so excited to do her report today, she said she told her boyfriend he needs to go back to school, because he can make a whole lot more money with an associates' degree in the job that she was assigned than he is making with a bachelor's degree. Melissa said "she isn't interested in that career but she wants to learn more so that maybe there is something she wants to do."

And the success of situating the math in context was evident with different topics throughout the course. Professor M journals "in a two-day class (this one) they didn't

seem to have problems with consecutive integers – my five-day couldn't get it. Don't know why? less experiences than in a five day.” As mentioned previously STCC is involved in the Achieving the Dream initiative, one outcome of that initiative was to create five day a week, six contact hour, developmental math classes. These classes cover the same content, but are designed for students who need a lot of support and/or have math phobia.

As a result of these discussions involving STEM careers, a great deal of advising was conducted in the classroom, as was noted in journals and focus groups. This was also reflected in the check-ins and exit interview with the faculty where Professor A stated “I couldn't believe how much advising I did in the course. I mean I usually talk to my students around priority registration, but because we talked so much about careers and with the projects I really did a ton of in class advising. You know about which math to take and which science class to take.” Professor K followed “yes, you know your right, I did talk way more about it, I just hadn't really thought about it.” “Yes, I think it just naturally fell out” Professor M followed up.

The other outgrowth was the conversations about what the different college math classes were like, and how the concepts covered in the algebra class directly related to the other courses. The constant source of advising, as the contextualized mathematics invoked genuine interest and a springboard for questions from the students. The students began to situate themselves in the different areas that were covered, some they outright rejected, while others sparked their interested and they spoke of their own abilities and backgrounds and how that would be a benefit in pursuit of certain majors or careers. As

Lilly clearly states in the focus group “It can take a while before you figure out what you want to do career focus and it waste students time and money.”

After looking at the earning potential, students were also re-thinking, or in some cases beginning to think about their majors and career paths. This was reflected in the data that twice as many students from the intervention went on to take the STEM track math class, as those in the control. The students were positively affected by the structure of these classes. And natural by-product of the structure of the class, in being up front about the goal of introducing them to STEM pathways and careers the students expressed a sense of interest and belonging, thus beginning to situate themselves differently.

During the focus group of the students who participated in the intervention classes, when the question was asked about the STEM focused class one student stated “people when they are going to college, they need to think of broader things, see what’s out there. It was cool to talk about different things.” While another stated “that career assignment, boy you can make some money, it made me think about things.” The introductions to these real-life careers help to lead students to situate themselves in these novel areas and to begin the development of a STEM identity.

This, however, did not manifest itself in terms of increased persistence. The students in both groups completed at a significant lower level than the cohort in its entirety. The intervention had 71% of the starters finish (not withdraw), versus 75% in the control, compared to 85% of all algebra one students finishing for that semester. Unfortunately, there was not a mechanism in place to critically analyze this phenomenon.

Keeping focus – frustrations arise – building efficacy (Q2a, Q2b, Q2e)

Without a doubt, the least embraced area of the intervention was journaling. As “math people” teachers are often not interested in recording ideas not directly related to their discipline. Yet, this was an extremely useful tool, as it provided snapshots of the interactions and feelings within the classroom. By continue to check-in, about the climate of the class, the benefit to the students, and keeping in focus that what is being taught is students, and not math, the result was to view the whole student.

Yet, the frustrations were very real and reoccurring. This was especially true for one of the classes in the intervention that was particularly weak academically. Professor M repeatedly wrote about the frustrations of her class “This class is my most lively class but it feels like many of them should not be in a two day. At least four seem to be very slow. I am not really liking it. I will try to change my attitude.” She goes on to journal “Maybe I just am not reading them right. I hate it when I can’t get a feeling for what they understand.” One of her final entries for the semester continued the theme. “At this level I think more time is needed. Two days a week at 8:00 am is not a good time for success. This class does not reflect an average class.” She also expressed this in the exit interview:

“I was very frustrated with the whole class and then it got to be part me and then part them, you know what I mean? When they are like that and I try to step out of it and get them involved and they were just so not involved and not knowing what they wanted to do, you know, the few students that did were looking at me like really and it was a very frustrating class overall.”

Yet, Professor M was hardly alone in venting her frustrations. Professor K journaled “Things started out so well and now I feel like nobody is learning anything! Not one student passed 203B (a quiz in the chapter on linear equations and inequalities in two variables) I’m discouraged!” While Professor A wrote “Boy, some days are tougher than others. I feel like I go over the same things over and over and they are not

retaining it.” The journaling allowed the faculty to voice their frustration, and refocus, keeping in mind the goal of the class is to reach students, and give them the best opportunity to not only be successful in that particular class, but open pathways and opportunities that could very well effect their future.

As a result, faculty kept a focus on the task at hand, and it not only made a difference in the intervention classes, but all three of the faculty involved in the interventions, commented on how it spilled over to all of their classes. Oftentimes, being caught up in day to day task, finishing material, and making deadlines, that teaching can become rote. By completing regular check-ins, there is an evaluation of practices, feelings, and events, which helps to negate the status quo.

During the exit interview Professor K stated “Although I was bad at writing a lot in my journal, it did help me to keep focused on the project, and just us talking during the semester. I needed that.” “Absolutely!” was the response to that statement. Professor M went on to say “well you know how I felt about this class, but you all and the journal really helped.” She also addressed this in her journal. “getting used to teaching two day, I am going along with the schedule, it’s helping me to stay focused, and will encourage the ones who need it to get extra help, the class has grown on me!” “Looking forward to the career assignment. They seemed open to talk about it, this is helping me stay focused, and some of them are making connections.” Professor A journaled:

“Things are flowing well, the first two chapters typically go fairly smoothly, I am already feeling a little anxious about starting the units on graphing. I hope that the mini-assessments help to from the equations and put some context that the students can understand. I am constantly trying to relate the content to “why”. I think it makes things a little easier to process, but gheez, it is not always easy.”

And the informal conversations that the three professors had on a weekly basis kept the focus of the study, as they checked in to ensure that all of the classes were covering the same material, and pacing was in sync.

A major event that motivated students and faculty alike was the graduate student panel. The panel consisted of three young women of color. A first-year Latina student in psychology (who is also a single mother), a third year African-American student in chemistry, and a recently minted African-American Ph.D. in polymer science. The panel was compelling as students shared their stories of struggles, defeats, and triumphs through their career. They spoke of that special teacher(s) or mentor(s) who saw something in them, and in turn made the students believe in themselves. They also spoke of the imposter syndrome, and forming their own community of support, to ensure a safe and supportive place as they pursue their often-difficult academic path.

The faculty and student response mirrored each other in the feedback. “Wow, what impressive young women” stated Professor M. While Professor K journaled “My class went to the graduate panel today and I got lots of positive feedback. Wow were they impressive. While Professor A stated “they blew me away, I’m so proud of them!” During the exit interview Professor K stated:

I also think it went well with the panel that you had. I think the panel was, at least in my class, generated more conversation about STEM fields probably because they were real people and I got to hear real stories. And then because we did the career activity after that I think they were already kind of thinking about different STEM, you know, um, careers, at least those of them that were on the fence. Not those of them that said absolutely not I am not interested, but those that were interested or had considered it, but didn’t really know I think.”

The students’ feedback that were collected after the talk had common themes. Quite a few students wrote of the panelist being inspiring and or motivating. “They were

all so awesome and positive. Also, inspiring! Definitely made me want to do well and continue schooling.” “I enjoyed hearing the ladies’ stories and what they went/are going through. It showed me some of the avenues I have at my disposal and made me think about where I can go.” Another student wrote “I was inspired by the panel. They all were/are women. I also liked how they stories were like mine.” Also, “I felt this panel was helpful and inspired me to stay in school and not give up.” “They gave me a lot of motivation. I have high goals and sometimes it’s difficult to think I’ll be in school forever.” Yet another wrote “I felt encouraged. I felt motivated. I liked how they explain their journey to success. I learned no matter what happens if I don’t give up I will reach my success.” “I thought the panel did a wonderful job. As a single mother of three daughters, I found it beautifully empowering to see such determination, intelligent focused women heading out to run the world.”

Other students spoke of how the panelist addressed building a support system that is conducive to their progress. “I’ve lived on my own, and I know how others can influence you by not staying as focused on your future but they are right – you have to just focus on yourself.” Another wrote “I really liked that the girls can compare what they had to go through with family, friends and support because I can relate and feel like that’s some of the problems I’m going through now.” “I found the panel very interesting. The fact that they had troubles to overcome made me feel more confident in continuing education. Yet another wrote “Got to find your resources and push through. Many programs don’t give you resources you need. Get you to a level you want to be at.” And the fact that they had to be creative in their pursuits “When the three students talked

about the graduate programs I liked the fact that they explained what they went through and how things get complicated, but there's always a solution to it."

Another theme was of their openness in sharing their stories including their struggles. "I liked how open they were and how they expressed their journey. Each of them has their own but all supported each other." Another wrote "The panel was very interesting and realistic. I appreciated the feedback because I am a single mom pursuing psychology and never considered a STEM career as Psychology. Also, I struggle with work and time management so it was very insightful." Another wrote "I enjoyed hearing real people issues. I felt like our stories with our relatives were very similar. They don't really understand college since I'm the first in my family to attend college. The panel motivated me." And then there was "I liked how they explain their journey and explained their struggles and how they overcame them." One student in particular was struck by one of the women on the panel,

"I like that Marielena was able to accomplish so much even with having a child. I like that she is studying how children perceive language and ways to increase their learning. Especially since my son was diagnosed with phonological disorder and speech therapy helped him so much."

Overall there was an abundance of positive feedback, the panelist stories both resonated with the students as well as affected their outlook, as is evident by "It was very nice. I was interested in the ladies' journey for their Ph.D. I loved the fact how they explained their struggles and made them stronger. I'll walk out of here valuing their words."

Yet, even with all the positive feedback from the panel and other positive interactions in the classroom, the students also exhibited their own frustrations about the class. From the intervention focus group Linda stated "I don't like math, I mean, I'm not really good at it, so I couldn't do any of those things." This statement was in response to

the question of STEM focused assignments and careers. Carlos followed with “A lot of students don’t get through the math, their program is stopped, so that’s our bigger focus other than STEM.” Sam suggested that “maybe you guys could have extra hours so that students can come in... maybe there could be study groups as well for them to come in.”

Gina also was open about her own level of frustration in getting the support she needed

“It’s the same. But the hours that were given didn’t work for some people. Like people who work two jobs and have kids like I did, the hours didn’t work. Yeah, it would have helped if it was different times, that’s what I noticed it would of help if there were different times, like it was like this hour and this hour, and I couldn’t make it, but I could have made it with those hours in between.”

The faculty also reflected on their students’ frustrations. Professor K journaled “One of them misses class to see a tutor and I can’t convince her that she’s better off in class. Maybe because when she does get there, she’s half an hour late. She gets so anxious she just can’t hear me.” Professor A wrote “It is frustrating seeing students dropping off, and I don’t know what I can do about it. I try to encourage them as much as I can, and acknowledge that it can be difficult but you have to fight through it.” She also went on to write in her final journal entry

“Cheryl, an older student in the class, who never actually had Algebra in high school, has been struggling the whole semester, she is often on the verge of tears as she works on the material. I constantly see her in the tutor center, and she works really hard, but just doesn’t retain the information. I told her she can do it, but I have to admit I sometimes didn’t believe it myself.”

This frustration was separate from the way the students viewed their teacher. Emily stated in the focus group “my teacher was nice and tried to help us, but I just didn’t get it, I barely passed the class.” which Lilly followed up an enthusiastic “me too!” Linda, went on to say “I’m not good at math, so I was glad our teacher was nice, and I went to see a tutor to help me get it.”

Yes, teachers matter, and so do students (Q2c, Q2d, Q2e)

Throughout the analysis, the notions of “my teacher” and “my students” were prevalent. There was this mutual possessiveness expressed on both ends. During the focus groups, in both the intervention and control the students spoke affectionately of their teachers. In the control focus group a student stated “Professor S is great, she really wanted us to come to her for extra help, she was easy to talk to and ask questions.” While a student in the intervention focus group stated “My professor always gave us time at the end of class to just ask questions. She was really nice and wanted to make sure everyone could get help.”

When asked about what could be done better or changed about the class, there was never an impugning of the teacher. One student stated “My teacher was great, but I just wish we had more time.” Arguably, part of this loyalty, on the part of the students, could be attributed to the fact that these focus groups were voluntary, and after the semester, and students may have been more inclined to show up if they did have a good relationship with their professor. Yet, it was evident in other ways as Professor K stated

“in this class, because I was so conscious about the study that I was doing and really making sure they understood where I was coming from and why this was important and I think I was just so focused. I definitely knew this class better. They were good, I really liked them, and I get to know, like pretty decently, even with the two days.”

Yet, it went further than that. When asked about support systems, a common response was, if students did not do well, it was not the fault of the instructor. There was general acknowledgement of faculty being very supporting, and caring about student success. There was also acknowledgement of extra supports from the college. Specifically, free tutoring and office hours were mentioned. “There is tutors and the

teacher always answers questions, if someone didn't do well it's because they didn't want to. There are resources there to help you if you need it, you just need to utilize and take advantage of what they offer." stated Mike. The Students were vocal about the fact that if students did not do well, it was because they did not put in the work they needed to in order to do well.

The structure of the study was a constant reminder that although the content is important, and should not be diminished, understanding and honoring the student is just as important. This relationship building process creates an equitable situation where all students are not only given the opportunity to learn and contribute to new ideas and pathways, but are also put in a position where the expectations are that they can excel. The social and cultural capital of the students were an integral part of the dynamics of the classroom, and students were more interactive in the classroom. Professor K journaled "The atmosphere is friendly and relaxed. These students want to learn!" While Professor A wrote in her journal nearly halfway through the semester "They seem to appreciate the dialogues we have had about careers and equity issues. My attendance/participation has never been so high at this point."

And there is a real connection between faculty and students, the student Professor A wrote about, Cheryl, she finished the entry with:

"Well she did it, she passed the final, barely passed the course, but she did it. She cried and I have to admit I teared up myself. This is why I do it. She is definitely not headed for a STEM career, but she made it, and she can go on and fulfill her goal of getting a college degree."

Faculty, in both journals and check-in meetings, expressed frustration about students' commitment to their own education. Professor M wrote "1/2 the students ask questions, do the work and will be fine. The others don't even stay for the class. It will

be very interesting how they do with Chapter 3.” Questioning whether the students took class seriously, and if they were doing enough, or even too much, in trying to get students to be responsible for their own education. Yet, the students freely acknowledged and touted the amount of care that their teachers showed for them, and were protective of the work done and the positive relationships. Carlos was quoted as “I like how, I don’t know, but when she would teach us a lesson she would go ok, and let us work on stuff and ask questions, and you know really wanted us to get it.”

Some of the things affecting students and their outside difficulties can be addressed by really getting to understand what students thought processes and needs are. This was evident in the focus group, Linda say’s “Yeah, I had like three different ideas, like I was interested in Ultrasound and I was like oh my God, you have to take physics, and I just found out they had to take physics this past semester, and I was never good at physics in high school, it was like torture for me.” As a follow-up “So the courses you have to take can affect what you major in?” “Absolutely, I’m not good at that stuff.” This was followed with “How about if they had something in place for physics with all this extra help like we have, would you try physics?” “Probably”. This student changed her major because she knew that there was not support, and in essence changed the projection of her life. She is now a general studies major trying to figure out what to do.

Yet, not everything can be addressed in the classroom. Students have some outside and serious issues that they have to deal with. Professor K journaled:

“I have three students that struggle. Two of them have children so I believe “life issues” are preventing them from spending the necessary amount of time on this course. The third student just has a difficult time. I may have to transfer her to self-paced. She works hard and has never missed a class. I feel bad. One of

them has a daughter under the age of 1. I think he's having a difficult time juggling his personal life. Additionally, he is not getting along with the child's mother. The other student, I am convinced, has serious learning disabilities. She's supposed to see me for help?"

Professor M wrote "one of the slower students hasn't been in so I think she dropped. I don't know what was going on with her, I think she had a lot on her plate, and she probably should be tested." And during the exit interview this idea was raised on several occasions. "Our students have so much going on in their lives, I'm not surprised that they just can't concentrate on the math." stated Professor K. "Yes, one of my students was going through treatment, I felt bad." followed Professor M, and Professor A added "I can't remember when I haven't had a student who is in transitional housing." These outside, and serious, distractions are not something that can be dealt within the constraints of the classroom.

More Frequency, a better recipe for success

One theme that emerged, that was not directly related to a research question, but was evident in all of the qualitative analysis was the meeting time of classes. All three of the faculty teaching the intervention classes met on a Tuesday/Thursday schedule, and all three of the faculty wrote numerous times in their journals about how much they disliked teaching the class twice a week. Professor A wrote "I feel like I am shoving information down their throats, and it's not doing any good." The sections ran Tuesday and Thursday for an hour and fifteen-minute time periods. The students were not retaining information with such a long period between classes from the Thursday to the Tuesday class.

Professor K journaled "This is the first time I've taught a standard algebra class that meets only two times per week. I don't like these two day a week algebra classes. I feel behind but unable to speed up for fear of losing more students." Professor K

followed up with this sentiment in the exit interview “It was ridiculous. I almost think we shouldn’t have Algebra one for two days. It is terrible.”

Professor M stated “It’s been so long since I taught an algebra class that only meets twice a week, I was totally blown away, I am used to teaching it five days a week and I am so sad and hope it is no reflection on my teaching.” She also journaled “I just don’t like them (2 day classes). I don’t like them at all in general. For me, just connecting with your students, getting to know their names and who they are, it is really difficult!”

This was also brought up by the students, in both focus groups. Those who had the class two days a week commented that math should meet more often. Lilly from the control focus group stated “I felt like it was a set-up, I am not good at math, and it was just too hard trying to like know and remember only meeting two times.”. Anna, a student from the control focus group stated “I had it three days a week, and it wasn’t enough time.” Tiffany from the intervention focus group states “I had this class before he didn’t give us time and I did terrible.” The feeling was that it sounded like a good idea when signing up for classes. Students notoriously try to be in class the fewest days possible when building their schedule. “I think the meeting times were fine, I work and I can only take classes on Tuesday and Thursday” stated Sam. This student reported that he did fine in the class, but that’s clearly not always the case. When the realization of the amount of work, and how demanding the class was, many students would have like to have it spread out over more days.

This was also reflected upon about having more problems incorporated into the class setting. Although Professor M. who was quoted earlier stating that she wished there

were more, she followed up by writing “We just didn’t have time to do more with them. Would like to incorporate the careers in five day (class).” “I wish we had more time, I am definitely doing this in my five-day. There I can really sit down and I know the students better.” The four-day break from Thursday to Tuesday proved to create a large problem. Developmental students often do not do a lot of work outside of class, therefore more time is taken reviewing material that students have not retained. This was also driven by the fact that the students were vocal about what they didn’t remember and understand. In the focus groups one student, Anna, who was in a control class stated that “I had it Tuesday/Thursday and it just wasn’t enough time.” It can be argued that more frequent meetings would situate the students in a better position to be successful.

It is worthwhile to explore how the number of meeting times effects students’ success, and persistence. Unfortunately, I was unable to gather this data from the college, but I believe it is a worthwhile topic to explore as community colleges continue their mission in how to best support students and place them in the best learning environments.

In summary, the students in the intervention classes showed an increased affinity for STEM careers and were more likely to enroll in a course that would serve as a pre-requisite for a STEM mathematics course. They were also more likely to pass the course, although not at a statistically significant higher rate. The teachers journaling lead to an increased sensitivity to addressing and relating to the whole student, honoring their cultural capital, and explicitly explaining their rights and responsibilities as they go through college.

CHAPTER 6

DISCUSSION AND RECOMMENDATIONS

“Until we get equality in education, we won’t have an equal society.” Sonia Sotomayor

The goal of the STEM empowerment curriculum was multi-faceted with some promising results, as well as generating more questions. An array of data was collected and analyzed, both quantitative and qualitative, and the results will be discussed below. Along with this discussion of results, recommendations, and limitations of the study will be addressed.

Discussion

How, if at all, does a STEM empowerment curriculum stimulate interest into STEM?

By constructing a collaborative and supportive atmosphere within the classroom that not only promotes STEM, but explicitly examines what STEM careers and pathways are, interest towards STEM is stimulated. The students in the STEM empowerment classes were a part of the conversation about what is available, and they were encouraged to pursue such pathways. In turn their cultural capital grew in the classroom, which allowed them to begin to develop a STEM identity. Students throughout the semester were positioning themselves in novel roles, and beginning to understand that they could be valuable assets to STEM.

This was also reflected in the STEM attitude survey’s which showed a higher positive attitude towards math in the intervention class than the control. With the mean of the control class falling from the beginning of the semester to the end by (- 0.027), where the intervention class had a gain (0.448). After math, science and technology had the next biggest difference with 0.306.

The overall results for all the STEM areas were higher in the intervention classes, although the area with the lowest gain was in science with the difference in the end of semester means merely 0.029. There were also some results that are unaccounted for. In the control group, there was a larger increase in interest for both computer science and physics over the intervention classes on the career section of the survey. However, the intervention class had higher interest over all in each area of the career portion of the survey.

How, if at all, does a STEM empowerment curriculum effect pass rates?

As students in the empowerment classes were engaged, their sense of agency was affected and in turn they were more successful in the course. The explicitness of the goals of the course, to not only increase participation in STEM, but also for students to be successful. And if STEM was not necessarily the path they saw for themselves, faculty still wanted to ensure the students would be successful in whatever program they chose. This addresses the key idea of equity in the developmental mathematics dilemma.

Because of the design of the course, a significant amount of time was spent talking about majors and careers. Students were afforded the opportunity to discuss their goals, and were given feedback on how to best proceed. Support systems, and areas to receive information as well as specific people to contact to receive help and answers were critical in keep students focused and ultimately more successful in the course.

As a result, the students in the intervention class had a 20% higher pass rate than the students in the control class. Although one area that the control students fared slightly better in, was the rate of finishing. The students in the control group finished the course (did not withdraw) at a slightly higher rate of 4% versus the intervention class.

One reason for this may be the two-day format that all of the students in the control group were enrolled in. The other classes, could have met two, three, or even five days a week.

How, if at all, does a STEM empowerment curriculum effect subsequent course selection?

The intervention class was much more successful in students enrolling in a STEM pathway math class, where nearly double the percentage of intervention students enrolled in that course. This can be contributed, to some extent, to the disrupting of Bourdieu's theory of reproduction. The students in the empowerment class were exposed to the cultural capital necessary to embark on new avenues.

Simultaneously their social capital was honored and upheld as being a positive influence to the monochromatic world of STEM. The discussions with the students about how they could be an asset to these fields, and that yes, it can be difficult, but the rewards are more than worth it, prove to be a motivating factor in their striving to attain new goals.

How, if at all, does teacher action research and a STEM empowerment curriculum affect teacher practices?

The teachers in the study were much more engaged and reflective when involved with this curriculum. The constant check-ins and journaling not only kept the focus of the course in perspective, but it also helped to discuss events and issues that arose in the class, which could be addressed immediately. The communication between colleagues allowed for thoughtful reflection of the task at hand, which was teaching the course, and addressing the needs of the students.

The STEM focused curriculum was a constant reminder that the students' progress and exposure is key, and that it was important to understand what the students

were thinking. It facilitated more open and free dialogues between the teachers and their students, creating stronger relationships. This fostering of teacher immediacy was a prevalent notion as day to day preparation occurred for the course.

How, if at all, does teacher action research and a STEM empowerment curriculum impact teachers' perceptions of their influence on their students?

As a result of this reflection, the faculty were keenly aware on how their own attitudes' and behaviors affect the students. Because of this sensitivity, the faculty were conscientious about their interactions with the students. In particular, the faculty noted how engaged the students were when the faculty discussed the STEM careers with them. They appreciated the fact that their teachers believed that they could be successful in these unfamiliar areas.

The faculty were also cognizant of their personal frustrations, and how those frustrations can affect their students. The focus was on staying positive and supportive so that the students can receive the full benefit of the course. In dealing with those frustrations from the students' perspective, it was important to let the students know that this was a difficult course, but they were more than capable of handling the work if they put in the time. It was important to acknowledge the students own frustrations. Equally as important was to reassure the students that the view that the teacher held about the them was not diminished because of difficulties the students were experiencing.

How, if at all, does teacher action research and a STEM empowerment curriculum impact teachers' perceptions of their students?

The teachers, as they introduced the students to these novel ideas and careers, started to view students differently, and held them in higher esteem. A practice that is

often carried out in upper level mathematics classes, where the faculty identify the stronger students and take special interest in their trajectory. This was now being practiced in the developmental mathematics class, where faculty were recognizing the potential of promising students and nurturing that potential. As a result of building out programs and pathways for the students, the faculty could envision them in their upper level classes, and encouraged them to pursue those pathways.

How, if at all, does teacher action research and a STEM empowerment curriculum impact students' perceptions of their teachers?

Although all students interviewed showed a positive affinity towards their teachers, it can be argued that the relationship between those in the intervention class were more multi-faceted. The students in the intervention group had the benefit of personal conversations about their future and pathways. The interactions between student and teacher were of a more dynamic and transformative nature. Thus, the students viewed their faculty as more than someone who is there to talk about math, but as someone who is an agent of change that could facilitate a different trajectory in their academic progress.

How, if at all, does teacher action research and a STEM empowerment curriculum impact students' perceptions of the course?

The attitudes of the students in the intervention classes were positively affected about the course. Students had a better understanding about why they were there. They were aware of the benefits of the course, and by putting the math in context, they felt more invested in the class. Furthermore, the students understood that this was a difficult course, and that it was not a reflection on any personal shortcoming. In essence, the

course was viewed more as a pathway, a means to an end, and less of a punishment. The execution of the course, promoted student agency, and with students feeling more control over their environment, there was a higher positive perception of the course.

Recommendations

The purpose of the STEM based curriculum redesign was to create an equitable environment that empowers students who have traditionally been marginalized, and give the opportunity to take advantage of opportunities that will benefit themselves, and ultimately all of us. With this foundation of equity and student success, several elements are recommended for transformation to occur.

Recommendation #1 - Advising is teaching

In order for change to occur, to afford the opportunity for students to develop a STEM identity the role of advising in the classroom is imperative. Teachers have the most direct contact with students, and have ample opportunity to expose them to opportunities they may not be aware of. They also have an obligation to educate their students, and that responsibility goes beyond strictly subject matter.

The conversations about careers and pathways were a natural progression in this study, and one that is critical in the pursuit of providing a quality and equitable opportunities for our students. They also serve to increase interest as the mathematics is contextualized. The abstractness of mathematics has proven to be a barrier for students. This study has shown that, although not statistically significant, student success as well as STEM interest were increased with the explicit exposure to STEM careers and STEM based mini assessments.

These types of genuine and relevant exchanges are extremely valuable and need to be more forthcoming in our developmental classrooms. With a large number of students entering the community college not having a clear academic/professional goal, this can be critical in their pursuit of higher education (Gardenhire-Crooks, Collado & Ray, 2006, Jenkins, 2011).

How to achieve this STEM identity, is intractably connected to exposure. The influx of STEM into a curriculum, allows students to get their oft times first exposure to what some of these disciplines entails. In addition, students' engagement is increased as the novelty of the situation, makes the math relevant in ways they may not have previously recognized. If this is situated in a caring and supportive environment, where the students are not only being exposed, but genuinely encouraged to envision themselves and pursue these opportunities.

Through a deliberate and concerted effort, a STEM identity can be fostered in students who have been largely excluded from this very prevalent, powerful and lucrative industry. As noted in Chapter five, one student wrote after the panel "I enjoyed hearing the ladies' stories and what they went/are going through. It showed me some of the avenues I have at my disposal and made me think about where I can go." As educators, it is our job to open minds so that students are exposed to possibilities they are not even aware of. The valuing of the whole student, and incorporating their unique backgrounds and cultures, with new programs and opportunities, can be advantageous to all involved. This leads to diversity of thought in the establishment, which leads to novel approaches to problem solving.

Recommendation #2 - Built in support is key

The students have a lot of outside pressures and influences that we cannot directly address in the classroom. They have busy and complicated lives. To offset things that we have no control over, built in supports need to be put into the classroom. To this end it is critical to have more contact time with the students. More frequent meeting times, like the classes that meet every day, would afford the time and opportunity to address student weakness and give them support inside the classroom.

Professor M journaled several times about this obstacle. Although, logistically this may not be the ultimate solution, more support has to be built in. With or without the increased contact time, there are supports that can be utilized. One solution is to incorporate more peer tutors in the classroom to increase student success. These tutors would not only attend class to give extra support, but also have outside help sessions. With the students' already comfortable with the peer tutor, they are more likely to see outside help. Another is to have faculty perform at least some of their office hours in the tutoring/math center. It can sometimes be intimidating for students to go to their professors' office.

It is imperative that relationships are built. The idea of care and teacher immediacy is critical in student success. Yet, it is not enough to build in support if the faculty teaching these courses have a diminished view of the students. This was echoed in both faculty and student responses. That sense of belonging and high expectations is essential for student success. It is important to ensure that quality faculty, who are truly invested in the students, and believe they are capable of achieving to have access to this vulnerable population. And students will avoid majors and classes if they do not feel they will receive that much-needed support.

Recommendation #3 – Create a Conducive Learning Environment

When addressing developmental students, it has been well documented the alarming lack of success with this population. The earlier a student is focused in on a specific major, the higher the chance of success and completion. Furthermore, at a closer examination of the demographics of this population, this is a social justice issue, one of which we are all responsible to rectify.

The students in this study, although faced with their own real life issues, were grateful and appreciative of faculty taking a personal interest in them, and their future. They were open to new possibilities, and although this particular group may not go into a STEM field, before the exposure they would almost definitely not. Emily stated in the focus group when responding to the question would it help if we introduced a career focus “Maybe, I still don’t know exactly what I want to do” it was her third semester at the school.

Students are coming into the classroom, with their own challenges, but in viewing them as inherently flawed, as the deficit perspective illustrates, faculty are limited to the scope in which they can reach a student. The faculty in this study held a strengths’ view of the students, and though it is true that students enter school with hindrances, they also enter with unique skills and abilities that can be utilized to overcome whatever difficulties that may arise. If we do not expose them to the possibilities we are reproducing an inequitable system. As one of the students wrote after the panel, “I liked the panel, I felt that the ladies were very informative of basically their career path. This panel actually gave me a more insight of the PhD’s program and encouraged me to continue on my educational journey.”

Acknowledgement of the cultural capital the student possesses and clearly explaining the social capital that is necessary to be successful in college, is a way to provide equal opportunity, while empowering students. The faculty member then becomes an agent for a student to gain access to an unfamiliar world, providing a positive supportive foundation, as the student takes on an unfamiliar identity.

In order to support and prepare students in such a way the culture of the classroom must be conducive to such a learning environment. Faculty hold a crucial role in this development. There needs to be a high level of academic rigor, and a genuine expectation that the students are capable of succeeding. When faculty are clear about their expectations, supportive in helping students to understand the culture of schooling, and hold high expectations of the students, they truly become agents of change. Therefore, competent and caring faculty are imperative.

None of the mechanisms in the intervention class were overly taxing to the professor, on the contrary the classes were enhanced with the constant reflection of the task at hand. A relevant professional development would be to put mathematicians and advisors and other STEM faculty together to ensure there is cross discipline dialogue, that students can see the relevance in each of their courses. Interdisciplinary learning communities is also another way to accomplish this goal. In this case, small faculty groups would observe each other's classes and curriculum and give feedback.

In this study, and is true in general, the Black and Hispanic students lagged in terms of academic success. This is a testament that much work needs to be done, and it needs to come from multiple fronts. Increase contact time can help to enhance those fronts. This, or any other intervention, is not a one-shot remedy. A concerted effort from

all aspects of the college, including advising and student support services is critical in ensuring students receive the support they need to level the playing field.

Recommendation #4 – Extending Learning Opportunities Beyond the Classroom

This investigation was designed not only to promote student success and widen the STEM pipeline, but also to create a replicable model. The goal was to implement a curriculum that was not overwhelming to the faculty, and could naturally be integrated into current practices. This can be enhanced by having faculty in technology and other STEM fields come in and talk about their programs in the developmental classroom. In conjunction with the talks they can help to situate the math into the requirements of their fields.

Along with introducing contextualized problems, a suggestion would be to create pre/stem clubs on community college campuses. The clubs for students already in the major, are comprised of students of which the developmental students have no connection, or common classes. A pre-STEM club would open up the same kind of activities and supports for students who are starting out at a disadvantage. Bringing in speakers, and field trips would be an excellent opportunity for broadening exposure and building interest in the STEM arena.

Recommendation #5 – Support/Encourage Teacher Reflection

And although it is arguably a foreign concept for mathematicians to keep journals about their feelings and experiences, that check-in was invaluable. If faculty are reluctant to keeping a regular journal, some sort of check, where instructors are reminded about the real influence they have can be beneficial to all. The increasing bureaucracy of the

profession can be stifling, and make one lose focus of the task at hand. By having a constant refocus, it can be a benefit of both the faculty and the students.

This can be supported by including journaling activity, and teaching reflection and check-in as part of college service activity. Faculty groups can meet as regular committee meetings to reflect on best practices, and to discuss teaching practices and address problems/concerns in the classroom.

Recommendation #6 – Create Supportive Technology Infrastructure

Another recommendation would be to create a free database, consisting of real-life applied problems, specific to different STEM careers into an open educational network that any teacher could access and incorporate into their curriculum. These problems would be categorized by mathematical topic, as to promote ease of use.

A federal, or private granting agency could support this work. This would ensure that it remains an open resource, so that access is not limited. It would also promote/support professionals from different disciplines adding to the body of knowledge, and have it freely and widely disseminated.

Future Research

A recommendation for future research would be to replicate this study on a grander scale, as far as the number of students involved in the intervention, and across different types of community colleges (rural, urban and suburban) is recommended. It would also be of interest to further understand what factors affect student persistence. A pertinent question would be to study what makes people withdraw. Also, what causes someone to return, even after a previous course failure. These factors could be both academic and non-academic in nature.

Another area of interest would be to research what is the best format for students to be successful, in terms of class meeting times. To examine contact days and times that have shown to be most favorable in terms of student success and retention. These results can be used to inform policy and practices as how best to support students.

Significance of the Study

The issue of supporting under-prepared students in their mathematics and exposing them to the world of STEM is important because as we examine post-secondary education, the role of the community college in developmental mathematics is indispensable. Add to that the majority of low-income, first generation and minority students attend community colleges, and are more likely to place into these remedial classes than their majority counterparts. Unfortunately, the chance of students successfully remediating and attaining a degree/certificate or transfer is slight. And although there has been plenty of blame as to who is responsible, the problem is undeniable. The challenge is to understand the best way to support these students to successfully navigate the mathematics, and the educational system at large, so that they may attain their goals.

As a country, we are always striving to be innovative and cutting edge. There has been a national outcry in regards to reduced prominence of the United States in regards to mathematic and scientific discovery. But when there is only one voice at the table, there is a uniformity of perspectives and the lack of diversity in STEM vocations is startling. Simultaneously, there is a national shortage of qualified workers in STEM fields. Yet, most students from underrepresented groups have no direct exposure to these occupations and often do not have a clear understanding of what they entail. By introducing a STEM

empowerment curriculum to these under-served populations we not only address inequities in our educational system, but also open the pipeline to people who have largely been excluded from the more lucrative professions, all the while filling a national

Limitations of the study

There are several limitations of the present study as follows: (1) The faculty in the intervention were highly qualified teachers who are strong advocates for the students, and with a proven record of success. Faculty who are not as invested or experienced may not produce the same results. Although this can be considered a limitation, it does reinforce the concept of care. (2) This study is carried out at one urban community college, that is a technical community college, calls into question the generalizability. (3) Because the surveys were completely voluntary and anonymous, accountability was a problem, which was evident in the mortality rate. Furthermore, the students who did fill out the survey at the end of the semester, shared certain characteristics. They volunteered to complete it, and showed up at the appropriate classroom time to take the post-test. This is not suggestive of the population as a whole. An electronic version of the survey would have been more accessible and may have increased participation, unfortunately the lack of lab space did not allow for such an option. (4) The small number of participants, both teachers and students, also is a limitation in terms of generalizability.

Conclusion

On all accounts, the need to provide an educated population is a key to a strong country, and economy. In particular, in this increasingly high-tech world, the United States is in need of innovation, and diversity of thought. This can only be done when people from different backgrounds, and experiences come together to solve problems.

Furthermore, STEM careers have been shown to be amongst the most financially lucrative. As we continue to fight for equity in our underrepresented population, and as we continue to enlarge and diversify STEM, community colleges, and the diverse and underserved population they serve are a logical and populous resource.

My interest in teaching mathematics comes from its beauty and creativity. I love the fact that there is not one way to get to a solution! I love seeing those “light-bulb” moments of my students. I want so much to look out into all of my classes, and see population parity. It seems mathematics is used as a weapon that divides the skillful from those deemed not worthy. But I know it is so much more, and that it can be accessible given the right opportunity and support. I know what it feels like to be the only one. I want to do everything in my power to bring diversity to this community so that it is a safe place and fertile ground for all who have interest.

This study addressed these very pressing issues, in a realistic and accessible manner. The students were empowered in their ability to define their goals more clearly, and build their self-efficacy. Without a doubt, the mathematics can be difficult, and STEM fields are known to be taxing. But, by helping students to set concrete goals, and being explicit about why the mathematics is important, in context to those goals helped them succeed when they faced trials and adversities. Ultimately the students in the intervention classes were more successful and had a higher interest in STEM fields.

APPENDIX A

WELCOME LETTER

Welcome! We want to invite you to participate in this Algebra I class, whose focus is to promote a STEM career pathway. The class was designed by Vanessa Hill as a research project for her doctoral studies at the University of Massachusetts, Amherst. The proposed title of her dissertation is:

Fostering STEM (Science, Technology, Engineering and Mathematics) Pathways and Student Empowerment in Developmental Mathematics

The course objectives will be the same as any other Algebra 1 class, but the context will be geared toward introducing students to STEM careers, and helping them to determine if this might be an option. We will also try to help students understand the process of how to get to whatever career goal they have in mind, regardless of whether it is STEM or not.

Attached to this informational letter are two copies of the informed consent. One for you to sign and return, the other is for your records. Please know that there will be no personally identifiable information **ever** published about you, and most of the data collected will be based on class averages and responses.

If you have any hesitation about continuing in this class, let your teacher know and we will gladly switch you to another section, without any penalty.

Here's to a great semester!

APPENDIX B

INFORMED CONSENT - STUDENTS IN CLASS

My name is Vanessa Hill and I am a doctoral student at the University of Massachusetts Amherst in the Mathematics, Science and Learning Technology Concentration. For my doctoral dissertation, I am exploring the ways in which Algebra students respond to a STEM career focused learning curriculum at this community college, along with Professors Lauren Brewer and Donna Bedinelli.

As a participant, you would need to agree to:

- a. Have samples of your work, with all identifying factors removed, be collected and analyzed.
- b. Complete questionnaires pertaining to your feelings and beliefs about mathematics and STEM careers.

All information collected will have all personal identify factors removed, your names or any part of your identities will not be shared in any way. I will use pseudonyms to protect confidentiality.

Your participation is voluntary and you are free to discontinue or refuse participation at any time without penalty or prejudice. You also have the right to review any of the materials used in this study and a summary of the results will be made available upon request.

You have been furnished with two copies of the informed consent, both of which should be signed if you are willing to participate. One copy should be retained for your records and the other for my records. Your signature below indicates that you:

- a. Have read and understand the information provided
- b. Willingly agree to participate
- c. May withdraw your consent at any time

If you have any questions about this research or your participation in it, you can reach me at:

Name: Vanessa Hill

Bldg 17 office 410 Springfield Technical Community College

Office: 413-755-4797

Email: vhill@stcc.edu

You may also contact my advisor:
Florence Sullivan,
Furcolo Hall 2A University of Massachusetts
Office: 413-577-1950
email: fsullivan@educ.umass.edu

Or the Associate Dean of Academic Affairs
Linda Griffin
Furcolo Hall
Office: 413-545-6985
Email: lgriffin@educ.umass.edu

Name: _____

(Please Print)

Signature: _____

APPENDIX C

INFORMED CONSENT – FACULTY PARTICIPANTS

My name is Vanessa Hill and I am a doctoral student at the University of Massachusetts Amherst in the Mathematics, Science and Learning Technology Concentration. For my doctoral dissertation, I am exploring the ways in which Algebra students respond to a STEM career focused learning curriculum at this community college, as faculty who will be teaching sections of this course you agree that I will be able to:

- a. Collect mini-assignments from your students to be copied and returned, and all identifying factors removed.
- b. Collect and analyze reflective journals that you will keep throughout the semester.
- c. During meetings, you agree that notes will be taken and recordings made.

All information collected will have all personal identify factors removed, your names or any part of your identities will not be shared in any way. I will use pseudonyms to protect confidentiality.

Your participation is voluntary and you are free to discontinue or refuse participation at any time without penalty or prejudice. You also have the right to review any of the materials used in this study and a summary of the results will be made available upon request.

You have been furnished with two copies of the informed consent, both of which should be signed if you are willing to participate. One copy should be retained for your records and the other for my records. Your signature below indicates that you:

- a. Have read and understand the information provided
- b. Willingly agree to participate
- c. May withdraw your consent at any time

If you have any questions about this research or your participation in it, you can reach me at:

Name: Vanessa Hill

Bldg. 17 office 410 Springfield Technical Community College

Office: 413-755-4797

Email: vhill@stcc.edu

You may also contact my advisor:
Florence Sullivan,
Furcolo Hall 2A University of Massachusetts
Office: 413-577-1950
email: fsullivan@educ.umass.edu

Or the Associate Dean of Academic Affairs
Linda Griffin
Furcolo Hall
Office: 413-545-6985
Email: lgriffin@educ.umass.edu

Name: _____

(Please Print)

Signature: _____

APPENDIX D

INFORMED CONSENT – INTERVIEWS/FOCUS GROUPS

My name is Vanessa Hill and I am a doctoral student at the University of Massachusetts Amherst in the Mathematics, Science and Learning Technology Concentration. For my doctoral dissertation, I am exploring the ways in which Algebra students respond to a STEM career focused learning curriculum at this community college.

As a participant, you would need to agree to be –

- a. Involved in a semi-structured audio-taped focus group

All information collected will have all personal identify factors removed, your names or any part of your identities will not be shared in any way. I will use pseudonyms to protect confidentiality.

Your participation is voluntary and you are free to discontinue or refuse participation at any time without penalty or prejudice. You also have the right to review any of the materials used in this study and a summary of the results will be made available upon request.

You have been furnished with two copies of the informed consent, both of which should be signed if you are willing to participate. One copy should be retained for your records and the other for my records. Your signature below indicates that you:

- a. Have read and understand the information provided
- b. Willingly agree to participate
- c. May withdraw your consent at any time

If you have any questions about this research or your participation in it, you can reach me at:

Name: Vanessa Hill

Bldg. 17 office 410 Springfield Technical Community College

Office: 413-755-4797

Email: vhill@stcc.edu

You may also contact my advisor:

Florence Sullivan,

Furcolo Hall 2A University of Massachusetts

Office: 413-577-1950

email: fsullivan@educ.umass.edu

Name: _____

(Please Print)

Signature: _____

APPENDIX E

**STEM (SCIENCE TECHNOLOGY ENGINEERING AND MATHEMATICS) CAREER
ASSIGNMENT**

Name:

Career:

What the job entails:

Level of Education (certificate, associate, bachelors, masters, doctorate?):

Median Income:

Job Availability:

Resources:

<http://www.iseek.org/careers/stemcareers>

www.bls.gov/oooh

<http://mappingyourfuture.org/PlanYourCareer/>

www.onetonline.org

weusemath.org

Careers Assigned

Chemical engineer

Electrical Engineer

Actuary

Mechanical Engineer Technologies

Statistician

Urban Planner

Computer Scientist

Machinist

Architectural Drafters

Environmental Science and Protection Technologists

Industrial Engineers

Microbiologists

Biological Technicians

Epidemiologists

Civil Engineers

Fuel Cell Technicians

Nuclear Engineers

Robotics Engineers

Operation Research Manager

Air Traffic Controller

Computer Programmer

Web Developer

Job	Description	Degree	Pay	Demand
Industrial Engineer	<ul style="list-style-type: none"> * investigates work <u>environment safety</u> * Estimate technical/resource requirements for development/production of products * quality control 	Bachelors	39.81 an hour 81,490 per year	247,570 jobs available
Air Traffic Controller	<ul style="list-style-type: none"> * coordinates movement of air traffic * issue landing/take off instructions * control ground traffic at airports 	Bachelors or work experience	59.80 an hour 122,340 per year	Slight decline
Biological Technicians	<ul style="list-style-type: none"> * record research/operational data * analyze chemical compounds * research microbiological/chemical processes/structures 	Bachelors	20.13 an hour 57,430 per year	Low demand now but anticipated rise in demand
Computer Programmer	<ul style="list-style-type: none"> * write/ update/ maintain computer programs and software packages * collaborate with others * resolve issues with technology 	Bachelors	37.28 an hour 77,550 per year	Steady growth
Robotic Engineer	<ul style="list-style-type: none"> * create robots/ robotic systems * to perform duties that humans can't or don't want to perform * makes jobs safer, easier especially in manufacturing 	Bachelors	96,350 per year	124,570 jobs available
Architectural Drafters	<ul style="list-style-type: none"> * operate CAD equipment * analyze building codes * draw plans for buildings, foundations, structures 	Certificate Associate Bachelor	24.03 an hour 49,970 per year	204,400 jobs available strong outlook
Fuel Cell Technicians	<ul style="list-style-type: none"> * operate/maintain fuel systems * build cell prototypes * collect fuel cell test data * calibrate equipment for testing * fuel cells take chemical energy and converts to electrical energy through chemicals 	Associates	\$ 61,580 per year	17,100 job openings expected Not much in MA
Chemical Engineer	<ul style="list-style-type: none"> * design equipment/ create ways to manufacture chemicals and products * Determine causes of problems * Research chemical/biological processes * determine operational methods 	Bachelors	42.43-60.11 an hour \$73,000 per year average	Vary based on location
Statistician	<ul style="list-style-type: none"> * collect/analyze data to help solve real world problems 	Masters	79,990 per year	Growth expected

Job	Description	Degree	Pay	Demand
Operation Research Manager	* troubleshoot issues with computer applications/systems * analyze data for problem solving as well as identifying trends	Bachelors	40.54 an hour	steady
Microbiologists	* examine specimen given by patients for infections * study how disease spreads * study growth, structure and other characteristics of bacteria, algae, or fungi	Bachelors	75,230 per year	Vary based on location Good prospects
Urban Planner	* public transportation planning * create communities/accommodate for growth	Bachelors	66,940 per year	6% growth in job availability
Environmental Science and Protection Technologies	* monitor environment * investigate sources of pollution/contamination – including those that are a health risk. * ensure environmental violations are prevented	Associates Bachelor's	<u>42,190 per year</u> 20.29 an hour	Expected job growth
Mechanical Engineer	* modify, develop and test machinery	Bachelors	66,890 per year	14,600 jobs
Electrical Engineer	* design, test and redesign electrical equipment * knowledge of mathematics computers and electronics * construction, mechanical, admin	Bachelors	61,300 per year starting 103,000 mid career	4% job increase
Web Developer	* configure computer networks * create backups to prevent loss of information * implement security measures * install hardware	Associates	\$ 30.56 per hour	Growth rate of 11.5%
Nuclear Engineer	* breakdown and fusion of atomic nuclei * nuclear reactors, power plants and weapons	Masters Doctorate	\$97,100 per year	Declining 4% per year
Actuary	* measure and management of risk and uncertainty * business profession dealing with the financial impact of risk and uncertainty	Bachelors degree and beyond	\$ 93,680 per year	14% higher growth rate than average jobs

APPENDIX F
MINI-ASSESSMENTS

Problem 1:

An urban planner has the job of managing and planning the development of cities and towns. Janice, an urban planner, has 6 weeks and \$500,000 to revitalize a park that was destroyed during the tornado for the grand opening and ribbon cutting ceremony. She has narrowed it down to two bids: Company A says it will take 5 weeks and they charge \$220,000 for labor, \$275,000 in materials. Company B says it will take 6 weeks, with \$180,000 in labor and \$300,000 in materials. Which company do you think she should go with and why?

Problem 2:

A climatologist job is to study weather patterns and use those patterns to understand the effects on the earth, people, and animals. They also use this information to make recommendations on the design of buildings and the heating and cooling needs based off of the weather patterns. Often the first bit of information collected and analyzed for the mean, median, and mode. Find the mean, median, and mode for the following set of temperatures:

10°, 0°, -5°, 5°, 17°, 22°, 15°, 7°

For each part explain in words what to do then, show your work with the answer you found.

I find the mean by:

I find the median by:

I find the mode by:

Problem 3:

A taxi company charges a base charge of \$2.50 and an additional \$0.50 per mile.

- c. Express the cost, C , of the taxi in the number of miles, m , that a person may travel.

- d. Complete the table, use at least four values:

m	C

- c. Choose an appropriate scale for the axes, and graph this equation.

- d. What does the slope of the line tell you? What about the y-intercept?

- e. You live 13 miles away and have \$10, do you have enough to get home?

Problem 4:

A plant biologist is measure the growth of a plant that is not native to the area to determine if it is destructive to native vegetation. She took measurements over 2 weeks and recorded the following data:

Day	Height (cm)
1	1.5
2	2
3	2.5
4	3
5	3
6	3.5
7	4
8	4.5
9	6
10	6.5
11	7.5
12	8
13	8.5
14	9.5

Plot the points on a graph and sketch a line of best fit. Then, calculate the slope of that line. What is the average growth of the plant?

Other plants in the area grow at a rate 1 inch per day, should she be concerned about this new plant taking over?

Problem 5:

Nuclear engineers design and build facilities that house power plant as well as research facilities. The research facilities examine how nuclear energy can be used in medicine in diagnoses as well as treatment of diseases.

The following formula is a way to calculate the number of Plutonium atoms, A , give the mass of the Plutonium, m .

$$A = 2.5 \times 10^{21} \times m$$

- 1 Calculate how many Plutonium atoms are in 0.75 grams of Plutonium
- 2 Calculate how many atoms are in 5 grams of Plutonium
- 3 If you were to write 2.5×10^{21} without scientific notation how many zero's would it have?

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