EXPLORING THE DEVELOPMENTAL MATHEMATICS PROGRAMS AT COLLEGES IN HAWAII

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Dedication

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Abstract

Developmental mathematics is a critical area of focus for Hawaii colleges. One in every three students places in remedial and developmental programs, and about one of every two students fail to successfully complete a developmental mathematics course. This high failure rate in developmental mathematics is a barrier to college completion. Colleges across the nation are starting to recognize the need to increase the student success rate in developmental mathematics and are experimenting with their programs with the aim of increasing student success. Each college in Hawaii has autonomy to select or design its own developmental mathematics programs. Failure to master basic mathematics is a national concern in the United States because it can significantly limit college and career success. The purpose of this mixed-methods multiple case study was to explore and analyze the first level developmental mathematics programs (2 levels below college level mathematics) in Hawaii's seven public colleges. Using linear and ordinal regression analyses, the study examined different semesters' success rates, placement exam scores (pre-test), and final grades. Multiple in-depth interviews with faculty and administrators from each college were conducted to obtain perspectives on the characteristics of their mathematics programs and to determine factors that may impact student success rates in developmental mathematics. The study sought to provide insight for future redesign of developmental mathematics programs. The conceptual frameworks applied in the study were andragogy theory, constructive-development theory, transformative learning theory, Tinto's principle of effective retention, Bean's model of retention, Astin's I-E-O model (input-environment-output), and the theory of student involvement.

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Chapter 1: Overview of the Research Problem

Introduction

The focus of this study was to explore the developmental mathematics programs at all the community colleges in Hawaii. Developmental mathematics programs, sometimes referred to as remedial mathematics, "typically cover some of the same curricular material as high school mathematics courses" (Lesik, 2007, p. 584). Many researchers use the terms developmental and remedial interchangeably. In Hawaii, the colleges' remedial mathematics is different from developmental mathematics. Remedial mathematics courses are referred to as Pre-College Mathematics and are at a lower level than developmental mathematics. Developmental mathematics programs are beginning Algebra, with topics such as the real number system, systems linear equations, and inequalities in one and two variables, functions, exponents, polynomials, factoring, rational expressions and applications, complex fractions, roots and radicals, and quadratic equations. The program objective is to develop proficiency in performing operations rapidly, accurately, and efficiently, and in applying the principles of mathematics to solve problems. In the *National Center for Postsecondary Research Brief*, Boatman and Long (August 2011) noted that developmental courses are one or two levels below college level, while remedial courses are lower level content intended for students who are extremely underprepared.

Developmental mathematics programs in colleges were instituted to prepare students with weak mathematical skills for college-level coursework. While the role of developmental mathematics is to improve the analytical skills of college students and the goal is to make them ready for college level mathematics, developmental mathematics has ended many students' dream of a college degree. Nationally and locally, developmental education is a major concern facing community colleges, and developmental mathematics represents a serious concern for educators and policy makers because it is a barrier to educational opportunity (Bailey, 2009a; Bonham & Boylan, 2011).

For the purposes of this study, the term developmental mathematics is used and the operational definition for developmental mathematics is mathematics courses that are just below the college level mathematics (college Algebra). Developmental mathematics courses are designed to take one or two semesters, usually taken in the first year, to prepare students for regular college mathematics. The gateway level 2 developmental mathematics programs, two levels below college math, were studied to highlight factors that affect success rates, students pre-test (placement test) scores, final grades, effectiveness, strategies, and implications for the colleges.

The study was an endeavor to identify the distinguishing characteristics of the colleges' developmental mathematics programs. Drawing attention to the strengths, weaknesses, opportunities, and threats (SWOT) of the various distinctive developmental mathematics programs at all the colleges in Hawaii can expand the knowledge base regarding successful developmental mathematics practices and inform positive social changes in the future redesign of the colleges' developmental mathematics programs. The individual colleges do not have a mechanism in place to share the successful aspects of their programs and this study may provide this mechanism.

Background of Study

Community Colleges across the United States are seeking new ways of instructing developmental mathematics programs to increase proficiency, retention, and success. Historically, the national focus has been to increase access to higher education, which has resulted in a tremendous increase of developmental mathematics students. Currently, one of the major challenges in higher education is to improve the success rate of students in developmental mathematics. For community colleges, it seems that the key to increasing student success is to reform developmental education. Thousands of students enter community colleges each year with “lofty goals and a fervent expectation that this educative experience they are about to embark upon will fundamentally improve their lives” (Merseth, 2011, p. 32). In actuality community colleges’ “developmental education, and particularly mathematics is a major barrier” (Asera, 2011, p. 28) to college retention and success. The gap in developmental mathematics is huge and the failure rate is enormous. According to Merseth (2011), “nowhere in the community college curriculum is this failure rate of graver concern than in developmental mathematics courses” (p. 32).

To curtail the huge academic success gap in developmental mathematics, the developmental mathematics programs in community colleges are facing unconventional reforms and redesigns to enhance developmental mathematics curriculum and instruction. Twigg (2011) explained that in redesign of developmental mathematics “many saw information technology as a silver bullet that could solve many of higher education’s problems” (p. 26), but success is only plausible if redesign is done correctly. Colleges are constantly tailoring their developmental mathematics programs, but the programs are not making substantial gains in student success. The reality is that throughout the United States, increasing numbers of students are required to enroll in developmental mathematics courses and this has grown to be a major concern for all colleges. In mathematics, over one-third of all college students are enrolled in developmental mathematics and less than 50% usually pass. In addition, the passing number is lower for underrepresented students (P. Johnson, 2007; Míreles, Offer, Ward, & Dochen, 2011; Rodgers, Posler, & Trible, 2011). Research in developmental mathematics is in multiple areas, but studies need to be done to determine if placement test scores are significant (Boylan, 2011), and to identify ways and effective strategies to successfully revolutionize the structure, policy, and delivery of developmental mathematics (McCabe & American Association of Community Colleges, 2000; Roueche & Roueche, 1999).

In education, there is a need for greater articulation to enhance programs. Greater success can be achieved when system-wide collaboration of institutional leaders can pinpoint and generate strategies and solutions to overcome the lack of student preparation (Boswell, 2000). In this study, colleges' developmental mathematics programs across seven colleges were articulated to uncover the characteristics of the individual programs and their effects on student success. The achievement gap in developmental mathematics and developmental education is significantly large, especially in Algebra (Spielhagen, 2006). This study addresses the need for institutions to articulate in comparing their common programs, and analyzing their data/programs to determine what is working and what is not working; that is, what is improving the programs and increasing student success. The colleges should collectively learn from each other, not just by examining final grades (success rate), but by looking at what each program is doing to enhance success. Comparing and contrasting programs may shed light on factors that can improve developmental mathematics at all U.S. colleges.

The scope of the study topic, developmental mathematics programs, affects all community colleges nationwide. In 2006, Noel-Levtz Inc., reported that almost 75% of all freshmen in two year colleges enroll in one or two developmental mathematics courses (as cited in Bonham & Boylan, 2011, p. 2). Efforts to enhance student success in developmental mathematics has resulted in either no improvement, or fluctuating or minimal success. In a nationwide analysis, the U.S. Department of Education found that 45% of students who took two or more developmental mathematics courses would eventually earn a college degree; that is, approximately 55% of developmental mathematics students drop out of college compared to 46% of students who did not need developmental mathematics (National Center for Educational Statistics, 2001). Other researchers discovered that developmental mathematics students leave or drop-out of college earlier compared to entry-level students who were in college level mathematics (Baxter & Smith, 1998; Burley, Bunter, & Cejda, 2001; Grimes, 1997; Hoyt, 1999). Performance in developmental mathematics is a "significant and positive discriminator of academic success in entry-level college mathematics" (L. Johnson, 1996, p. 341), because students who do well in developmental mathematics usually succeed in entry-level college mathematics.

Problem Statement

Colleges are confronted with the problem of finding effective ways to remodel developmental mathematics programs with the objective of improving student success. According to Rutschow, Cullinan, & Welbeck (April 2012), "improving the success of academically underprepared students who are in need of developmental (or remedial) education is a key challenge facing community colleges today" (p. iii). Nationwide and in Hawaii, the redesigned developmental courses are not significantly improving success rates. According to Twigg (2011), "one of our most persistent learning problems is the dismal record of student performance in developmental and college level mathematics at our two- and four-year institutions" (p. 26). Community colleges are perceived to be the gateway to success for many adults in America. Approximately sixty percent of new college students are in developmental classes and about forty percent are in developmental math classes (Oudenhoven, 2002). However, "too many students find developmental mathematics to be an insurmountable impediment to their academic success" (Merseth, 2011, p. 37).

Nationally, developmental mathematics crushes the dreams of many citizens. "Math courses — in particular developmental math — present a persistent and frustrating barrier. Across the county, developmental math has an unwanted distinction: the course offered most frequently and … the course with the lowest rate of student success" (Bradley, 2011, p. 6) . Developmental mathematics courses can be a nightmare for freshman college students. For community college students, the traditional course delivery model does not often lead to success in developmental math, so colleges are focusing on reforming developmental mathematics programs using innovative redesign (Bonham & Boylan, 2011; Le, Rogers, & Santos, 2011). Researchers are studying factors that impact student success and retention in developmental mathematics. Research is lacking an examination and analysis of different college's unique developmental mathematics programs to determine: (1) effective and ineffective program reform initiatives, (2) what role (if any) placement scores play in student success, (3) what colleges deemed important in their developmental mathematics programs, and (4) what is being done to enhance the programs. In summary, this study aims to identify ways in which colleges are tailoring their developmental mathematics programs, what colleges are doing to address the need for improvement, and what success and challenges they are experiencing.

Rationale of Problem

A large percent of developmental math students do not pass their courses. This poses an urgent need for community colleges to redesign and reform their developmental mathematics programs. In 1995, 34% of freshmen were enrolled in developmental/remedial mathematics in public 2 year colleges/community colleges and 23% of freshmen were enrolled in developmental/remedial mathematics in private 2 year colleges (U.S Department of Education, 1998). Due to unsatisfactory student success in developmental education, with math being the worst, in 2004 the Lumina Foundation for Education launched a national initiative called "Achieving the Dream: Community Colleges Count", which aspired to improve student success in the community colleges. The Achieving the Dream: Community Colleges Count program initially tracked the progress in 26 colleges from 2004-2009 and found that "students' persistence and the percentage of students completing developmental math, developmental English, developmental reading, and gatekeeper math courses remained substantially the same" (Rutschow et al., 2011, p. iii). Examination of 2002 data from Achieving the Dream: Community Colleges Count participating institutions found that "at one extreme, 81 percent of students at one institution were referred to developmental math; at another institution, the figure was 25 percent" (Rutschow et al., 2011, p. 15). For academic year 2010-2011, one of the largest local community colleges in the University of Hawaii College System had 42% of students in two levels below college level, and 56% of students in one level below college level mathematics (developmental mathematics) had successful completion (equivalent or C or higher) (University of Hawaii, 2011, p. 2).

Nationally, "out of 100 students entering a community college for the first time, only 15 will complete a degree or certificate within three years, while 45 will leave school without completing a credential" (National Center for Education Statistics, 2008, Table SA-25), (as cited in Scott-Clayton, 2011, p. 1). Improving developmental education may enhance student success in college; college degrees are critical in today's society because it is progressively dictating the likelihood of life success (Bonham & Boylan, 2011; Taylor, 2008). While a successful developmental mathematics program is significant for the success of many college students, it is also essential because "there has been an ever increasing population of students who have not been prepared adequately through their high school education to meet the rigors of college/university-level content" (Taylor, 2008, p. 35).

According to Bonham & Boylan (2011), a considerable number of students who place into developmental mathematics are prevented from attaining their educational goals because they never pass these courses. Developmental mathematics is a barrier to educational opportunity and represents an acute concern for students and policy makers. Examination of successes and challenges of current developmental mathematics programs can inform future redesign. Developing and reforming developmental mathematics programs that enhance academic success and growth of citizens are vital for national growth; especially with the increase in global demands for 21st century analytical skills.

Purpose of Study

The purpose of this study was to examine what colleges' in Hawaii are doing to make their developmental mathematics programs more effective, to determine if redesigns and modifications are improving student success, and to determine if there is any relationship/patterns with programs and success through a mixed methods paradigm. There is a pressing need, locally and nationally, to solve the developmental math proficiency problem of college students. While the gap in math skills is a major problem, community college faculty, administrators, and staff are also faced with the problem of effectively teaching developmental mathematics to college students with much diversity. Developmental mathematics students are required "to gain both fundamental and problem-solving skills. They need a strong mathematical foundation for obtaining their educational goals because most degree plans require at least one non-remedial mathematics course" (Mireles, 2010, p. 82). Effective developmental mathematics programs are necessary to improve mathematics education because strong quantitative and analytical skills are increasingly important for citizens who will be working in an economy that will be increasingly technical in nature and global in scope. Also, effective developmental math education is needed to address a critical national issue and is a macro level societal problem, that is, the failure of the United States to educate the scientists, tech experts, engineers, and mathematicians as demanded by the 21st century economy (Ness, 2010).

There is a need “to find an approach to teaching and learning [in mathematics] that could provoke or enable new ways of seeing and, possibly, being for our students” (Fetherston & Kelly, 2007, p. 263). While developmental mathematics is a macro societal problem, locally it is both a meso (community) and micro (individual/student) societal problem. Due to poor math skills, individuals may not be able to complete college, thus affecting the progress and development of the community. Lack of community growth can have a negative impact on the community’s global interactions. On average, “only 30 percent [of students] pass all of the math developmental classes in which they enroll” (Bailey, 2009b, pp. 13-14). Due to globalization, America’s title as the “home of innovation” is being challenged by nations with higher mathematical skills such as China and India. “Today, America faces not a streaking satellite [Sputnik] but a rapidly changing global workforce. The spread of freedom is spurring technological innovation and global competition at a pace never before seen. We have to run to keep up” (US Department of Education, 2006, p. 5). Mathematics is a critical skill necessary for the 21^{st} century; in *The Looming Workforce Crisis 2005*, the National Association of Manufacturers reported that “U.S. manufacturing will no longer employ millions in low skilled jobs. Tomorrow’s jobs will go to those with education in science, engineering, and mathematics and to high-skill technical workers .… an important key to future growth, productivity, and competitiveness” (US Department of Education, 2006, p. 5). Finding ways to improve mathematical skills will enhance individuals, the community, and the nation’s human capital.

Justification of the Study

Hawaii's colleges face the same challenge as the nation; to redesign developmental math programs to increase student success (performance and success rate) and the "need to improve learning outcomes and control the ever-upward trajectory of higher education costs" (Twigg, 2011, p. 26). Colleges throughout the state are in various stages of redesigning developmental mathematics and are tailoring and molding their programs differently. A study exploring the different developmental mathematics programs in these colleges is particularly vital to identify the characteristics of the different programs, and to identify the characteristics that promote and hinder student success. Having a better understanding of the diverse aspects of these developmental math programs could prove useful in providing insights for future redesign of developmental mathematics programs in Hawaii and the nation.

Research Questions

Three primary research questions guide this study, two quantitative and one qualitative.

The quantitative questions are:

1. What is the current success[1] rate of developmental mathematics at Hawaii Colleges?

[1]Success is defined as grade C or higher.

2. Is there a statistically significant difference (relationship) between the students' scores on the Mathematics Placement Exam and students' final grades in developmental mathematics at the different colleges in Hawaii?

The qualitative research question is:

3. What are the colleges’ administrator and faculty perspectives about the data trends (success rate, placement test scores, and grades), the effective aspects, the challenges or barriers, and the future vision for developmental mathematics?

Theoretical Framework and Conceptual Framework

Developmental mathematics problems are challenging and insights are gained from many theories and educational concepts. Developmental education should be based on a combination of theoretical approaches drawn from cognitive and developmental psychology. Developmental programs should combine theoretical approaches, effective practices, and technology in order to provide effective developmental education (Merseth, 2011; Mireles, 2010). This study is grounded in the theoretical framework of andragody theory, the constructive-development theory, and the transformative learning theory; plus, the conceptual framework of Tinto’s principal of effective retention, Bean’s model of retention, Astin’s I-E-O model (input-environment-output), and the theory of involvement.

Developmental mathematics educators have a huge task ahead of them, to redesign mathematics programs to promote student success in the nation’s colleges. “I think that this new condition requires a redefinition of the purpose of education and the meaning of the ‘educated person’ ” (T. W. Knowles, 1989, p. 132). There is consensus that the educational system, including developmental mathematics, needs to integrate more technology into the classroom so students can keep up with the skills needed for the twenty-first century. However, the focus cannot be on acquiring hardware and equipment while neglecting the theories that improve learning. While the schools and colleges need “technological stuff”, the big disconnect is how can these tools be used to enhance learning. According to Knowles (1989), the nineteenth-century definition of the purpose of education is to primarily transmit knowledge (with some nodding to skills, understanding, attitudes, and values), unfortunately a large percentage of the current education platform is similar. While extoling the preeminent value of 21st century learning, technology alone will not solve learning problems for adults. There should be significant effort to find the best theories for learning and development for the twenty first century and put them to work with new technology. Knowles (1989) envisions an educational system for the twenty-first century that develops cooperative people who are global citizens, highly creative, and self-directed learners. "I would want them to be knowledgeable too – but expandingly, not statically knowledgeable" (p. 132). Politicians, educators, and stakeholders need to first visit how humans learn best with the aid of technology. There is a need to first educate the educators and stakeholders on how to use technology to improve learning and intelligence. As Knowles pointed out, to increase effectiveness of a program such as the developmental mathematics program, stakeholders need to explore multiple programs and theories, and implement them to increase student success.

Andragogy Theory

Colleges in Hawaii have unique developmental mathematics programs that need to be explored and redesigned to increase effectiveness. Many colleges, instructors, and students are "set in their ways" and have little interest in learning new techniques or technology. This could be remedied if the stakeholders in education understood Knowles' vision of becoming "expandingly" knowledgeable and tied this to his andragogy theory. Knowles (1980) described andragogy as a learner-centered approach which is the “art and science of helping adults learn” (p. 43). Knowles postulates six assumptions in the andragogical model for adult learning. According to Merriam, Caffarella, & Baumgartner (2007), Knowles derived four original assumptions: (1) The adult or mature person’s self-concept develops from that of a dependent personality, to one of a self-directing individual. (2) As adults gain experiences, this reservoir of knowledge is a great stimulator for future learning and development. (3) An adult’s social roles prepare them to be ready to learn. The learning experience must align with his/her developmental tasks. (4) Time perspective is important because immediate application is vital for adult learning. “Thus, an adult is more problem centered than subject centered in learning (Knowles, 1980, pp. 44-45)”.

Knowles derived two later assumptions: (5) “The most potent of motivations are intrinsic rather than extrinsic (Knowles, 1990, pp. 44-45)”. (6) “Adults need to know why they need to learn something (Knowles and associates, 1998, p.12)” (p. 84). The andragogical model can be extended to help all learners; thus having a more ideal learning environment of expandable knowledge with less static knowledge. Andragogy theory implies that adult learning must be relevant, authentic, and meaningful and that they are goal-oriented learners, who seek learning for intelligence and status (Od-Cohen & Od-Cohen, 2009).

Constructive-Development Theory

The exploration of the Hawaii colleges’ developmental mathematics programs is aligned to the constructive-developmental theory, which is grounded in the idea that development consists of progressive stages in how people create meaning. The conceptual roots of the constructive-developmental theory lie in Piaget’s theory. The constructive (constructing) and developmental (throughout the lifespan) of the constructive-developmental theory are meaning-making ventures (Kegan, 1980, p. 373). Robert Kegan created theories that describe how identity and the nature of the self change with increasing maturity. According to Kegan (1994), as we grow and develop we become less subjective to our perceptions of the world and develop a more objective perspective that enables a person to entertain multiple points of view. Kegan's developmental theory is applicable to the exploration of developmental mathematics because different institutions can embrace different perspectives. Also, reflection and learning can guide change, growth, and maturity; thus can positively impact the effective redesign of developmental mathematics programs.

People and society are constantly changing. Thus, the experiences and current demands of society are critical factors in informing how individuals perceive learning and education. Examining the developmental mathematics at colleges in Hawaii intertwines with Kegan's constructive-developmental theory which "allows us to consider how individuals understand and experience their socially prescribed roles differently as they grow and see their world differently. And, it helps us to see how abilities are differently valued according to the implicit messages of our cultural contexts and norms" (Helsing & Drago-Severson, 2002, pp. 11-12).

Examining the strengths and limitations of current developmental mathematics programs in Hawaii colleges will determine the mechanisms the colleges are using in the process of development/improvement. According to Helsing & Drago-Severson (2002), Kegan's constructive-developmental theory "attends to the ways that a surrounding culture sets the curriculum and then supports, challenges, and evaluates individual growth and performance" (p. 16).

Colleges across Hawaii are dispersed in the methods used to redesign their programs. While they try to make meaning from their varied programs, Kegan (1994) recommends that organizations envision their relation to the whole, see the relation of the parts to the whole, from the "outside in" rather than see the rest of the organization and its parts only from the perspective of our own part, from the "inside out" (p.302). To make meaning of major programs like developmental mathematics programs, the perceptions of college faculties and administrators in Hawaii can be integrated as parts of the whole, from the "outside in". Like a good constructive-developmentalist, "developmental education is a matter of collaboratively building a "consciousness bridge", then the bridge builder … creates a firm foundation on both ends …. [and] invites his students to join in constructing … a bridge they could chose to walk out on" (Kegan, 1994, p. 279). Organizations, such as colleges, have to lay a rigid foundation for their students; an effective developmental mathematics program is a critical part of laying a rigid foundation. Colleges can make "use of constructive-developmental theories to shape the learning environment" (Kegan, 1994, p. 297).

Transformative Learning Theory

Transformative learning is embedded in the schema that learners are guided to change how they view learning by communicating, critically reflecting, and by using their realities, emotions, and perspectives to enable actions. Transformative learning theory (Mezirow's theory) is rooted in communication and addresses the rational, analytical, and affective learning processes. Learners shift toward a frame of reference that allows for more inclusion, reflection, and integration of experience (Mezirow, 1997).

Transformative learning is a lens through which developmental mathematics programs can be analyzed, thus assisting in the understanding of the study's questions. Transformative learning is changing the frames of reference on how programs are examined to a more fundamentally logical way, and by finding new ways of understanding and reflecting. The frames of reference are the meaning given to experiences, and the constructs used to arrive at the meaning, and are the reflection of the inherent make-up and cultural assimilation of the particular individuals. Reflective practice is critical in transformative learning and to shift consciousness involving the understanding of self and self-location, thus altering the way of being in the world (Abela, 2009; O'Sullivan, Morrell, & O'Connor, 2002). Transformative learning is the "process by which we call into question our taken-for-granted habits of mind or mindsets to make them more inclusive, discriminating, open, and reflective in order to guide our actions" (Keegan, 2011, p. 66).

This study is a coherent way of learning about developmental mathematics programs by shifting to a more practical examination of what programs are actually accomplishing. Transformative learning is using the learning experiences from the colleges to shape learners (colleges), as such, producing a more significant impact or paradigm shift (Herlo, 2010). The paradigm shift is to learn quickly from each other to inform future reform of the developmental mathematics programs from real life experiences. Sharing of experiences, and interacting with others can help to shift views and change the frame of reference of how developmental mathematics redesign initiatives can be more effective.

"Transformative or transformational learning is about change – dramatic, fundamental change in the way we see ourselves and the world in which we live" (Merriam et al., 2007, p. 130). Stakeholders can use this theory to guide them as they search for effective educational reform. "Transformation happens through discerning, exploring, and challenging one's own underlying assumptions about the self, society, and reality" (Daloz, 1999, p. 134).

Conceptual Framework – Tinto's Principle of Effective Retention

In educational programs the concepts of success, challenges, and effectiveness are linked to student success. Student success is associated with their classroom experience and the way the instructor, curriculum, and pedagogy is significant to student development and persistence (Tinto, 1997). The redesign of developmental mathematics to address the demands of society, low student success rates, and the learning needs of students, can be informed by Tinto's model of institutional departure which integrates Tinto's principle of effective retention; thus this principle will guide the research questions and analysis of the characteristics of the programs and the impact on success. One aspect to improving retention and graduation in colleges is to monitor student progress and institutional performance (Tinto, 2004).

The colleges in Hawaii are part of a system, so, it is essential to understand how the different programs operate. According Tinto (2004), numerous students register at multiple institutions during an academic year, often concurrently, and many transfer between institutions. The pattern of student enrollment among institutions is not uniform.

Due to time factors and resources, many programs (such as developmental mathematics) work in isolation and there is little or no articulation and alignment with each other. In the ideal case, institutions collaborate, articulate, and learn from each other's experiences (Tinto, 1987).

Exploring the developmental mathematics programs at the different colleges is parallel to Tinto's principles of effective retention. According to Tinto (1987),

> "the growing body of research on student retention and on program effectiveness provides us with information as to the essential features of successful retention programs. Though programs on different campuses will vary somewhat in their structure and in the specific sorts of actions they take on behalf of students, successful programs are invariably similar in a number of important ways, specifically in the way they think about retention, in the sorts of emphasis they give to their retention efforts, and in how they direct their energy. These commonalities, or what I call here the principles of effective retention, can be described as an emphasis upon the communal dimensions of institutional life, an enduring commitment to student welfare and a broader commitment to the education, not mere retention, of all students" (p. 7).

Effective retention, intended for student development, is related to many factors, for example, "developmental mathematics students may experience a different social environment and may differ significantly in social integration from a typical student in a residential college and university setting. In Tinto's model, academic integration was predicted to have a direct effect on retention" (Umoh, Eddy, & Spaulding, 1994, p. 43). Tinto's principle of effective retention is applicable to the study of retention of developmental mathematics and to another model that explains retention, Bean's student attribution model.

Conceptual Framework - Bean's Student Attribution Model

Bean's student attribution model and Tinto's theory of student departure are linked to college retention. Integration and persistence affect retention and success. Bean's student attribution model provides a framework of relevant factors that contribute to persistence/attrition and retention. Variables such as remedial and developmental classes are recommended for research because "retention research indicates they are associated with college performance, persistence, and certificate or degree completion, or because they are identified in the college database and related to the models recommended by Tinto (1975) and Bean (1980)" (Andreu, 2002, pp. 334-335).

Bean's model of retention is explained by intention to leave, opportunity, grades, and family views. Institutional variables (courses, grades), personal variables (educational goals, conviction in selecting field of study), and environmental variables (opportunity to switch to another school, family support) affect students' commitment or loyalty to the school. The Bean model perceives success in education as a product of the student's social and academic experiences at the institution and external environment (Bean, 1982; Soen & Davidovitch, 2008; Solis Jr., 1995).

Conceptual Framework - Astin's Theory

Students have to be committed and motivated to learning. Astin's input-environment-outcomes (I-E-O) model of student involvement can be used as a framework in exploring environmental factors which may affect the persistence and retention of college students (Heaney & Fisher, 2011). Astin's I-E-O model posits that

"Inputs include students' pre-entry characteristics when they enter college; Environment includes all of the factors experienced during the student's time in college; and Outcomes pinpoint the characteristics of the student after being exposed to the environment" (Heaney & Fisher, 2011, pp. 65-66). That is, inputs are the individuality and experiences prior to college, and the college environment such as programs, peers, and physical environment affect the student's college outcomes.

The I-E-O approach enhances the understanding of how environmental variables can affect outcome variables (Astin, 1993). Astin's I-E-O model explores the power of the environmental experiences that can be manipulated or changed to involve students in learning and possibly improve learning outcomes; but lacks the student's personal responsibly in the college environment (Astin, 1993; Stage, 1989). Astin's I-E-O model stipulates that the college environment plays a critical role in students' outcomes such as success, persistence, retention, efficacy, and motivation. Astin's theory of involvement highlights that the quality of student effort and student involvement impact both retention and success (Pascarella & Terenzini, 2005).

Operational Definitions

There are multiple definitions of the term developmental mathematics. However, for the purpose of this study the definition used is Algebra/mathematics courses that are one or two levels below college level mathematics. Developmental mathematics was defined by Lesik (2007), as

> "a course in intermediate Algebra. The mission of the program is to provide support for students who are at the greatest risk for dropping out of the university due to poor academic preparation in mathematics, by giving them another chance

> to learn the mathematics that they were supposedly taught in high school. Ideally, the program helps match students' mathematics abilities with those expected at the university, and thus helps students persist towards earning a college degree" (p. 588).

Developmental mathematics prepares college students who lack the academic proficiency to succeed in entry-level STEM related college course (Le et al., 2011). College students have to be college ready for college level mathematics courses and other pertinent college classes that require at least some college level math skills.

Gateway level 2 was defined as any developmental mathematics course that starts at 2 levels below college level mathematics.

Success was defined as grades of A, B, C/CR; these are the grades that allow a student to enroll in the next higher level math class in a sequence of math courses. Retention was defined as students actively enrolled and completing a sequence (2 or more) of developmental mathematics and a college level mathematics course.

Pretest was defined as the Compass exam which is also referred to as the placement test.

Limitation of Study

This study, exploring the developmental mathematics programs at multiple community colleges, has the following limitations:

1. The interviews were done with only one or two key developmental mathematics members at each college.
2. The perceptions from the key members may be subject to personal biases.

3. The gateway level 2 developmental mathematics at all the colleges in the state have the same expectations/requirements in terms of mathematics content, but the curriculum is not the same.

4. The placement test data was only for the current 2 years, from when the data was pulled for the study, because placement test scores expire after 2 years.

Significance of the Study

As the colleges seek innovative ways to redesign and enhance their developmental mathematics programs to address the need to increase student success and retention in developmental math; it is critical to highlight success, barriers, and challenges to inform effective changes.

Colleges are faced with the problem of finding effective developmental mathematics programs that will increase student success. Examination of developmental mathematics programs, and the implemented and possible changes to redesign, will shed light on the distinctiveness of the different redesigns/reforms, and how this is impacting student success. Placement exam scores play a key role in assigning students to developmental mathematics and an analysis of the scores and final grades allows for further examination of the relationship between scores and final grades, and the reliability of the one test score procedure in placing students in developmental classes. This study will help to inform developmental mathematics programs of possible traits that are linked to student success.

Transition Summary

Reforming and redesigning developmental mathematics programs to improve student success is a critical problem facing the nation colleges because a significant percentage of students find developmental mathematics too challenging to pass. Studying the developmental mathematics programs will shed light on what link (if any) placement tests, final grades, and the different programs have on student success. By exploring quantitative data from the colleges' databases and engaging in multiple case studies, the data were examined for emerging trends. This research study engages qualitative and quantitative methods, and a mixed methods study, to explore the developmental mathematics programs at all seven colleges in Hawaii. Results provide a mechanism for the individual colleges to share their experiences.

Chapter 2: Review of Literature

College, affirmed as early as the 1800s, is a "system of mental gymnastics" (Porter, 1878, p. 36), (as cited in Veysey, 1965, p. 24) because students can forget the information learned. It is the strenuous morality of academics glorified in exertion of its own sake because to bring the mental power up, the mental organs have to be taxed to its utmost (Veysey, 1965, p. 24). The reality of college being labeled a mental gymnastics and that developmental mathematics is called the graveyard course can be intimidating to students (Merseth, 2011; Veysey, 1965) . According to Veysey (1965), "if knowledge was administered as a proper, albeit subordinate, …. [colleges will have to] re-examine the content of the curriculum which foreshadowed the ultimate downfall of … education" (p. 25). Reviewing and reforming education has always been a challenge and the biggest challenge is developmental education, especially developmental mathematics.

The purpose of this study is to explore how Hawaii's colleges are changing their developmental mathematics programs to make them more effective, to determine if these redesigns and modifications are improving student success, and to determine if there are any relationships or patterns between program changes and student success. Developmental mathematics is one or two levels of pre-college mathematics below college level mathematics (College Algebra). The objective of this study is to determine and highlight strengths, weaknesses, challenges, and barriers that can inform future redesign.

An initial literature search was conducted to learn more about college developmental mathematics, using the key words developmental education, remedial education, reformed remedial mathematics, and developmental mathematics. After learning about the history, challenges, and issues of developmental mathematics programs, the search was expanded to include the following key words: college success, retention, mathematics, retention model, redesign, STEM, computer assisted instruction, and placement test. The frameworks for the study include andragody theory, constructive-development theory, and transformative learning theory; and the conceptual framework of Tinto's principle of effective retention, Bean's model of retention and Astin's I-E-O model (input-environment-output) and theory of involvement. Vincent Tinto's model of institutional departure, and model of persistence and retention examine the important aspects of student retention. Alexander Astin's I-E-O model and theory of involvement entails the dynamics of students' change, development, and persistence.

There are many theories and concepts that supplement Tinto's, Austin's, and Pascarella's theories (Astin, 1993; Hu & Wolniak, 2010; Milem & Berger, 1997). To develop a better understanding of the study's framework, concepts such as learning, motivation, self-efficacy, andragogy, pedagogy, and the learning environment are explored because they are linked to change, success rate, retention, and persistence. Boolean/Phrase search were done using the databases of the Educational Resource Information Center (ERIC), Education Research Complete, and ProQuest Dissertations and Theses. Also, the internet search engine Google was used to find supplementary information and articles.

Developmental Education

Developmental education was introduced to prepare the increasingly diverse college population for college level classes. According to Higbee, Arendale, & Lundell (2005), "many underprepared community college students must participate in prerequisite remedial or developmental courses before they can enroll in classes that carry credit toward a degree or certificate" (p. 9). The main purpose of developmental education is "to enable students to gain the skills necessary to complete college-level courses and academic programs successfully" (Weissman, Bulakowski, & Jumisko, 1997, p. 74).

A Brief History

The signing of Morrill Acts of 1862 after World War II by President Lincoln, the GI Bill, the launch of Sputnik in 1957, and the Civil Rights Act of 1964 prompted the nation to increase access to postsecondary education to all individuals. Education became a national priority since it was perceived to ensure economic strength, national security, and competitive globalization (Parker, Bustillos, & Behringer, 2010). The main principle in the democratization of education and knowledge is inclusiveness, a commitment to make higher education broadly accessible to all who seek to advance themselves through knowledge (Simon, 2010). Developmental education was introduced to better prepare postsecondary students to take college classes.

Developmental education serves as the doorway for many entry level college students in America (Smittle, 2003). The initial goal of developmental education was to prepare students to gain access to a college education. Casazza (1999) stated that the National Center for Developmental Education (NADE) defined developmental education as a comprehensive process which focuses on the intellectual, social, and affective growth and development of all learners at all levels. The theoretical foundation of developmental education is grounded in developmental psychology and learning theory. Developmental education is sensitive to individual differences and special needs amid learners.

Enrollment

In 1995, approximately 78% of higher education institutions that enrolled freshmen offered at least one remedial reading, writing, or mathematics course. Developmental/remedial courses were especially common at public 2-year institution (100%) and institutions with significant minority enrolments (94%). Public 4-year institutions provided 81% of remediation (Lewis & Farris, 1996, p. iii). Hawaii is a state with a very diverse population including Caucasians, Polynesians, Hawaiians, Micronesians, Asians, Latinos, African-Americans, and Hawaiians; many of whom are considered minority because of their ethnicity and/or socioeconomics. For institutions with high minority enrollment, "43% of first-time freshmen were enrolled in remedial writing, reading or mathematics compared to 26% at institutions with low minority enrollments" (Lewis & Farris, 1996, p. 9).

Usually, students enrolled in developmental courses are faced with some level of restriction in their college mobility. "About two-thirds of institutions placed some restrictions on the regular academic courses that students could take while they were enrolled in remedial courses" (Lewis & Farris, 1996, p. 20). In most cases, "developmental credits may qualify a student for financial aid, but may not count as "degree credits" toward graduation" (Scott-Clayton, 2011, p. 5).

There is no consensus nationally on how best to serve developmental students. The redesign of developmental mathematics seems like an on-going experiment to "find the magic". According to Engstrom & Tinto (2008),

"Institutions need to avoid the tendency to place developmental-education programs and the academically underprepared students they serve at the margins of institutional life.

They have to stop taking an "add-on" approach to institutional innovation that marginalizes successful efforts, constrains their ability to expand, and limits their effectiveness. Until institutions take these steps, they will continue to struggle to translate increased access into real opportunity" (p. 50).

Developmental Mathematics

Typical developmental mathematics is introductory Algebra and these courses are "designed to ameliorate knowledge and skill deficiencies for students entering college" (Higbee et al., 2005, p. 9). Developmental mathematics has the highest rate of enrollment for first time college freshman of all remediation courses. "First time freshmen took more remedial courses in mathematics (24%), than in writing (17%) and reading (13%)" (Lewis & Farris, 1996, p. 9). In public 2-year colleges across the United States, including the Hawaii Community Colleges, approximately 66% of students passed or successfully completed developmental mathematics (Lewis & Farris, 1996, p. 13).

Students classified as needing remedial and developmental course work are "a very diverse group" (Levin & Calcagno, 2007). Many students entering community colleges are unprepared in mathematics. Deficiencies in mathematics for arriving community college students stem from inadequate high school studies, nontraditional students with adequate preparation that need a refresher course, poor study habits, mild to serious learning problems, and varying social and academic integration challenges (Kalojo, 2004; Tinto, 1975; Zeidenberg, Jenkins, & Calcagno, 2007). A study of 8000 first-time Ohio college freshmen, from 1998 to 2002, concluded that "success at remedial mathematics improves a student's chances of graduation" (Attewell, Lavin, & Domina, 2006, p. 892).

Challenges

Passing developmental mathematics is a challenge for many college students and has "become a frightening obstacle" (Bonham & Boylan, 2011, p. 3). Community colleges have struggled to remediate the significantly large number of underprepared students through remedial and developmental programs; but these remediation programs have posed their own challenges and barriers to college success (Attewell et al., 2006; Bailey, Jenkins, & Leinbach, 2005; Calcagno, Crosta, & Bailey, 2006; Levin & Calcagno, 2007). The challenge for developmental mathematics programs is to find effective means of teaching and learning that integrate the student's prior experience as stipulated by Astin's I-E-O model. Increasing success/outcomes is a challenge that is addressed by redesign of programs to integrate factors that are recommended by research. Research recommends that developmental programs build partnerships with each other and with the community. There is a need to build community understanding and support for changes in developmental mathematics.

National projects hope to determine effective redesign of the content and delivery of developmental mathematics. However, for these endeavors to be successful the community (professional associations, foundations, policy makers, and developmental mathematics instructors) have to collaborate in making effective changes. The challenge to increase success is not an easy or short-term process; stakeholders and the community have to work in partnership to change the way developmental mathematics courses are structured, taught, and delivered (Adelman, 2006; Bonham & Boylan, 2011; Boylan, 2002).

Placement Exams

Placement exams scores are usually used to determine the level that a student will start mathematics in college. Stakeholders are examining data to see if there is a relationship between students' college placement test scores in mathematics and the completion or withdrawal for particular instructional modes such as, lecture-based, hybrid, or distance learning (Zavarella & Ignash, 2009, p. 7). Placement tests, entry exams, and exit exams are being examined as possible barriers to developmental mathematics. According to (Attewell et al., 2006) “placement in remedial courses *per se* did nothing to enhance students’ subsequent academic achievements, [but] success in remedial courses did make a significant difference” (p. 891).

Developmental mathematics programs are exploring the effectiveness of computer-assisted adaptive tests for placement exams and for remedial/developmental mathematics. While new ways are being explored to enhance learning, stakeholders must consider the fairness of the testing and approach, and establish consistency across-the-board for all (George, 2010).

Colleges are using placement exams to initially place students in mathematics courses. In 2006, nearly 48% of 3.04 million high school graduates took the SAT, and approximately 81% of non-profit colleges and universities without open admissions policies use SAT scores for admission (Scoropanos & Coletti, 2006). Research conducted by Foley-Peres & Poirier (2008) noted that SAT scores were not the best indicators of the mathematical ability of a student and that the college math placement assessment score is an effective evaluation method for student placement according to initial midterm grades. Placement exams should be scrutinized for reliability and effectiveness. Students' motivation may be a factor that influences the outcome of placement exam scores. Some studies found that a combination of high school rank, high school mathematics grades, ACT mathematics scores, SAT scores, and placement exam scores is a better indicator of success than any one single score or single indicator. However, other studies indicate that placement exam scores are a sufficient indicator of a students' math level. Varying types of curricula/courses and time in college have a statistically significant impact on students' mathematics placement and the first mathematics course grades (Armstrong, 1976; Davis & Shih, 2007; Norman, Medhanie, & Harwell, 2007; Pugh & Morgan, 1970).

A 1990s study conducted at Merrimack College in Massachusetts compared the grades of students who took the recommended mathematics course, as determined by their mathematics placement exam score, to those who did not follow the mathematics placement recommendation. The study found that students who took the recommended course or an easier math course, performed much better than those who took a higher-level course or did not take the placement exam. However, in 2000 there was no significant difference among the average grades received by those students who took the recommended course and those who took a higher-level course (Rueda & Sokolowski, 2004).

Mathematics and Innovation

Colleges are major sites for innovation, but how truly innovative are their programs? Colleges have existed for centuries and are their own archaeology. So how different are the features of modern day college programs, such as developmental mathematics, compared to the middle ages? According to Tinto (2000b), "the classrooms of today differ little from those of the Middle Ages, except perhaps in the dress of their inhabitants" (p. 3).

Exploring different developmental mathematics programs and dissecting them for their different characteristics provides different views of the programs. Using different lenses, archaeological and photographic, serves to keep discourse open to multiple and sometimes quite foreign perspectives. The inclusion of differing views and voices is a valued social goal and is essential to fully understand how collective actions in colleges influence, perhaps unintentionally, our individual behaviors and those of our students (Tinto, 2000b).

If colleges are serious in the pursuit of student learning, they have to reorganize themselves with the guidance of voluminous research on the sorts of environments that best promote student learning. Instead, current practice seems to be discussion about the importance of student learning and how it should be, but little is done to reorganize the settings in which students are asked to learn and ourselves to teach (Tinto, 2000b). Redesign has to be creative, innovative, and increase student success. The main goal of redesign has to attend to the needs of the students and to tailor the environments they function in. Developmental mathematics programs have to explore, integrate, and evaluate factors such as the mode of instructional delivery, teaching strategies, affective matters, community partnerships, professional development, alignment of exit and entrance requirements (placement exams, pretest, post-test), and design of curriculum (Adelman, 2006; Bonham & Boylan, 2011; Boylan, 2002). Emphasis is usually placed on redesigning the curriculum; "redesigning the curriculum content is necessary but not sufficient to stem the crises of failure and non-completion in developmental mathematics" (Bonham & Boylan, 2011, p. 4).

For the past fifty years, and with the new understanding of the human mind and brain, and scientific and technological changes, the basic desires and demands of global cultures have undergone a paradigm shift. There is need to find more effective ways to conceptualize the human intellect (Gardner, 1999). Gardner's multiple intelligences theory has become an area of interest for many educators and is "an inclusive pedagogy that could better inform teaching and learning" especially in higher education where the Western model "does not always allow for socio-cultural differences" (Barrington, 2004, pp. 421-422).

Developmental education is experiencing intensive reform and redesign; thus educators need to work even harder to bridge academic gaps and to increase retention and success. Intelligence theories can shed some light on bridging the developmental mathematical learning gaps in an increasingly diverse college society. One of the most popular intelligence theories in education is multiple intelligences theory. Learning happens in multiple ways and the multiple intelligences theory is an innovative and inclusive way to explore content in the twenty first century. According to Bas (2005), "the theory of multiple intelligences offers eight ways of teaching and learning styles." Thus educators "armed with the knowledge and application of multiple intelligences" can ensure that students are exposed to an assortment of activities so that as "much of their learning potential can be tapped as possible" (p. 1).

Marcus (2007) revealed that “with the addition of technology, there is the added difficulty of the elimination of some of the very learning styles that we hold dear”. Students in the 21st century are “digital natives who tend to be social, experiential multitaskers”, so educators have to re-evaluate how they communicate information. Educators are finding that the range of intelligences in multiple intelligences theory helps meet the needs of the diverse 21st century education community.

21st Century Skills

The diversity of students enrolling in college ranges from students with limited skills in 21st century technology to very tech savvy students. The influx of college students that are tech savvy is increasing, especially with new high school graduates. The local and global markets are integrating 21st technology into their businesses and are increasingly hiring college graduates that are more math literate and tech savvy. With the developmental math crisis and the increasing demand for more analytical and technical skills, researchers are proposing that colleges rethink and redesign their programs to meet the needs of their students for the 21st century (Astin, 1993; Bonham & Boylan, 2011; Boylan, 2002; M. S. Knowles, 1980; Tinto, 1993; Twigg, 2009, 2011).

Rapid development of technology has made the use of computers in education inevitable and it provides a learning environment that serves to create interest, a learning centered-atmosphere, and enhances student motivation (Isman, Baytekin, Balkan, Horzum, & Kıyıcı, 2002; Serin, 2011). Technology can take a difficult concept and change it from abstract to concrete to make it easier to understand (Isman, Yaratan, & Caner, 2007). Software and audiovisual materials such as animation and simulation are used as assistive instruction, and has resulted in the development of computer-based instruction. Computer-Based Instruction (CBI) enables the students to learn by self-evaluating and reflecting on their learning process (Serin, 2011).

Educational software is associated with enhanced instruction and increased classroom learning. An examination of computer-based instruction at more than 100 higher education institutions found that using computer tutorial programs to supplement regular instruction has a positive effect on learning (Kulik & Kulik, 1986). Full lecture courses are ineffective in engaging students; however, the effectiveness of computer assistive instruction declines when used as the primary delivery tool in developmental education (Bonham, 1992; Twigg, 2009).

Student Success

Student success is linked to retention and persistence. In colleges, persistence must be viewed as a longitudinal outcome of an interactive process between the individual and the institution in which he/she is registered. Due to a low success rate, increasing attention is being directed to enhancing student success, retention and graduation; thus making sure that students not only get in the door of higher education but also are successful (Tinto, 2004). Student success, retention, persistence, and student satisfaction appear to improve when efforts are geared toward integrating the student's total educational experience (Tinto & Cullen, 1973; Umoh et al., 1994).

In a study conducted by Umoh et al.,(1994), relative to developmental mathematics, student age, gender, parent’s education level, and grade point average (GPA) were found to have an insignificant direct effect on student success and retention. The study indicated that developmental mathematics instructors and students' positive self-motivation to succeed appear to produce a significant positive effect in developmental mathematics classes.

According to Bean (1990), “retention rates are related to the interaction between the students attending the college and the characteristics of the college” (p. 93). Bean agrees with Tinto’s integration model that suggests a need to match the institutional environment and student commitment. Students tend to drop out of college or transfer to another institution when the match between the student and college is poor (Hagedorn, 2005).

There is a growing need to reform and redesign developmental mathematics education for the twenty first century. However, reforms must be thoughtful and be informed by research. How a human makes meaning depends on his or her everyday experiences, which is what Albert Bandura called Social Learning Theory. This theory centers on the premise that people can learn through observing the behavior and attitudes of others. Exploring the individual colleges’ developmental mathematics programs will help the broader educational community learn and grow. Bandura (1986) specified that if knowledge acquirement occurred only through one’s own actions, the process of cognitive and social development would be seriously retarded. Most human behavior is learned by observation through modeling. People form rules of behavior by observing others, and on future occasions the coded information serves as a guide for action. Theories such as the social learning theory, the I-E-O model, Tinto’s integration theory, and Tinto’s model of institutional departure can inform effective reform of developmental mathematics programs. A very important aspect is increasing interaction between all stakeholders before they draft and enact policies to reform/redesign developmental education.

Student success is impacted by social integration and programs that are focused on increasing engagement and improving student involvement affects (Bean & Metzner, 1985; Tinto, 1993). A student's background (family, education, socioeconomic status, race, gender, academic skills) and ability interact with each other and influence college goals (goal commitment) and graduation. Peer group and faculty interaction can enhance academic integration, intelligence development, and increase student success (Braxton, 2000; Umoh et al., 1994). Tinto postulated an interactionalist theory that recognizes student entry characteristics and background, and academic and social integration as directly related to level of commitment and student success (Braxton, 2000; Tinto, 1975, 1982).

The classroom is the heart of college programs and student success. To increase success in developmental mathematics, the discussions have to include restructuring the pedagogy, interactive classrooms, learning communities, building supportive peer groups, hiring effective instructors, and sustaining student motivation and engagement. Integrating out-of-class experiences into college classrooms is significant to student learning and development. The need for a seamless learning environment is critical to increase enhance student success (Kuh, Schuh, & Whitt, 1991; Tinto, 1997, 2000a).

Effective Action

The nation's colleges have been successful at increasing access to college and reducing the gap in access between low income and high income students. However, colleges have not been able to translate the increased access to college opportunity into increased student success. Programs to increase retention and completion have not been successful because programs incorrectly assume that persistence is the mirror image of the leaving/departure process. Knowing why students leave or are unsuccessful is not equivalent to knowing why students stay and/or are successful. Social engagement plays a role in retention but does not directly inform practitioners how to enhance social and academic integration. Colleges often invest in efforts that are a laundry list of disconnected actions. Institutional actions must be centered on the classroom, by changing how classrooms are structured and lessons are taught. Classes have to align with coherent pathways that thrust students towards a timely completion. Success is more likely in settings that establish clear and high expectations for students, offer academic and social support, provide frequent feedback and assessment on performance, and actively involve other classrooms and campuses (Tinto, 1993, 2012; Tinto & Cullen, 1973).

Student input and involvement are critical for success. Individual commitment, values, abilities, and prior academic preparation matter in academic success. Also, students can succeed by sheer will power, perseverance, and skill. Success is not due to a single program or isolated action, but by full institutional action that aligns all its plans and numerous parts, and the goals and stakeholders to improve success for students (Tinto, 2012). No single approach to teaching, subject matter, resource allocation, or learning is adequate for all students. Rather, an eclectic approach that is flexible to the needs of the individual student and integrates effective pedagogical approaches is more successful. The eclectic approach is extremely expensive because it requires extensive individualized attention (Astin, 1999).

Due to increased pressure to increase retention and degree completion, colleges are examining the effectiveness of their programmatic interventions and designs. Developmental studies and remedial programs are manifestations of the efforts to enhance academic performance and persistence of underprepared college students. The need to enhance student success has led to many reforms and redesigns of developmental mathematics courses since these courses seem to play a critical role in college retention and graduation (Pascarella & Terenzini, 2005).

Summary of Literature Review

Success in mathematics and science seems to play a significant role in students successfully transferring from a community college to a four year college. “Community college students who take two math courses were 19% more likely to transfer” (Cabrera, Burkum, & La Nasa, 2005, p. 171). Developmental mathematics and remedial education are crucial factors in student success. Due to the staggeringly low rate of student success in developmental mathematics, many reforms are being initiated; but colleges have to be mindful that “the nature of remediation also plays a role in the likelihood of a community college student eventually attaining a four-year degree” (Cabrera et al., 2005, p. 168).

Parallel to Astin’s I-E-O model, Tinto’s interactionlist theory and principle of effective retention emphasize that effective retention programs such as institutional commitment to students, and supportive social and educational communities in which all students are integrated, are needed to help students to persist in remedial programs and college. The individual characteristics of a student is the initial motivator to commitment. The college environment, especially academic and social integration, is critical to maintain consistent student commitment and motivation. The emerging model for instructional reform today is moving from being teacher-centered to learning-centered where students actively engage in learning. Academic and social integration are encouraged because people tend to avoid situations that are not favorable (Bandura, 1977; Pascarella & Terenzini, 2005).

Spady (1970) stated that "no one theoretical model can hope to account for most (let alone all) of the variance in dropout rates either within or across institutions" (p.64). Theoretical limits should not be the constraint from seeking to improve existing models or replace them with better ones (Tinto, 1982). Programs and institutions should focus on interaction between the individual student (dispositions, interest, attitudes, and skills), the college environment, expectations, and demands from a variety of sources (including courses, faculty members, administrators and peers). Collaboration and articulation between and within colleges are aspects that can inform reforms and increase college and program success (Spady, 1970).

Developmental mathematics programs have attempted to identify the features of successful programs and community colleges have tailored their programs with the hope of meeting the needs of their students to increase retention and success. However, these changes have not resulted in significant improvement in the success rate of developmental mathematics students. This study is an attempt to explore the different models of developmental mathematics programs in Hawaii colleges. The study will provide insight into the factors that promote progress and success, and will add to the field of developmental mathematics education.

Chapter 3: Methodology

The method or research approach for this study is mixed methods. A mixed-method approach is a “methodology used in research, where the researchers collect both quantitative and qualitative data from the program and participants” (Spaulding, 2008, p. 58). The purpose of combining qualitative and quantitative data is to “give an in-depth picture of the implemented program, in organizational context, and the broader environment” (Wholey, Hatry, & Newcomer, 2004, p. 88). A major advantage of mixed methods is that it “combines the strengths of both qualitative and quantitative methods …. and the researcher has flexibility in choosing methods of data collection” (Lodico, Spaulding, & Voegtle, 2010, p. 282).

Research Design and Approach

A mixed methods approach was used to gather data from all seven colleges in Hawaii. The mixed methods approach was used to examine placement test data, success rate, and the colleges’ perspectives/experiences on the characteristics, vision, and barriers of the developmental mathematic programs. The research was a multiple case study using a mixed methods research design to collect both qualitative and quantitative data; and is appropriate for this study because quantitative data on placement test scores, and success rate, were analyzed and the result was used to drive some of the qualitative questions in the interview phase.

To explore the developmental mathematics programs at the colleges, case studies were utilized. Case study is used in multiple situations to “contribute to our knowledge of individual, group, organizational, social, political, and related phenomena” (Yin, 2009, p. 4). There are six different types of case studies: historical (focused on the development of an organization over time), observational (study of a single entity using participant observation), life history (a first-person narrative completed with one person), situation analysis (a study of a specific event from multiple perspective), multicase (a study of several different independent entities), and multisite (a study of many sites and participants the main purpose of which is to develop theory) (McMillan, 2010). Some specific categories of case studies are exploratory, explanatory, and descriptive. Exploratory, explanatory, and descriptive case studies can be used to study either single or multiple cases. A descriptive case study presents a complete description of a phenomenon within its context and more aptly describes this study. Whereas, the exploratory case study defines the question and hypothesis of a study or determines the feasibility of the desired procedures, an explanatory case study presents data bearing a cause-effect relationship and explains which cause produces which effects (Yin, 1993).

Multiple Case Studies

The design used for the study of the colleges' developmental mathematics programs was multiple case studies because each of the seven colleges was treated as a separate case. "Case studies can cover multiple cases and then draw on a single set of cross-case conclusion" (Yin, 2009, p. 20). Case studies are a strategy of inquiry where programs, events, activities, and process are explored in depth (Creswell, 2009). In each case for this study, the developmental mathematics programs are examined to develop insights and understanding of the different models of developmental mathematics programs at different colleges. According to Lodico, et al., (2010), "case study is a form of research that endeavors to discover meaning, to investigate processes, and to gain insight into an in-depth understanding of an individual, group or situation" (p. 269). The multiple case studies are an undertaking to learn more about the characteristics of developmental mathematics, its successes and barriers.

Multiple case studies are practical and useful for exploring educational innovations, evaluating programs, and informing policy (Merriam, 2009). The developmental mathematics programs at the seven colleges were examined and analyzed to determine what features are successful in promoting students' success. McMillan (2000), defines a case study as "an in-depth analysis of one or more events, settings, programs, social groups, communities, individuals, or other bonded systems (p.266). Also, to determine if there are common elements across the different programs that can inform future developmental mathematics programs.

Multiple case studies commonly used for a study with more than one case are collective case studies, cross-case, multicase or multisite studies, or comparative case studies (Merriam, 2009). This multiple case studies is a descriptive case study aimed at exploring the cases and examines the developmental mathematics programs to gain a thorough description of the programs. Descriptive case study design, "attempts to present a complete description of phenomenon" (Hancock & Algozzine, 2006, p. 33). This multiple case studies design is an intrinsic case study focusing on learning more about a particular individual, group, event, or organization and examine in-depth contexts, processes and interactions (Hancock & Algozzine, 2006). The cases are the developmental mathematics programs at the colleges and the study was an in-depth exploration of the different programs to provide insight into developmental mathematics in Hawaii.

Mixed Methods Sequential Explanatory Strategy

For the purpose of this study, a mixed methods sequential explanatory strategy was employed. Phase 1 design involved the ex post facto, or after-the-fact, technique where archival data on placement test scores, grades, and success rates were analyzed. The results of phase 1 were used in phase 2 to explore the colleges' perspectives on the findings. Sequential explanatory strategy is used in mixed methods design where collection and analysis of quantitative data is done in the first phase and the second more qualitative phase builds on the results of the initial quantitative data (Creswell, 2009, p. 211). For the overall study, Phases 1 and 2, the mixed methods procedure is more in the realm of sequential explanatory strategy because quantitative analysis results are nested in the qualitative phase to provide a compound view of the developmental mathematics programs at the colleges.

The qualitative data were derived from interviews and the quantitative data were from the colleges' databases. Qualitative research is usually associated with narrative. According to Lodico, Spaulding, & Voegtle (2010), "qualitative approaches summarize data using primarily narrative or verbal methods" (p. 6). Studying the key faculty members' perceptions of an individual college's developmental mathematics program is a qualitative research because it "focuses on the study of social phenomena and on giving voice to the feelings and perceptions of the participants under study" (Lodico et al., 2010, p. 264). In quantitative research the word 'quantitative' is usually associated with numbers. According to Lodico, et al (2010), "quantitative approaches summarize data using numbers" (p. 6).

A case study "allows greater latitude in seeking out and assessing program impacts" (Balbach, 1999, p. 5). A mixed methods case study was a justifiable design to explore the developmental mathematics programs. According to Fitzpatrick, Sanders, & Worthen (2004), a case study is one of the most frequently used design in exploring programs and draws heavily on qualitative methods, but can employ both qualitative and quantitative methods.

The activity study (developmental mathematics) in the research is a "normal" educational practice because, in an educational setting, programs are studied to highlight effective factors and things to change with the hope of enhancing students' success. Developmental mathematics programs are studied in colleges across the nation in order to highlight factors that can aid in the effective redesign of their developmental math programs to increase success.

Sample and Setting

The participants in the study were recruited from the seven public colleges in Hawaii. One or two participants were sought from each college's developmental mathematics program. The participants for the one-on-one interviews were key members (faculty/staff/administrator) working directly with the colleges' developmental mathematics program. If one person from the college could not answer all the questions for the interview, a second key member was sought. Nine participants were recruited; one or two from each of the seven colleges.

The sampling technique for the interviews was purposeful sampling. "Purposeful sampling is based on the assumption that the investigator wants to discover, understand, and gain insight, and therefore must select a sample from which the most can be learned"

(Merriam, 2009, p. 77). Purposeful sampling identifies key informants or participants that have explicit knowledge pertinent to the topic being investigated. There are many types of purposeful sampling. The sampling procedure employed in this study was convenience sampling. Convenience sampling is a nonrandom sampling technique utilized in educational settings because the participants are usually directly involved with the program being studied and they have firsthand knowledge (Lodico et al., 2010).

Data Collection: Quantitative Data

Quantitative research utilizes "specific, narrow questions to obtain measurable and observable data on variables" (Creswell, 2012, p. 14). The quantitative data were collected for the seven colleges from the system wide Institutional Research Office. The existing quantitative data in phase 1 were all placement test scores (pre-test) for students placed into and taking the initial level of developmental mathematics course at the seven colleges from Fall 2010-Fall 2012, their final grades, and the passing and failing rates of students that were enrolled in the initial level (gateway level 2) developmental mathematics course. The college success rate data were from Spring 2007 - Spring 2013. The students' names were de-identified; the college system office provided data that did not identify individuals.

Quantitative data collected in Phase 1, were analyzed and the result was used to address research questions 1 and 2 and drive the initial interview portion of phase 2. The results from the quantitative data were shared with the colleges and the key members were asked to reflect on what the findings imply for the college.

Ex-Post Facto Research Design

For the quantitative portion of this research an ex-post facto research design (also called causal comparative research design) was used. Post hoc data analysis is “a Latin phrase meaning after the fact”(Faherty, 2008, p. 233). The ex-post facto research design is a non-experimental design. According to Andreu (2002) “an ex-post facto research design is recommended for mining data from community college databases. This sort of research is necessarily applied and non-experimental in nature” (p. 333).

Ex-post facto research explores probable causes and effects. It is where the independent variable is not manipulated because it has already been applied, and focuses initially on the effect, then tries to determine what caused the observed effect. The independent variable was the placement test scores.

Data Collection: Qualitative Data

Qualitative data were collected in Phase 2 after the analysis of the quantitauve data. Phase 2 consisted of one-on-one interviews of one or two key members associated with the developmental mathematics programs at each of the seven colleges. The interviews were either face-to-face, or by phone. The key members (faculty/staff/administrator) in the developmental mathematics program were recommended by the college and were willing to participate as a conduit for the multiple case studies. The data were the existing knowledge of the key members (faculty/staff/administrator), that is, their perspectives.

According to Merriam (2009), qualitative research is trying to understand how people interpret their experience, construct their worlds, and the meaning they attribute to their experiences. The advantage of using qualitative research for this particular issue is that the qualitative data will provide insights into the strengths, challenges, and barriers in the different developmental mathematics programs geared to help adult learning in the 21st century. Qualitative data will aid in discovering what is working, and what needs to be changed, to enhance learning. According to Merriam (2009), qualitative research is an endeavor to understand the nature of a setting and what it means for participants.

The interviews were semi-structured, open-ended, and the exact wording and sequence of questions determined in advance (Appendix A). Open-ended interviews allow for the discussion of the topics in detail and allows the interviewee to elaborate on a response or follow a line of specific inquiry if deemed necessary (Finn & Kohler, 2010).

Data Analysis

The quantitative data, existing data from the University of Hawaii Institutional Research Office (IRO) operational data store, on the seven colleges' success rate, placement test data, and final grades for gateway level 2 developmental mathematics were analyzed. Descriptive statistics was used to summarize data either by graphical or mathematical procedures and to depict patterns in the data (Lodico et al., 2010). Simple frequencies and percentages were calculated using the SPSS 22 software. A post hoc analysis of the longitudinal data for college success rate (Spring 2007- Spring 2013) and placement test data (Fall 2010-Fall 2012) for the seven colleges was employed.

There were two quantitative research questions for this study. For question 1, What is the current success rate of developmental mathematics at Hawaii's Community Colleges? Data on success rate and student enrollment were analyzed for multiple years, and the percentage success rates per semester were graphed and compared for trends and patterns. Question 2, Is there a statistically significant difference (relationship) between the students' scores on the Mathematics Placement Exam and students' final grades in developmental mathematics at the different colleges in Hawaii? Data on students' placement scores for developmental mathematics were statistically correlated with the students' final grades for the developmental math class. The result was analyzed to determine if there was a relationship between the students' scores on the mathematics placement exam and students' final grades in developmental mathematics at the different colleges. Existing data college data for multiple years were analyzed, graphed, and compared for trends and patterns.

Quantitative Analysis

Research Question 1: Examining the Trends in Passing Developmental Math Over Time

The first research question looked for any trend observed in passing rates over time. The dependent variable examined changes over a period of semesters. The independent variables were time (specified as the change in passing rate from the beginning to end of the study), semester (spring, summer, fall), and campus. A two-level growth model was defined with time (specified as semesters) nested within the seven institutions. The resulting model for institution *i* at time *t* is as follows:

$$y_{it} = \beta_0 + B_1\, time_{1i} + \varepsilon_{it}, \qquad \text{(Equation 3.1)}$$

where β_0 is the initial passing rate and B_1 represents the change at the end of the study and ε_{it} represents errors in predicting the growth for individual institutions (which are assumed to have a mean of 0 and some variance). Preliminary analysis examined differences in initial status and growth by institution; however, there was no apparent upward or downward trend for individual institutions. Differences were observed in the percentage of students passing for different semesters. Therefore, at the institutional level, a covariate was added to investigate possible differences in initial status (β_0) due to the semester in which the course was taken and whether the semester affected change over time (B_1). These intercepts are considered as randomly varying across units (u_{oi}) but the time effect was specified as fixed (i.e., no random effect to indicate difference in growth variability) across institutions since there are only seven institutions in the study and there was no apparent growth trend over time.

$$\begin{aligned} \beta_0 &= \gamma_{00} + \gamma_{01} semester + u_{oi} \\ B_1 &= \gamma_{10} + \gamma_{11} time * semester. \end{aligned} \qquad \text{(Equation 3.2)}$$

Through substitution, the combined model is as follows:

$$y_{it} = \gamma_{00} + \gamma_{10} + \gamma_{01} semester + \gamma_{11} semester * time_{1i} + u_{oi} + \varepsilon_{it}.$$

(Equation 3.3)

Research Question 2: Explaining the Effect of Student Previous Knowledge on Grades

The second research question examined the relationship between students' previous knowledge as measured by their Prealgebra or Algebra Compass score and their grade in the developmental math course taken. Ordinal outcomes accommodate an ordered set of categories ($c = 1,2,\ldots,C$) defining the dependent variable. The outcomes are assumed to represent a multinomial sampling distribution. The model predicts the probability of a response being at or below the c^{th} outcome category, as denoted by:

$$P(Y \le c) = \pi_1 + \pi_2 + \ldots + \pi_c. \qquad \text{(Equation 3.4)}$$

Because the model is a *cumulative probability* formulation, the complement was being at or above the c^{th} category, which was expressed as the following:

$$P(Y > c) = 1 - P(Y \leq c). \qquad \text{(Equation 3.5)}$$

In contrast to considering the probability of an individual event, such as in the dichotomous case [$\pi / (1 - \pi)$], in the cumulative (or proportional) odds model, one considers the probability of the event of interest and all the events that *precede* it. As a result, only the first C-1 outcome categories ($Y_c, \ldots, Y_{c-1}$) were needed, since the cumulative probability must always be 1 for the set of all possible outcomes (Azen & Walker, 2011).

In this case, the response variable had four categories. The grade outcomes were coded 0 = did not pass (e.g., D, F, No credit, withdrew), 1 = passed (e.g., credit, C), 2 = B, and 3 = A. For a response variable with four categories, for individual *i* the cumulative probabilities (which sum to 1) are then:

$$\mathrm{Prob}(Y_{1i}=1) = \mathrm{Prob}(c_i=1) = \pi_{1i} \qquad \text{(Equation 3.6)}$$

$$\mathrm{Prob}(Y_{2i}=1) = \mathrm{Prob}(c_i=1)+\mathrm{Prob}(c_i=2)=\pi_{2i}$$

$$\mathrm{Prob}(Y_{3i}=1) = \mathrm{Prob}(c_\mathrm{i}=1)+\mathrm{Prob}(c_\mathrm{i}=2)+\mathrm{Prob}(c_\mathrm{i}=3)=\pi_{3i}$$

$$\mathrm{Prob}(Y_{4i}=1) = \mathrm{Prob}(c_\mathrm{i}=1)+\mathrm{Prob}(c_\mathrm{i}=2)+\mathrm{Prob}(c_\mathrm{i}=3)+\mathrm{Prob}(\mathrm{c}_i=4)=1.$$

The last category does not have a probability associated with it, since the sum of the probabilities up to and including the last ordered category is 1.

What was predicted was not the observed values of the dependent variable, but the logistic transformation of it; that is, the ordered categories comprising the outcomes were considered as comprising an underlying continuous predictor η_{ic}. The odds of the cumulative probability are defined as being at or below the c^{th} outcome category relative to being above the c^{th} category, and the log odds for that ratio is as follows:

$$\eta_{ic} = \ln\left(\frac{\mathrm{P}(\leq c)}{\mathrm{P}(Y > c)}\right) = \ln\left(\frac{\pi_c}{1-\pi_c}\right), \qquad \text{(Equation 3.7)}$$

where $c = 1,\ldots, C\text{-}1$.

In a cumulative odds model, the probability of an event occurring is redefined in terms of cumulative probabilities; that is, ordinal regression models use the odds of *cumulative counts*, not the odds of individual levels of the dependent variable. The key feature of the model is that it assumes a common slope between each set of odds modeled; that is, the effects of the predictors are specified to be constant across the categories of the outcomes (i.e., which is also referred to as a parallel regression model). Thresholds (θ_c), or cut points, at particular values of the latent continuous variable η_{ic} determine which categorical response is observed, with one less threshold than the number of ordered categories (C-1) required to specify the estimated probabilities (Hox, 2010). Therefore, only the thresholds are different in modeling the cumulative logits.

The structural part of the model is often presented in the literature as follows:

$$\eta_{ic} = \ln\left(\frac{\pi_{ic}}{1-\pi_{ic}}\right) = \theta_c - \beta_q X_q, \qquad \text{(Equation 3.8)}$$

where θ_c are increasing model thresholds dividing the latent continuous η_{ic} of expected probabilities of Y_i. Each logit has its own threshold term, but the slope coefficients (β_q) are the same across categories. In Equation 3.8 above, a negative slope indicates a tendency for the response level to *increase* as the level of *X decreases*. Hence, the regression coefficients in the cumulative probability model will have a sign that is the opposite of what might be expected in the corresponding multiple regression model (Hox, 2010). Because of the confusion that can result from the *inverse* relationship between the ordered outcome categories and the direction of the predictors in the linear model to predict η_{ic}, the IBM SPSS software program simply multiplies the linear predictors $\beta_q X_q$ by -1 to restore the direction of the regression coefficients such that positive coefficients increase the likelihood of being in the highest category (i.e., in this case obtaining an A grade) and negative coefficients decrease it (Hox, 2010). After this change, the proportional odds model then becomes more familiar looking:

$$\eta_{ic} = \ln\left(\frac{\pi_{ic}}{1-\pi_{ic}}\right) = \theta_c + B_1 X_{1i} + \ldots + \beta_q X_q, \qquad \text{(Equation 3.9)}$$

where c =1,2,…,C-1. In this case, there were three thresholds, since the ordinal grade variable has four ordered categories. There were three predictors in the model. These include students' score on the Prealgebra or Algebra placement test, the campus the student attended, and semester the student took the course (coded 0 = summer, 1 = spring or fall).

Probability can be converted into odds ratio; for example, a success rate probability of 0.6 corresponds to a failure probability of 1- 0.6 = 0.4. The odds of success is then 0.6/0.4 = 1.5. The odds ratio can be transformed to log odd by the natural log or ln (1.5). The natural log is the inverse of the exponential function. Log odds coefficients can be transformed to an odds ratio to predict probability by the exponential e^{β} where the Euler's constant is e= 2.71828183 (Heck, Thomas, & Tabata, 2012).

Qualitative Analysis

Research Question 3: Exploring the Colleges' Administrator and Faculty Perspectives about the Data Trends (success rate, placement test scores and grades) the Effective Aspects, the Challenges or Barriers and the Future Vision for Developmental Mathematics.

Qualitative data were obtained from one-on-one interviews with key members (faculty, staff, and administrators) who have in-depth knowledge of the developmental mathematics program at each college. Qualitative data collected from Phase 2 were transcribed and coded to determine if iterative patterns emerged. The seven college transcripts, in word document format, were imported into NVivo and converted to an NVivo project. Nodes were used to code the sources (transcripts) for emerging themes. Themes were highlighted in different colors and then selected themes were exported as a separate word document. The compiled themes for each interview question were analyzed and then summarized. Emerging themes and patterns were identified and used to build interpretations and formulate conclusions.

The intent of the qualitative component of the different developmental mathematics programs study was to discover, from the college point of view, what distinctive elements of the developmental mathematics programs exist and how the key members perceive the programs. The qualitative data were also merged with the quantitative data to draw conclusions and present possible explanations for data trends and patterns.

Validation

Multiple case studies is a common strategy for enhancing the external validity or generalizability of the finding (Merriam, 2009). All research ethics and protocols were followed, such as, triangulation of data, peer examination, and member checking. Triangulation of the data from multiple colleges aids in the reliability of the study because the study incorporates qualitative and quantitative data from different sources to enrich the reliability process. Triangulation is defined as "a device for improving validity by checking data either by using mixed methods or by involving a range of participants" (Bush, 2002, p. 70). All the data (qualitative and quantitative) collected and the interpretation of data were validated with the participants and institution (member checking).

Protection of Participants

The research did not contain any observations or videotaping. For the interview, the participants were asked for their permission to audiotape and permission was granted by all participants. The audiotapes were transcribed into interview transcripts and stored in a locked filing cabinet. All audiotapes were erased after the data were transcribed. To protect the interviewees' anonymity, raw transcript data cannot be released.

Informed consent forms (Appendix B) were given to all the participants. Only individuals that signed the consent form participated in the study. The consent form stated that participation was voluntary and that participants would be protected from biases and discrimination if they declined to participate in the study. Participants were informed that they had the right to withdraw from the study without any penalty and with protection from harm, and with ensured confidentiality. Also, approval by the Intuitional Review Board (IRB) was obtained and data were collected after IRB approval.

Chapter 4: Results

The purpose of this chapter is to provide an analysis of the data and present the results of the study. The information is presented in a sequence to address the research questions and findings. First, preliminary data are presented to illustrate the significant number of students affected by developmental mathematics. Then, the success rate patterns in developmental mathematics are presented followed by the Mathematics Placement Exam (Compass) scores and final grades for the public colleges in Hawaii. Finally, the colleges' perspectives on the placement scores-final results, student success rates, and implications are reported.

Developmental Mathematics Enrollment and Success – Gateway Level 2

The first part of the results examines enrollment trends and success/failure over time at each of the seven colleges in the study. Each year, hundreds of students enrolled in college developmental mathematics; that is, 2-levels below college level mathematics (Gateway Level 2). In this study, success rates are mainly discussed using percentages, so the enrollment numbers present a way by which actual number of the student population can be gauged and the scope of the impact.

The data in Table 4.1 provide a comparison of the student enrollment patterns across the seven colleges, summarized by semesters (from Spring 2007 to Fall 2013).

Table 4.1

Student Enrollment in Developmental Mathematics (Gateway Level 2)

	College A(1)	College B(2)	College C(3)	College D(4)	College E(5)	College F(6)	College G(7)
2007-S	152	356	644	136	777	26	206
2007-5u		36	176	89		9	38
2007-F	185	450	854	147	452	37	258
2008-S	201	349	716	105	427	22	240
2008-Su		32	172		67	2	43
2008-F	200	486	910	137	469	33	265
2009-S	219	409	734	129	462	37	268
2009-Su		36	147		74		67
2009-F	263	532	985	195	512	53	309
2010-S	264	447	824	174	505	51	297
2010-Su		41	184		64		51
2010-F	282	622	960	184	408	49	332
2011-S	253	510	689	148	381		304
2011-Su		81	194		24		44
2011-F	262	537	908	172			362
2012-S	262	438	713	164			222
2012-Su	12	67	232				121
2012-F	326	504	773	174			288
2013-S	236	418	633	122			209

Table 4.1 provides several preliminary results of interest. First, it suggests that, except for summer semesters, for the past 6.5 years the enrollment numbers in Gateway Level 2 developmental mathematics remained high for each college. Hence, there is no downward trend indicating no significant progress in reducing the number of students requiring developmental math. For example, excluding summer, College A has enrollments ranging from 152 (Spring, 2007) to 326 in Spring 2012.

The next set of figures examine enrollment patterns, success and failure over time excluding summer (since these enrollment figures are much lower). Figure 4.1 illustrates that for fall and spring semesters the enrollment pattern maintained a static trend for each college.

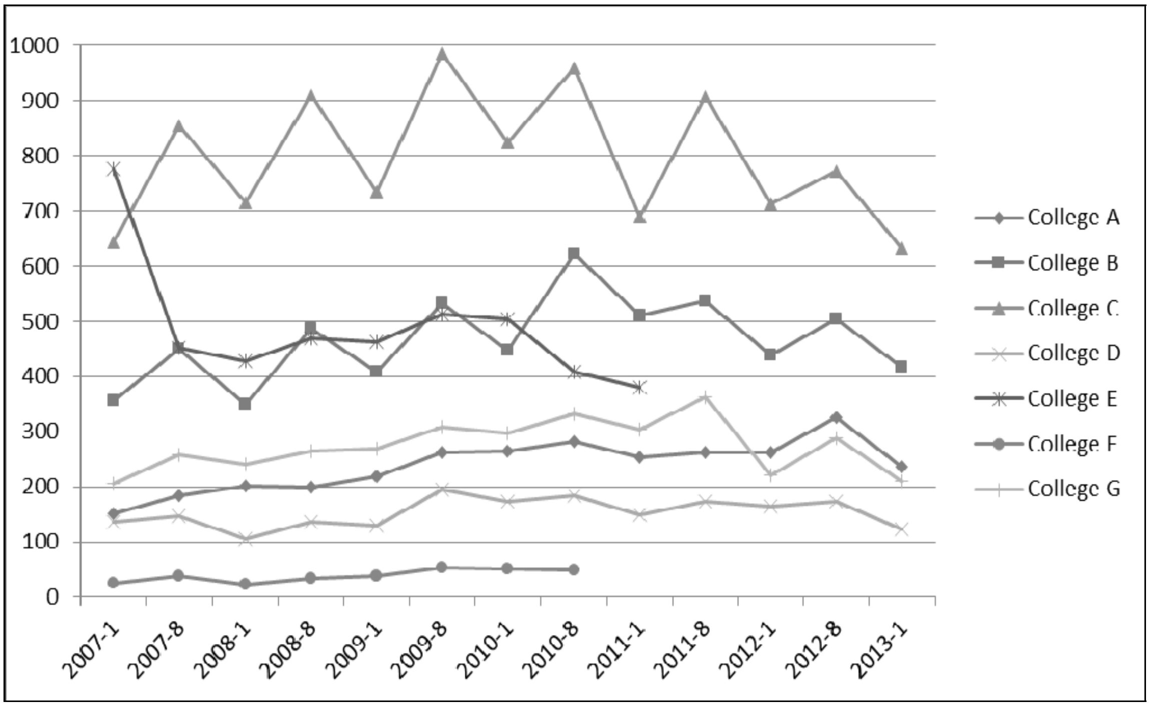

Figure 4.1. Enrollment patterns (summers not included)

Figure 4.1 illustrates that a large number of students continue to enroll in developmental mathematics in their early college career. There is no substantial change in enrollment pattern over the semesters for the individual colleges, except for colleges that stopped offering the course/program. Enrollment is basically a flat line over time for each college.

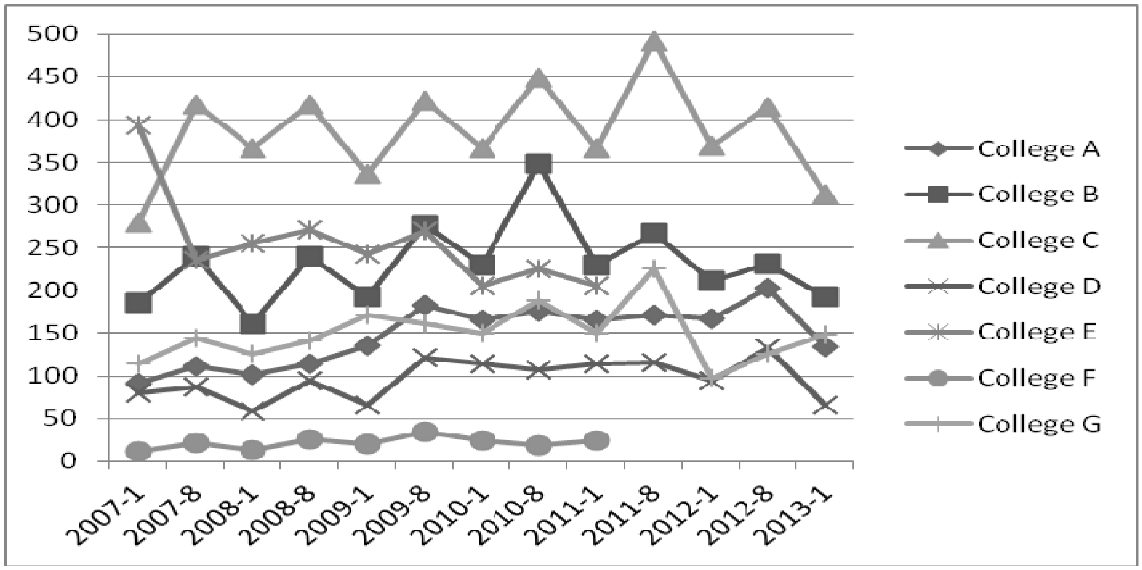

Figure 4.2. Success (grade A, B, C and CR) - number of students (summers not included)

Figure 4.2 illustrates that college enrollment in developmental math is directly propotional to the number of students succeeding - that is, most colleges have similar proportions of success to enrollment over time. Visually, there is no constant trend up or down over time.

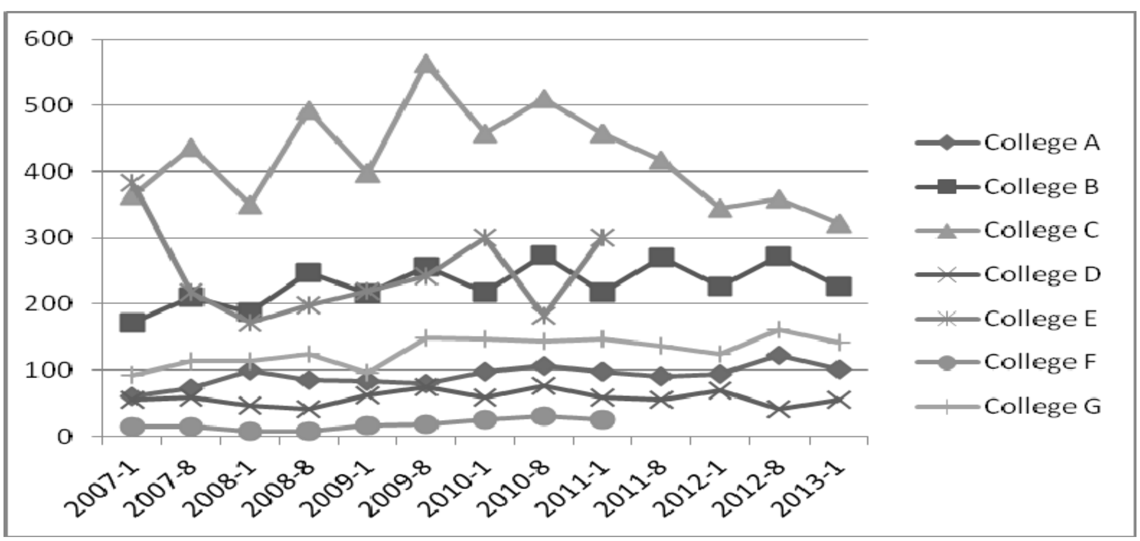

Figure 4.3. Non-success (grade D, F and NC) - number of students (summers not included)

Figure 4.3 illustrates that the college enrollment number is also directly proportional to non-succesful student number. Comparing Figure 4.3 to Figure 4.2, it is evident that colleges with high enrollment and success numbers also have higher non-success/failing numbers of students in developmental mathematics.

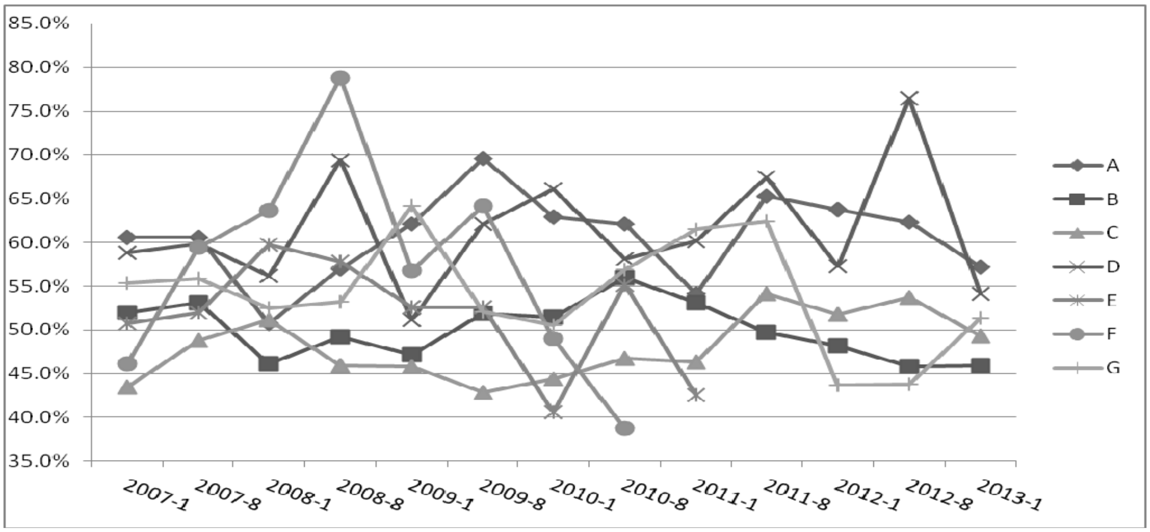

Figure 4.4. Percent success rate (summers not included)

Figure 4.4 illustrates the genenal trend that higher enrollment numbers in developmental mathematics, correlates to lower success rate. For example, Figure 4.2 illustrates that College C consistently has the highest enrollement numbers, and Figure 4.3 illustrates that College C consistently has the highest number of unsuccessful gateway level 2 developmental matematics students. Also, Figure 4.4 illustrates that the average success rate for College C is the lowest over time.

In Figures 4.5 and 4.6, summer enrollment patterns are included, and the figures illustrate that whenever enrollment is high (Gateway Level 2), success rates tend to decline. Summers have a tendancy to have higher average success rates (most peaks were above 70% in Figure 4.6). This trend becomes apparent when the effects are modeled over time, that is, summer success is considerable higher over time. The success rate during fall and spring fluctuates between an average of 40%-60%.

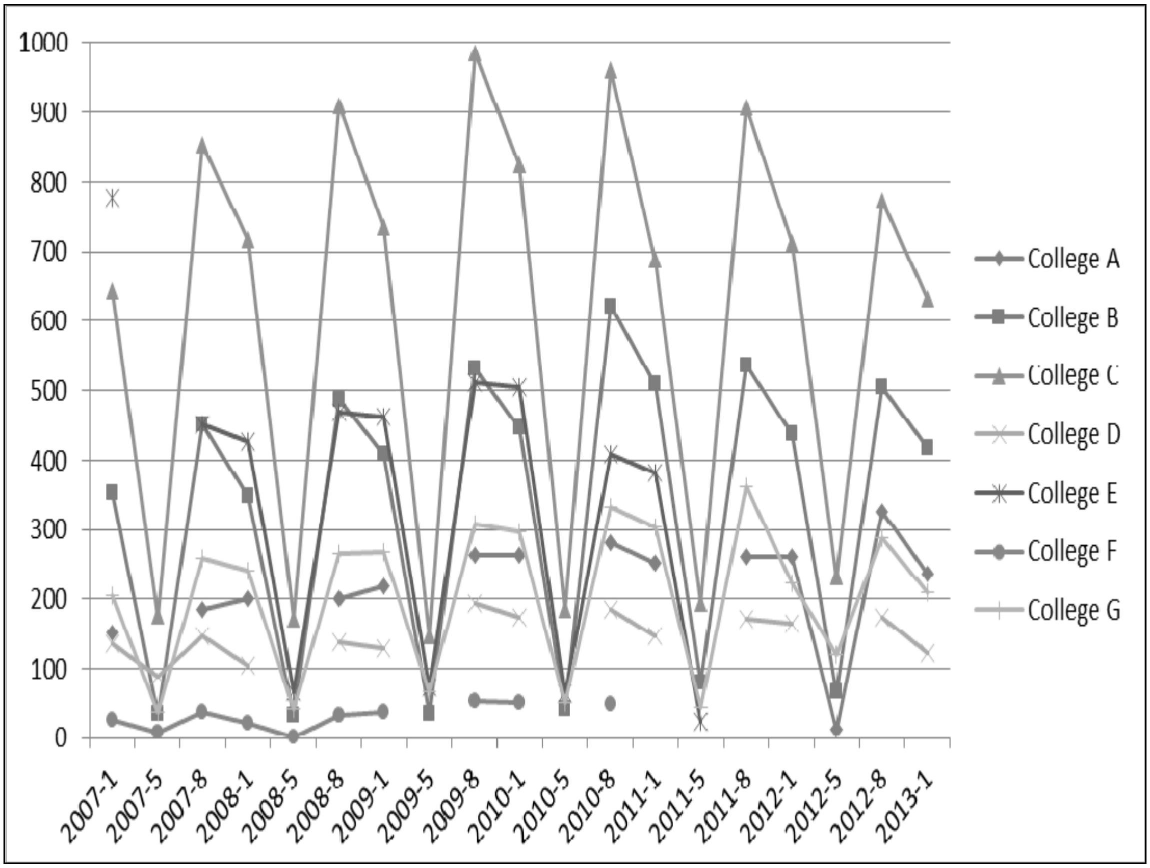

Figure 4.5. Enrollment patterns all semesters (summers included)

Figure 4.5 illustrates that enrollment is sunstantially lower in the summer semesters compared to fall or spring semesters.

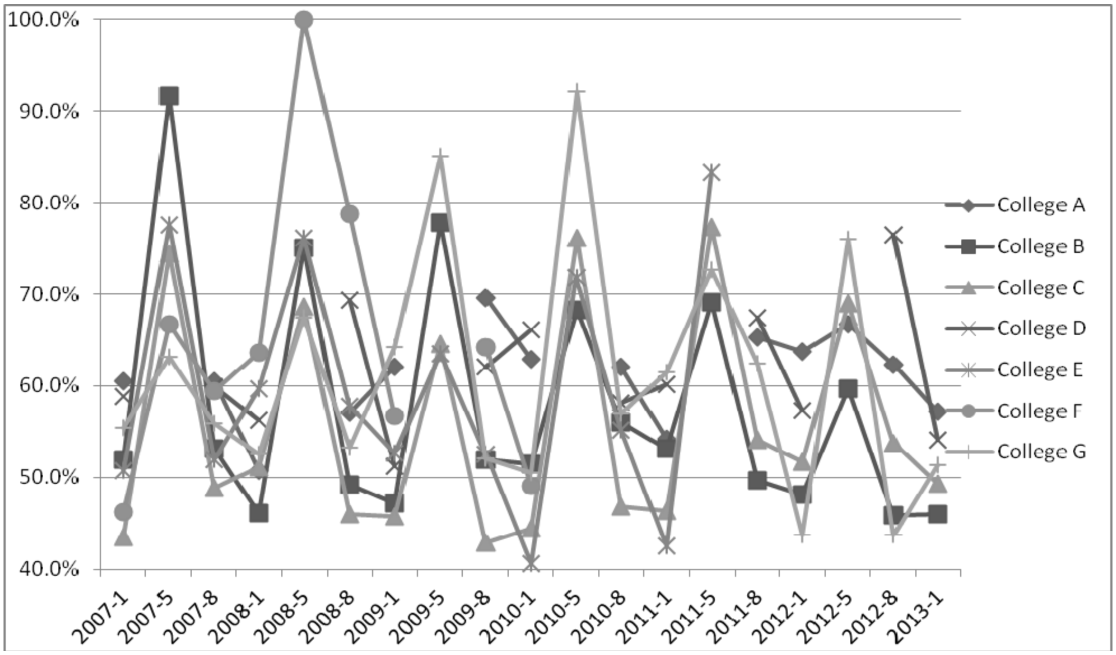

Figure 4.6. Percent success rate (summers included)

Figure 4.6 illustrates that the percent success rate is substantially higher in the summer semesters compared to fall or spring semesters.

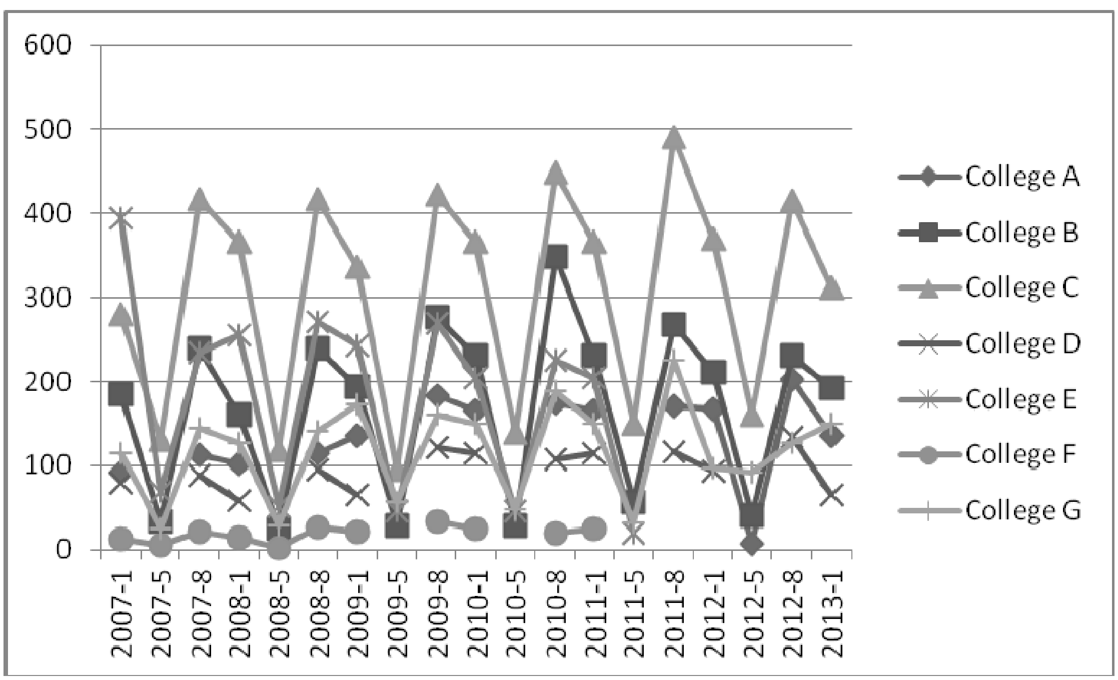

Figure 4.7. Success (Grade A, B, C and CR) - number of students (summers included).

When summer data were included, Figure 4.7 illustrates that, higher enrollment frequently correlates to lower success rate. For example, College C had the highest number of students enrolled in the summer semesters, and Figure 4.6 illustrates that success rate of College C was never the highest and for multiple semesters lower than many of its counterpart colleges.

Developmental Mathematics Success Rate – Gateway Level 2

Research question 1: What is the current success[1] rate of developmental mathematics at Hawaii's Community Colleges? Success in developmental mathematics, at the seven colleges in Hawaii, is defined as grade C or higher.

Table 4.2 shows the success rates of each individual college at the beginning of the study. For example, College 7 has an intercept of 54.91. The table suggests that the beginning levels of success are different across the colleges. For example, College 1 has the highest beginning success rate (i.e., 54.91 + 4.44 = 59.35). In this table, the change in developmental mathematics for the seven colleges in Hawaii was defined by semester from Spring 2007 – Spring 2013, where time is measured in yearly intervals.

Table 4.2

Success Rate Trends for Each College by Time in Yearly Intervals

Parameter	Estimate	Std. Error	df	t	Sig.
Intercept	54.905800	1.670137	9.135	32.875	.000
[College=1]	4.443332	2.365131	9.085	1.879	.093
[College=2]	-4.648462	2.361931	9.135	-1.968	.080
[College=3]	-8.352624	2.361931	9.135	-3.536	.006
[College=4]	2.993146	2.366814	9.058	1.265	.238
[College=5]	-5.760455	2.571658	5.282	-2.240	.072
[College=6]	-5.450467	2.711703	4.111	-2.010	.113
[College=7]	0[b]	0	.	.	.
time	.467213	.966628	.656	.483	.743
[College=1] * time	.397463	1.367635	.662	.291	.837
[College=2] * time	.894525	1.367018	.656	.654	.672
[College=3] * time	.678277	1.367018	.656	.496	.737
[College=4] * time	.805254	1.367959	.665	.589	.696
[College=5] * time	1.071956	1.461916	.751	.733	.627
[College=6] * time	4.633377	1.523295	.847	3.042	.237
[College=7] * time	0[b]	0	.	.	.

a. Dependent Variable: Success.

b. This parameter is set to zero because it is redundant.

The data for college 7 were used as a benchmark to compare the other colleges. Table 4.2 suggests that, with summer included, the success rate starts at College 7 at 54.91% and that for the other colleges varies somewhat for that first semester (Spring 2007). One of the limitations of this, however, is that the change interval for *time* in Table 4.2 only refers to the change from the initial status intercept (54.91) through the next semester. For College 7, this change is 0.467. From this, it is apparent that College 6 made the most change initially (4.633). Most of the other colleges do not show any substantial trends over this first interval. Thus, as the graphs confirm, the college success rates vacillate with no clear upward or downward trend apparent over time (i.e., the graph mean being relatively flat).

The data in Table 4.2 is limited by short changes over one semester. In order to address the problem of short changes over semester, the time-related data were recoded to account for the change taking place from the first interval to the last interval measured in terms of years instead of semesters. This was accomplished by coding the first data point as 0 and the last data point as 1. The results of this analysis are summarized in Table 4.3. This table summarizes two important findings. First, summer enrollment (semester=2.00) was consistently higher over yearly time intervals. Examination by year simplifies the observed trend. For example, for the reference college (college 7) the reference semester (in year 2007), which is fall semester (semester=3.00), the beginning mean is 55.81% and its summer semester is significantly higher by 21.97 % ($p < 0.05$). In addition, spring is lower by 2.96%, but this is not statistically significant. The second finding is that Table 4.3 suggests that over the years 2007-2013 for most institutions there is no appreciable difference in success rates ($p > .05$). Possible exceptions include College 4, which went up 4.25% over the length of the study and College 6, which declined by 6.30% points over time. This tends to confirm the assumption that the semester coefficients remain the same over time (as preliminary tests were done for those).

Table 4.3

Test of Success Rate over Total Years

Parameter	Estimate	Std. Error	t	Sig.
Intercept	55.813955	.002033	27453.930	.000
[College=1]	4.726587	.002875	1643.972	.000
[College=2]	-2.702843	.002875	-940.086	.000
[College=3]	-6.984916	.002875	-2429.450	.000
[College=4]	4.049992	.002875	1408.643	.000
[College=5]	-3.822803	.002875	-1329.623	.000
[College=6]	3.645504	.002875	1267.956	.000
[College=7]	0[b]	0	.	.
[semester=1.00]	-2.960949	1.098114	-2.696	.012
[semester=2.00]	21.970407	1.916768	11.462	*.000
[semester=3.00]	0[b]	0	.	.
Total years	-.821744	2.354527	-.349	.752
[College=1] * total years	2.382637	3.007372	.792	.535
[College=2] * total years	-3.204627	2.944179	-1.088	.413
[College=3] * total years	4.253123	2.944179	1.445	.313
[College=4] * total years	1.789039	3.033464	.590	.634
[College=5] * total years	-.413594	4.985881	-.083	.934
[College=6] * total years	-6.298863	7.167888	-.879	.388
[College=7] * total years	0[b]	0	.	.

a. Dependent Variable: Success.

b. This parameter is set to zero because it is redundant.

Figures 4.8, 4.9, and 4.10 graph the data by semester and by change over each year as a time interval. The figures confirm the lack of a clear trend upward or downward for most institutions.

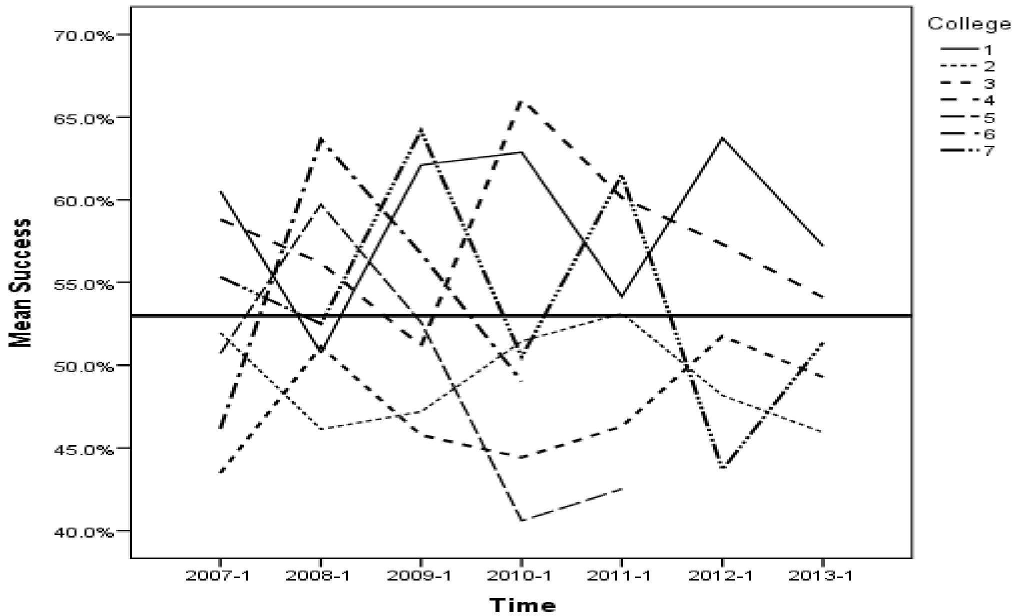

Figure 4.8. Spring semester success rate over time

Figure 4.8 shows that the mean success rate of the spring semesters over time for all seven colleges is flat and that the mean success rate is 53.00%.

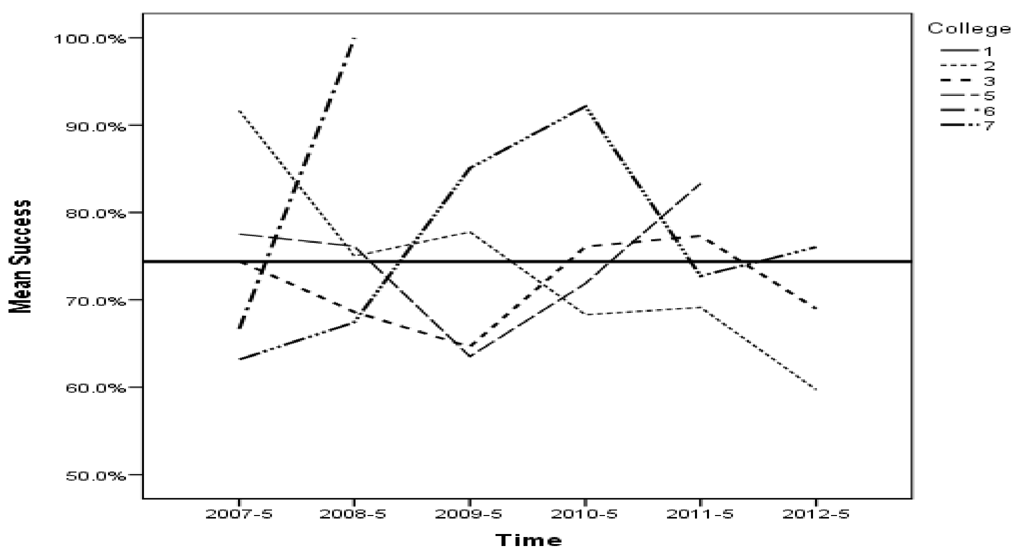

Figure 4.9. Summer semester success rate over time

Figure 4.9 examines the summer success rate for each college. There is no clear trend by college to indicate that one college was considerably stronger or more successful than the others. On average, the passing rates in Figure 4.9 show that mean success rate of the summer semesters over time for all seven college is flat and the mean success rate is 74.43%.

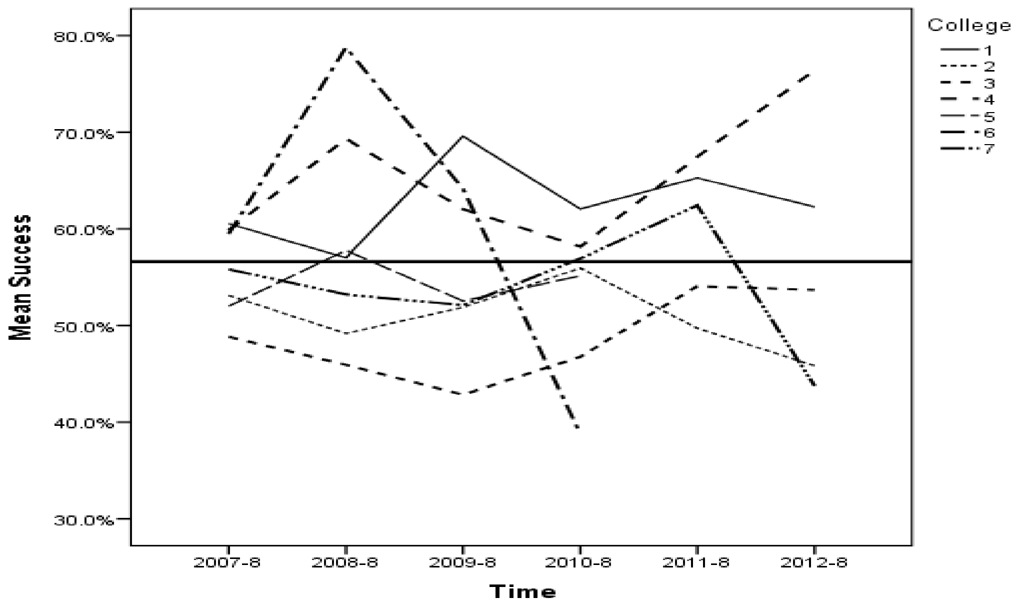

Figure 4.10. Fall semester success rate over time

Figure 4.10 shows that mean success rate of the fall semesters over time for all seven colleges is flat and the mean success rate is 56.60 %.

Placement Test/Compass and Final Grades

Research question 2: Is there a statistically significant difference (relationship) between the students' scores on the mathematics placement exam and students' final grades in developmental mathematics at the different Hawaii Community Colleges?

First, Tables 4.4 and 4.5, are the relevant descriptors for the recoded grades (over time) and the Prealgebra and Algebra placement tests. College 7 is the reference college.

Table 4.4.

Descriptives on Grades by Test Type (Prealgebra)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.00	2894	45.4	45.4	45.4
	1.00	1547	24.3	24.3	69.6
	2.00	1088	17.1	17.1	86.7
	3.00(A)	849	13.3	13.3	100.0
	Total	6378	100.0	100.0	
Missing	System	1	.0		
	Total	6379	100.0		

Table 4.4 indicates that 45.4% received below a passing grade (C or better).

Table 4.5.

Descriptives on Grades by Test Type (Algebra)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.00	1311	33.7	33.7	33.7
	1.00	1282	33.0	33.0	66.7
	2.00	651	16.7	16.7	83.4
	3.00	646	16.6	16.6	100.0
	Total	3890	100.0	100.0	

Table 4.5 indicates that 33.7% did not achieve C or better and 66.7% received a C or lower.

Table 4.6 presents the results of the ordinal regression to explain the likelihood of a student receiving a higher versus lower combined grade. One advantage of an ordinal model is that a single slope coefficient can be used to explain the odds of receiving a higher versus lower combined grade. In the table thresholds represent cut points for each category (but do not carry any substantive importance). Table 4.6 indicates that when controlling for Prealgebra, College 1 is significantly higher ($p < 0.05$) and College 6 is significantly lower when compared to College 7. For Prealgebra, an increase in 1 point translates to an increased odds [Exp(B)] of passing of 2.3%. The Odds ratio suggests the odds of obtaining at least a C grade go up by a factor of 1.023 for each point increase on the placement test, holding other variables constant. This increase would be the same for receiving a B (versus lower combined grade). Regarding institutions, if attending College 1, the odds of receiving a higher versus lower combined grade are increased by a factor of 1.45 (45%). In contrast, if attending College 6, the odds of receiving at least a C grade are decreased by a factor of 0.79 (or 21%).

Table 4.6.

Prealgebra Compass Scores Compared with Final Grades for the Seven Hawaii Colleges

				95% Wald Confidence Interval		Hypothesis Test			
	Parameter	B	Std. Error	Lower	Upper	Chi-Square	df	Sig.	Exp(B)
Threshold	[recodegrade=.00]	.881	.1375	.611	1.150	41.044	1	.000	2.413
	[recodegrade=1.00]	1.952	.1390	1.680	2.225	197.149	1	.000	7.043
	[recodegrade=2.00]	3.051	.1424	2.772	3.330	459.183	1	.000	21.136
COMPASS_PRE_ALG		.023	.0013	.020	.026	291.506	1	.000	1.023
[IRO_INSTITUTION=College 1]		.371	.1419	.093	.649	6.851	1	*.009	1.450
[IRO_INSTITUTION=College 2]		.124	.1312	-.133	.381	.889	1	.346	1.132
[IRO_INSTITUTION=College 3]		.194	.1263	-.053	.441	2.361	1	.124	1.214
[IRO_INSTITUTION=College 4]		.232	.1808	-.122	.587	1.650	1	.199	1.261
[IRO_INSTITUTION=College 5]		.016	.1205	-.220	.252	.018	1	.895	1.016
[IRO_INSTITUTION=College 6]		-.240	.1221	-.479	.000	3.857	1	*.050	.787
[IRO_INSTITUTION=College 7]		0[a]	.	.	.	.	.	.	1
(Scale)		1[b]							

Dependent Variable: recodegrade

Model: (Threshold), COMPASS_PRE_ALG, IRO_INSTITUTION

Table 4.7 presents the same analysis for the Algebra pretest. The table suggests the skills tested on the Algebra pretest are more consequential in determining success as measured by grades. A point increase in the pretest increases the odds of at least receiving a passing grade C by a factor of 1.040 (4%), holding other variables constant. Once again, this increase would also hold for receiving at least a B grade or an A grade. Attending College 1 increases the odds of at least receiving a passing grade of C by a factor of 2.21 (or 121% increase) with $p < 0.05$. Attending College 5 decreases the odds of success by a factor of 0.39 (or 61%) with $p < 0.05$, and attending College 6 decreases the odds of passing by a factor of 0.75 (25%) with *p* significant at 0.061.

Table 4.7.

Algebra Compass Scores Compared with Final Grades for the Seven Hawaii Colleges

				95% Wald Confidence Interval		Hypothesis Test			
Parameter		B	Std. Error	Lower	Upper	Chi-Square	df	Sig.	Exp(B)
Threshold	[recodegrade=.00]	.207	.1472	-.081	.496	1.986	1	.159	1.230
	[recodegrade=1.00]	1.684	.1491	1.392	1.977	127.622	1	.000	5.389
	[recodegrade=2.00]	2.731	.1534	2.431	3.032	317.039	1	.000	15.354
COMPASS_ALG		.039	.0027	.034	.044	200.220	1	.000	1.040
[IRO_INSTITUTION=College1]		.793	.2437	.315	1.271	10.591	1	.001	2.210
[IRO_INSTITUTION=College2]		.043	.1397	-.231	.317	.096	1	.757	1.044
[IRO_INSTITUTION=College3]		.012	.1424	-.267	.291	.007	1	.931	1.012
[IRO_INSTITUTION=College4]		.099	.1980	-.289	.487	.251	1	.616	1.104
[IRO_INSTITUTION=College5]		-.941	.1330	-1.201	-.680	50.031	1	.000	.390
[IRO_INSTITUTION=College6]		-.287	.1532	-.587	.013	3.507	1	.061	.751
[IRO_INSTITUTION=College7]		0[a]	.	.	.	.	.	.	1
(Scale)		1[b]							

Dependent Variable: recodegrade

Model: (Threshold), COMPASS_ALG, IRO_INSTITUTION

In Table 4.8, for the Prealgebra Compass Test, attending in summer increases the odds of an A versus a lower grade (B versus lower, etc.) by a factor of 2.38 (138%) relative to peers attending during fall or spring, and controlling for other variables. The other odds ratio coefficients change slightly when the semester variable is added to the model (e.g., College 4 increases by a factor 1.36, College 6 is decreased by a factor of .813*, $p < .10$*). Also, College 1 is significant at $p < 0.05$ and there is an increased odds of getting at least a passing grade by a factor of 1.56 (56%).

Table 4.8.

Final Grades (3 Thresholds) and Prealgebra Compass Scores for Summer and Fall + Spring

Parameter		B	Std. Error	95% Wald Confidence Interval Lower	Upper	Hypothesis Test Wald Chi-Square	df	Sig.	Exp(B)
Threshold	[recodegrade=.00]	.938	.1380	.667	1.208	46.177	1	.000	2.554
	[recodegrade=1.00]	2.016	.1396	1.742	2.289	208.523	1	.000	7.505
	[recodegrade=2.00]	3.121	.1430	2.840	3.401	476.162	1	.000	22.659
COMPASS_PRE_ALG		.023	.0013	.020	.025	285.087	1	.000	1.023
[IRO_INSTITUTION=1]		.445	.1425	.166	.725	9.768	1	.002	1.561
[IRO_INSTITUTION=2]		.191	.1317	-.067	.449	2.111	1	.146	1.211
[IRO_INSTITUTION=3]		.199	.1264	-.049	.447	2.485	1	.115	1.221
[IRO_INSTITUTION=4]		.308	.1813	-.048	.663	2.881	1	.090	1.360
[IRO_INSTITUTION=5]		.061	.1209	-.176	.298	.257	1	.612	1.063
[IRO_INSTITUTION=6]		-.207	.1223	-.447	.033	2.869	1	.090	.813
[IRO_INSTITUTION=7]		0[a]	.	.	.	.	.	.	1
[summer=.00]		.868	.1220	.629	1.107	50.673	1	.000	2.383
[fallspring=1.00]		0[a]	.	.	.	.	.	.	1
(Scale)		1[b]							

Dependent Variable: recodegrade

Model: (Threshold), COMPASS_PRE_ALG, IRO_INSTITUTION, fallspring

Finally, in Table 4.9, for the Algebra Compass Test, adding the fall and spring semesters suggests that attending during summer (fall/spring (B) = 0) increases the odds of obtaining an A grade (versus B or below, etc.) by a factor of 3.16 (216%) relative to peers taking the course in spring/fall and controlling for the other variables in the model. Attending College 1 increases the odds of passing by a factor of 2.43 relative to peers attending College 7, controlling for the other variables in the model, while attending College 5 results in reducing the odds of A versus below (etc.) by a factor of 0.416 (or 58.4%). Those for attending College 6 is decreased by a factor of .776 (or 22%).

Table 4.9.

Final Grades (3 Thresholds) and Algebra Compass Scores for Summer and Fall + Spring

				95% Wald Confidence Interval		Hypothesis Test		
Parameter		B	Std. Error	Lower	Upper	Wald Chi-Square	df	Sig.	Exp(B)
Threshold	[recodegrade=.00]	.304	.1482	.014	.594	4.208	1	.040	1.355
	[recodegrade=1.00]	1.791	.1503	1.497	2.086	141.963	1	.000	5.997
	[recodegrade=2.00]	2.848	.1549	2.544	3.151	338.116	1	.000	17.247
[IRO_INSTITUTION=1]		.888	.2446	.409	1.368	13.195	1	*.000	2.431
[IRO_INSTITUTION=2]		.129	.1406	-.147	.404	.840	1	.359	1.138
[IRO_INSTITUTION=3]		.036	.1428	-.244	.315	.062	1	.804	1.036
[IRO_INSTITUTION=4]		.193	.1989	-.197	.583	.938	1	.333	1.212
[IRO_INSTITUTION=5]		-.877	.1337	-1.139	-.615	43.013	1	.000	.416
[IRO_INSTITUTION=6]		-.253	.1534	-.554	.048	2.723	1	.099	.776
[IRO_INSTITUTION=7]		0[a]	.	.	.	.	.	.	1
[summer=.00]		1.151	.1761	.806	1.496	42.746	1	*.000	3.162
[fallspring=1.00]		0[a]	.	.	.	.	.	.	1
COMPASS_ALG		.039	.0028	.034	.045	203.652	1	.000	1.040
(Scale)		1[b]							

Dependent Variable: recodegrade

Model: (Threshold), IRO_INSTITUTION, fallspring, COMPASS_ALG

Perspectives on Data Trends and Initiatives

For question 3, the qualitative research question, seven colleges were interviewed. The results for the eight interview questions are presented and tables are used for clarity.

Factors Impacting Higher Summer Success Rate

For interview question 1a, the preliminary findings for the seven colleges' mean success rates for each semester (Spring 2007 – Spring 2013) were shared with the interviewees. They were asked to share their perspectives on what they thought was happening in summer to improve success from a 50% range to a 70% range (spring 53.00%, fall 56.60% and summer 74.43%).

The following perspectives were presented as the possible reasons for the higher summer success rate:

Table 4.10

Factors that may Impact Higher Summer Success Rate

Possible Reasons	Example of Responses from the Colleges
Lighter Class Load Daily Classes Memory Fresh	1. The students are taking fewer other classes. 2. Most of the classes are six weeks and students are focusing on only two classes in the summer and they can concentrate on one or two classes and we meet every day so their memory is still fresh. 3. Regular semester we meet every other day and after the weekend. For Tuesday and Thursday classes we meet after five days so students forget things they learn from previous sessions but in summer we meet every day so student memory still fresh.

Table 4.10 (cont.)

Possible Reasons	Example of Responses from the Colleges
Extra/Higher Tuition Greater Effort More Investment	1. If you're investing in paying this large amount of tuition you're a bit more invested to finish. 2. The students themselves are more invested in what they have to pay for (the tuition) in the summer than the regular semesters. So when they have to commit, they have greater investment in their endeavors. Therefore, they will put greater effort in something they paid for in the larger way than during the regular semester. 3 We have motivated students who are willing to pay that extra tuition because summer tuition is higher than regular tuition. 4. A couple of years ago we started to lever the summer expense by flattening the tuition rates, so the rate for summer tuition is the same as the rest of the year, that caused the number of students enrolling in summer to go up. I think when that happened the success rate went down slowly but still it was quite a bit higher than the rest of the year. 5. Willing to pay extra money to pay for school so their motivation level is much higher than regular semester so it's not that it's much different than fall or spring.
One-on-One Individualized Instruction Counselor	1. If they're falling short, the instructor can have a conversation with the counselor, in the middle of the class to say [name withheld] is in trouble, make sure she's in tutoring - there's that support that's happening. 2. Just more on the one-on-one, not necessarily just class but there's a counselor attached to it.
Length of Course Number of Classes	1. It could be the length of the courses also, in six weeks as opposed to sixteen weeks has something to do with it. But I think that the fact that they're taking perhaps only one course as opposed to five courses, they can concentrate on that course - has a greater effect than the length of the overall course. 2. Most students take maybe just one class. 3. Usually, much smaller class size.

Table 4.10 (cont.)

Possible Reasons	Example of Responses from the Colleges
Higher Motivation Speed up the Process/Graduation More Focus Supplemental Instruction	1. Another important factor to consider is that students in this summer program are focused, motivated, and usually take only their math course during the summer program. 2. Students are motivated to be there. 3. Many of the students who take summer classes are on the brink of graduation or have less time to spend seeking a degree so therefore they are taking a summer class to speed up the process of receiving a diploma. That contributes to them being more highly motivated to sign up for a summer class. 4. I think what I meant by different motivation was that students that were paying that much more money were probably more motivated to complete the class because it was costing them so much more. But that's no longer the case because the tuition rate is flat. 5. They're really just focusing more completely on math, and maybe they have a stronger motivation. 6. I think it's the motivation. They sacrifice their summer and they're willing to spend more money in the summer so the students' motivation level is higher. 7. On top of having supplemental instruction, the instructors there use our modularized math curriculum in the summer. However, it's modified in that every day of class time, the instructors actually lecture in the beginning of class and then the students work independently with supplemental instruction (SI) and with instructors. The students work independently after the lecture to complete their assignments and test and keep up so it's not just go at your own pace, it's paced as well. Those are the major components of our summer math bridge and we brought it to scale last year with over a hundred students and had a 93% success rate.
Complete Daily Homework	1. Students do the homework while they've attended the class so they're doing the homework while their memory is still fresh. So I think they remember better, they learn better. So next class they understand much more when they've completed the homework.

Table 4.10 (cont.)

Possible Reasons	Example of Responses from the Colleges
Federal Funding Tutors Summer Bridge Modularized Curriculum	1. Federally funded program that is focused on getting more students to succeed. 2. some grants where we had coaching and other tutoring. 3. Have an intensive mathematics Summer Bridge Program with proactive intrusive instruction. 4. Mandatory tutorial and supplemental instruction (SI). 5. Multiple strategies are integrated during summer that is not happening in spring and fall. 6. We use our modularized math curriculum. It is not just work at your own pace but it is also paced. 7. Yeah, we have three Title III grants. The one that's the most important is for this initiative, we have a Title III developmental grant which provides funding for the supplemental instruction initiative, and professional development. It provides some of the funding for the summer so it's been very crucial. It's really hard to do major academic innovation without funding. So, the Title III grant has been really critical because it steps up in a lot of places.
Student Population Cohorts	1. Different student population during the summer. 2. Students from other campuses enroll. 3. Have modularized math in the summer with specialization cohorts. 4. Nontraditional adult learners and new high school graduates groups.

Higher summer success rates can be credited to multiple factors but the major elements are higher student motivation to pass the class because they may have more at stake, such as tuition and graduation, smaller course load, and fresher student knowledge.

College Perspectives Due to Higher Summer Success Rate

Interview question 1b, the interviewees were asked to share their perspectives on the success rate findings.

Table 4.11

College Perspectives Due to Higher Summer Success Rate

Perspectives	Examples of Responses from the Colleges
Rethink Model	1. We could try some initiatives to shorten the length of, you know, chop up the length of the courses, not to completely go away from the content but to chunk it up to smaller pieces might increase their success rate. 2. Chunk it up to smaller pieces to succeed. It's modularized in our remedial math and it seems to work. 3. I think accelerated, help [memory] retention. 4. Cut out the number of exit points.
Research/Study	1. You have to do a study on how successful that [new model] might become.
Accelerate Spring and Fall	1. Somehow it didn't quite work over the regular semester. Not too many people were too interested in taking accelerated classes and yeah, we haven't had too much success.
Pedagogy Curriculum	1. In tune with teaching strategies. 2. We're also working on pedagogy. 3. Redesigning the curriculum.
Increase Spring and Fall Success	1. I'd like to see the spring and fall improve to the same level as summer and we're working on that. 2. Like to see our developmental math success rate be 70-80%.

Table 4.11 (cont.)

Perspectives	Examples of Responses from the Colleges
Teamwork Collaboration Attitude Support Instructor	1. Good teachers equal higher student success. 2. Success is built on the team effort of the student tutors, the tutor coordinator, the instructors, and the directors. 3. A "can-do" attitude is the prevailing attitude. 4. Show them [students] that they can succeed.

Colleges would like to see their spring and fall semester success rates increase and are "learning from summer and been trying to scale for the rest of the year" (interviewee response). Summer usually has more investment and special programs, and the colleges are "starting to see in summer a return in that investment and higher success rates but we still got a long way to go" (interviewee response).

College Perspectives on Placement Test and Final Grade Results

Interview question 2, the preliminary findings for the seven colleges' placement test COMPASS scores and grades were shared with the colleges. Interviewees were able to share their perspectives on the finding that the Algebra test score is more consequential to student final grades than the Prealgebra test score.

Table 4.12

College Perspectives on Placement Test and Final Grade Results

Perspectives	Examples of Responses from the Colleges
High School Preparation Confidence Level More Research	1. They're more prepared from high school perhaps, because they probably took Algebra from high school, and they feel confident in taking that exam and they do pass at a higher rate than the ones that select the Prealgebra compass. 2. I suppose there should be more studies as to why someone who takes the Algebra compass test does a lot better. But I suspect that they feel more confident when they select the Algebra compass as opposed to the Prealgebra compass test. 3. Students choosing to take the Prealgebra rather than the Algebra, their confidence level is lower than the students who are taking Algebra. 4. I think there's a strong relationship between confidence level and performance so students taking Algebra over Prealgebra, their confidence level of course is a little higher and they think they know they can handle Algebra and they probably know more than students taking Prealgebra. 5. Students sitting for the Algebra pretest most probably had more math (Prealgebra, Algebra) under their belts. 6. Their prior knowledge or exposure to Algebra probably reflect better algebraic skills as well as basic math skills than students taking the Prealgebra pretest.
Brush Up	1. I think the bigger question is probably how then, operationally for the college, how we can get them up one or more points. So what do you do to make sure they score higher, which will be things like the brush up. 2. If students think they forgot some stuff, not that it doesn't mean they don't know how to do it, they just forgot, then college has to offer math brush-up. 3. We did offer math brush-up. So, they could just take the math brush-up and they can review some of the math skills and usually after they successfully finish brush up, they usually place in higher level.

Table 4.12 (cont.)

Perspectives	Examples of Responses from the Colleges
Prealgebra Barrier Algebra Pretest Over-placed Fractions Percentages and Word Problems	1. We're almost creating a barrier before they get to the Algebra test; it might be better to just do the Algebra test first and if they really do poorly, then back up and do the reverse. 2. I wonder if we should be more proactive in telling them what to take when they come in. Maybe we should just tell them to take Algebra, and just cut the other out, since it's going to kick you back anyway. 3. It is my understanding that there's a better chance of students placing in the higher level if they start in the higher level math. I am not really sure if that's good or bad. It's good that students place higher. However, if you know, if they got lucky a little bit and they over placed them? 4. We've found that our students coming from the DOE from the high schools, they get hung up when they take the Prealgebra test. They get hung up on the fractions and the percent and the word problems that come with that so they get stuck in the Prealgebra domain. So we've always told our testing center to start with the Algebra domain. 5. They may know the Algebra, they may mistake the fractions and you only have on the COMPASS test a few questions and if you miss a couple of those questions you get kicked down to the lower level. 6. We should just have all students possibly test or take the Algebra pretest versus the Prealgebra pretest or we just make those choices. 7. Lots of time. They can just self-select, unless somebody has absolutely no Algebra background whatsoever, but then chances are that if they had not had any Algebra whatsoever they will come in at basic math. In high school most people have had math. The expectation is up to Algebra 2, so I say everybody take that same test, or I think that would be a more accurate placement than a test lower than that. 8. We always recommend that students start at the higher level [Algebra test] so that's something our counselors have been really aware of and we've incorporated that into new student orientation.

Table 4.12 (cont.)

Perspectives	Examples of Responses from the Colleges
Incorrect Placement Negative Motivator Lack of Interest Placement Contradiction	1. What happens is students already taking trigonometry in high school, they would get stuck in the Prealgebra domain and the motivation factor if they come into a Prealgebra class, if they test into a Prealgebra class is almost none. 2. They have no motivation to learn because they think they know all of this stuff. Or all of this stuff is just easy for them. So they cruise by, they miss class, and guess what? By the end of the semester they've failed because they haven't done much work. So, yeah, I mean, you can see why placement is very important here. 3. More often now than before that I have seen students in this sort of situation where they kind of just cruise through even though we offer them a choice to move up. We're pretty flexible here. If we see a student in our class that should be in a higher level, we would just call the other instructor and say, "Hey, can you take this guy?" You know and we would be okay with that, but most often, students choose to stay where they are placed at. 4. They probably think it's going to be an easy A, but then it doesn't turn out to be because when you don't have interest in learning, you won't do well. 5. Or worse is they scrape by, got a C, move into college level math and all of a sudden, "Oh, math is hard and that's never been hard for me. Why is this class so hard? I don't like math anymore". 6. We've actually done this pilot where we've taken recent high school grads that have passed their high school Algebra at a C grade or higher, so they're basically ready for college level Algebra based on that data point, but when they take the Compass placement test they place in Prealgebra. We've given them the option of ignoring the Compass test and registering in 103 [college level math] and basically what we've seen is they do pretty well in 103 so this contradicts what Compass is telling us. We had one group, this was again during summer, so some of that—this is 103. We had a group of 17 last summer and 16 of the 17 made it through math 103 with a C grade or better. One student got a D.

Table 4.12 (cont.)

Perspectives	Examples of Responses from the Colleges
	7. Worse situation is they cruise through Prealgebra, cruise through elementary Algebra, nothing new. They're just like, "Whatever, math is easy." And they hit college Algebra and when they actually have to learn something new, it's hard. And they would quit. 8. We did a little study a couple years ago where we looked at Compass scores of our [Prealgebra] students and we then looked at the grades they received in [Prealgebra] and there was absolutely no difference between a student scoring 15 on Compass and a student scoring 45 on Compass and how well they would do [Prealgebra]. The percentage of students making it through [Prealgebra] with the score of 15 was the same as the percentage of students making it through [Prealgebra] with the score of 45 and to me this screams that math isn't the issue.
Intelligence Bank Forgot Basics	1. Maybe that their intelligence bank in Algebra is still probably there. 2. The tendency is that they start at Prealgebra, they mess up, and not necessarily that they don't know math, it's because they forget the easy stuff or basic stuff, but they know the harder stuff.
High School Math Level	1. We thought, well, let's do a little test here. Let's test them on Compass and if they don't test into College Algebra because of their other experience in math in high school, we'll give them the choice. If you want to still take college Algebra, you can, and we wanted to do that just to see if we could prove whether or not Compass was even important for them to be taking. And the results, in my mind, indicate that maybe we shouldn't be giving them Compass at all if they've made it through their high school level math courses. Especially if they've made it through their advanced placement math course they should be allowed to go into college level math without even worrying about taking the Compass test.

In attending one of the colleges, students had a 121% increase in the odds of passing or receiving a better grade from a comparison of pre-test scores to final grades. That college representative credited its success to knowledgeable and good instructors. All of their developmental mathematics instructors meet the minimum qualification. In addition, this college did not implement major redesign initiatives, because the evidence did not seem convincing, and the only major change was the introduction of MyMathLab as a supplemental resource for students. The interviewee from this college stated,

> "Pretty much we're on our own, the right to determine how we want to teach students, so to blanket one whole course and say these are the ways the students are going to learn; we don't want to dictate that". Also, "I put myself in the students' place. I wouldn't want to learn math like that. Let me admit that a few of us went to the John Squire workshop where he described course redesign. But it sounded like the whole - every single class has to change to that computerized model, so it leaves out the options for students to select the lecture method, or some other method, right? So that's kind of dictatorial to students… like saying, this is the only way you're going to learn this. I'm not against innovation. It's just that the innovation better be well-researched. And you better give me some good reasons why to change to it before you jump into it. You have to do studies, you have to prepare for it; you have to convince the instructors involved and get them to buy in before just say this is great, this is going to work, because we're dealing with human lives here".

At this college, the instructors have the authority to tailor their courses to the required learning needs of their students. Instructors choose their own delivery preferences, these being lecture, one-on-one, computer software, or their own hybrid model. There is not a single method of instruction across the board for students learning developmental mathematics.

College Perspectives on Findings and Implications for the Colleges

For interview question 3, the interviewees were asked to share what they think the findings on success rates and placement results implies for the colleges.

Table 4.13

College Perspectives on Findings and Implications for the Colleges

Implications	Examples of Responses from the Colleges
Lighter Course Load	1. Students should carry a lighter course load during the fall/spring semesters when enrolled in developmental mathematics.
Support Brush-up	1. Need good teachers working in the developmental math program. 2. Support services: counseling, tutors, pre-advising. 3. Do a lot of one-on-one. Sometimes group work. 4. Offering the brush-up. 5. Mandatory New Student Orientation (NSO) and Strengthen the NSO program. 6. Probably take some time to review some stuff [with students] before they actually take it [placement exam], so students know what they're expected to do so that might help students score a little better on Compass. 7. Counseling is a big, big, big deal. 8. Well, we don't know yet about the coaching. We don't have enough data, as I've said.
Data	1. Surveys could be ran during the summer time to see why they felt they were more successful, from the students' viewpoint and the instructor's viewpoint. Maybe survey students on what they're more comfortable with? Yes, what do they think are contributing to this, and the instructors themselves. 2. Challenge for us here is the lack of data from the state's Department of Education (DOE).

Table 4.13(cont.)

Implications	Examples of Responses from the Colleges
Attendance Homework	1. Attention on attendance and doing their homework which is no big secret. Everybody knows that.
Continuity Chunking/Truncating Accelerated Classes	1. Another thing that contributes to math success is the everyday, you chunk it into pieces but you have them do work on it every day. That continuity helps their skills. It's like you're not giving them a chance to forget. 2. But for math, smaller increments, frequent smaller increments, they learn math better than one long day or hour long math - that would kill them. 3. We should really look at the value of truncating the length of our classes. 4. We could look into doing classes with an accelerated schedule, blocking our students' schedules based on that. That way you could run two math classes back to back rather than having a student go a whole year. They actually finish two in one semester. If we coordinate, everything will be accelerated. 5. Maybe only taking two classes at a time giving those two classes your full attention versus if I'm taking four classes at a time, diluting my attention across four. So I do think there is some value to doing an accelerated schedule. If we do that on a larger scale so students can fit multiple accelerated schedules in a semester, they can still take the same number of credits. It's just a different mode, and I think the ability to focus on two versus having to try to focus on four might be beneficial.
Rethink Pretest New Strategies Human Decision vs. Computer Look at Multiple Dimensions	1. Perhaps investigating the way students select their placement tests. 2. Investigate ways to improve the way the placement test is administered. 3. I think it's the way we handle placement when they come in, so maybe just have them take the Algebra test. I wonder if that would be a system, I wonder if we could do that on our own - I would think we could do that on our own.

Table 4.13(cont.)

Implications	Examples of Responses from the Colleges
	4. I think the implication is probably go back, before the testing, to where they [advisor/counselor] counsel them when they come in and should not give them a choice and put them all in Algebra. 5. Back then the department had to grade it by hand and they actually decided where they went, where they placed. I would actually say it was better. 6. Maybe we should look at different dimensions, not just one.
Academics and Non-Academic College Readiness	1. Assessment that gets more to their preparedness to be in college in the first place. I mean, they may have all the prerequisite knowledge to be successful in college and they're just not in a place in life yet when they're ready to be in college. I think if we could somehow kind of come up with an inventory or an instrument that we can use to help us figure that out, that would be incredibly valuable but I don't know what that would look like. 2. Compass is telling us they're not likely to do well or they're not prepared, but I think a better test would be something that's more around motivation. This is a word you've heard a lot. You know, preparedness. What are the goals? Help the students sort out whether or not they're ready to learn as opposed to whether or not they're ready for math. If they're not ready to learn, we can use that information to prescribe things that will help them get ready to learn. For instance, we find out that they've got two jobs and three kids and you know the problem may not be that math is so hard. The problem may be that they just can't find time to take the math class and 7 or 8 other classes. The three or four other classes they signed up for so maybe we need to talk to them about reducing their course load. Or if you find out that their competence level is such that they need extra support or positive reinforcement or their study skills aren't very strong and they need help with that. I kind of believe that a lot of what gets in the way of developmental math has nothing to do with the ability to learn math, or very little to do with the ability to learn math.

Surprises on Findings and Perspectives on Implications for the Colleges

For interview question 4, the college representatives were asked to share what surprised them about the success rates and placement results, and what this implies for the colleges.

Table 4.14

Surprises on Findings and Perspectives on Implications for the Colleges

Surprises/Perspectives	Examples of Responses from the Colleges
Higher Success in Fall vs. Spring	1. I am kind of surprised that fall is higher than spring. It's not much higher, it's about the same, really. I don't know why that would be much of a difference, but think about developmental math, with the math sequence, I could see now that spring could be a little bit lower just because who persisted through from fall to spring. The ones who are coming up at the lower level, so you would have basic math students from the fall semester going into Prealgebra in the spring. You see what I mean? 2. Nothing that I haven't already shared with you. 3. Yes, that's a surprise – the Algebra and Prealgebra placement and grades. 4. No, actually I'm not that surprised. 5. I'm very surprised about their number because at [college name withheld], they're offering accelerated classes.
Hope for Good Surprises Due to Innovative Changes Motivation	1. We'll hold on to surprises until we pilot again. We want to be surprised and we're happy to have that surprise but, as we expected, and the reason we wanted to do this, is our math teachers here are very, very innovative. So we were counting motivation as the factor when we did the high school pilot project and we really expect it to work and it seems to be working. But the numbers are small so we're going to try it again and see if we can improve the data part of it.

Table 4.14 (cont.)

Surprises/Perspectives	Examples of Responses from the Colleges
Accelerated Class	1. No, because the whole summer, fall, spring comparison in my own twenty-something years history of teaching showed me those kinds of results, and my little experiments on an academic year of accelerating classes gave me those same improvements. I did share this when I was still teaching - there are different styles within the mathematics discipline. There are some people that would say that there is no possible way that you can teach that in less than a semester, or that you can't possibly teach that course in the summer. There are people that say you can't teach calculus in the summer. I don't know, I took calculus in the summer. It was fine. You have to get into a different pace, but you adjust to the pace. I do think that is significant. If you are looking for mathematics courses, I think there's something there, just the improvement. Why don't we take something that seems to be working in some way that we can incorporate into our fall/spring semester, then why not do that. 2. Well, it was just pretty much what we expected to happen [during summer]. I mean, what surprises me is that not all of the schools are doing that already. The data is so positive. I'm just surprised that this isn't something that's automatic. Why aren't you all doing it? 3. The accelerated learning. The combination of all of that initiative.

College Initiatives in Developmental Mathematics

For interview question 5, the interviewees were asked to share some initiatives their colleges are taking in developmental mathematics.

Table 4.15

College Initiatives in Developmental Mathematics

Initiatives	Examples of Responses from the Colleges
Accelerated Learning STEM and Non-STEM Pathways	1. We're doing accelerated learning. We're splitting into STEM, non-STEM paths, and we are also trying the high school pilot project.
Lab Tutors Group/Collaborative Learning Collaborative Office Hours Critical Care Self Pace and Paced Faculty Help All Students Modularize Instruction Pathway Oriented Cohorts Supplemental Instruction	1. The latest one that we did was several years ago, the open lab, the students just sign in. They get a math tutor, and they should be able to get tutoring at all levels. 2. We do a lot of group learning. 3. We have a tutoring center - we have a peer-assisted tutor program. 4. We have peer-assisted tutors and we have power hour and we also have critical care. These are study groups that the instructor initiates. Every class, you have probably about 4 or 5 students that are just so behind, and that's where the term comes in. So we would pull them out and organize study groups. During our office hours we would have instructor lead study groups just to get those students caught up. 5. No longer teaching face-to-face. Straight-on, I'm not in charge of the class. You are basically assisting because the Emporium model is self-paced. We have an Emporium lab, students are floating in and out. Then, what you're doing is assisting one-on-one with students rather than I'm in control of this. I put in three hours a week with that class, grade their tests. Now you're basically helping all students who in those classes. 6. Just couple years ago, our move was to modularize so our students can self-pace through. The improvements we made based off of our work with summer bridge is, (1) incorporation of mandatory SI, and (2) the addition now of lectures. This spring, they're piloting having lectures as part of that core sequence rather than just do it on your own at your own pace. Having lecture kind of keeps the students on task and provides help. So those are two major initiatives.

Table 4.15(cont.)

Initiatives	Examples of Responses from the Colleges
	7. We have the summer math bridge. We talked about the overall cohort initiative. On top of that, we're looking at different components within the summer math bridge that have given success and are trying to scale those into the regular semester. So the first is supplemental instruction. Some of our math classes currently have time that's actually part of the math class where we scheduled extra class time that's devoted to supplemental instruction, and all students are expected to stay for it. Basically, looking at the fact that we've seen so much success when we do the resource intensive summer bridge and figuring out how that success can be broadened in the general semester. That's where we're heading.
MyMathLab ALEKS	1. Text book from Pearson, and it has the MyMathLab attached to it. 2. We use ALEKS. 3. ALEKS is a good diagnostic program so they think students don't have to do the materials. The topics they already know so they can move ahead without actually repeating the things that they already know.
Retention Specialist Time Management Instructor Follow-up First Week Attendance	1. During class, we have a retention specialist come in. She comes in, talks about time management. She focuses not on academic planning but on delivering the skills that's going to help them succeed. 2. But I think, we as instructors need to do a better job, checking to make sure that the follow up is there. Like taking notes, right, we need to go and do a better job, to take a look at and make sure that they're actually doing it, like a follow-up. 3. And another thing we tried is the first week attendance policy. So if we dis-enroll those students who don't come to the first week, then our success rate might be improving a little bit but we never did it before so some people could raise a question about it.

Table 4.15(cont.)

Initiatives	Examples of Responses from the Colleges
Revise Curriculum Align Curriculum Shorten Time Course Combo (less exit points) Offer Multiple Modes of Instruction	1. Revise the curriculum every summer. 2. Offering courses in the same mode that were offered in a special summer program (lecture-based rather than computer-based). 3 Remedial is currently being modified to align with the developmental math. 4. Students have a choice of taking courses taught in a more traditional way as opposed to computer-based courses. 5. Include piloting “combo” courses which allow students to enroll in two courses during the semester. 6. The discipline is also reviewing combined courses which are taught at two other colleges. These offer students the opportunity to shorten the time to complete their math studies.
Vocational Route Cohort: Pathway Oriented (Area/Subject Specialty	1. One is we’re not offering precollege/remedial math. We put the students we used to place in remedial math into Just In Time and I Can, so it’s pretty much a vocational program. For students placing in pre-college math, the chance to take and pass the college level math is really slim. So we think we’re not serving the students the right way. Because telling them to finish the college level and major in something and graduate and most of them won’t. So by putting them into a vocational program, they may have a better chance to get some kind of a certificate or some kind of vocational program done so they can find a job. 2. In the summer time, there were grants for cohorts. We now, as of last fall, have freshmen cohorts for entering freshmen. So for fall entry freshmen, that show a developmental need, all of them are mandatorily placed into cohorts if they’re full time. We did that in fall of 2013, and our preliminary results show that out cohort freshmen with developmental need, outperformed our regular population who came in without developmental needs - preliminary findings. We’re working really, really hard on their success here. The other thing that is possibly a factor that you need to look into is that non-summer bridge classes. Sometimes there’s a much smaller class size as well.

Table 4.15(cont.)

Initiatives	Examples of Responses from the Colleges
Retake Exams Tag Questions	1. We give them all similar types of exams and they get to retake the exam. They have to pass by 75% or more. 2. We tag the questions to see which ones they're having problems with.
Emporium Model Hawkes Learning System Computer Assisted Learning Instant Feedback to Homework Model Written Math	1. Movement to reform and remodel the way we deliver our lecture and based on the study we did, we follow the Emporium model and we created our own self-pace based on that. It's not exactly the same thing but we based it on the Emporium model to increase the success rate for developmental math. 2. Now what we're doing is using computer programs. We're using the Hawkes Learning System or MyMathLAB, which is the more popular one. Basically, just computer software assisted learning so that students can do homework and get instant feedback at home so that saves a lot of time in class, not having to go over problems that they got stuck on. 3. We like to see our students more often and we like for them to work in groups and collaborate. I think that's the thing, students' lack of communication using math terms to communicate. You know, work with each other to solve problems so we feel in the emporium model, students lose that. Also, the modeling of mathematics, how you show your work, it's about the process not the final result. Without that instruction, even though we lecture less, that 15-20 minutes, we model how math is written and that's important for the students to see - how to organize their thought process. 4. One of the things we did was take our standardized developmental sequence and converted our entire developmental program into an Emporium model.

Table 4.15(cont.)

Initiatives	Examples of Responses from the Colleges
Teacher Training College Articulation Changes Geared to Increase Success Need for More Data	1. I went to Nashville once and another College once because they invited a person who was doing an Emporium model over there and they were producing good success rates. After some consultation and study, we decided to try the emporium model. So before we tried this model, the average pass rate for math 24 was below 50%. Now we're consistently producing over 50% passing rate. There was strong concern about how students would do when they move to the next level which might be delivered in a different format – usually a traditional model. There was a big concern. We couldn't track the students and we cannot tell whether the students are doing better than before or worse than before. The passing rate in math 25 [one level below college math] has been improving as well so that's at least a good sign.

Faculty Reactions to Developmental Mathematics

For interview question 6, the interviewees were asked for some general reactions from the developmental mathematics faculty.

Table 4.16

Faculty Reactions to Developmental Mathematics

Faculty Reactions – Developmental Math	Examples of Responses from the Colleges
Buy-In Supportive	1. There's no huge conflict. 2. Our math faculty, are very united. We're going in the same direction. We have our differences here and there but we put our students first. 3. They were really positive and they are supportive of us going even further than we have.

Table 4.16 (cont.)

Faculty Reactions – Developmental Math	Examples of Responses from the Colleges
Data Access to Data Change/Shift is Difficult Problem is Same (as years ago) Data Driven Evaluation Specialist	1. That's where the data comes in. If we have convincing data to change, then we'd look at it and be willing to keep an open mind. So if there's a need for change, then of course we would be willing to look at it. 2. Every college has an IR (Institutional Research) office, but ours is so busy with program review data to actually look into statistics that we want to look at. So we actually have to request data but even when we do that they refer us out. So it's difficult to get data. 3. Analyze it first and see if it's working. 4. One question raised by one of our faculty was how do we generate the data? How do we generate the success rate? 5. When you do change, from what people are accustomed to doing, you're going to have some say, "Yes, let's change," and you're going to have some people that don't want to change. I would say most people have adapted to it. There are probably still some isolated people that would prefer to go back to the traditional. But, if the data shows that our students are more successful, then we're probably not going to go back because we're really here for the students. 6. There are always going to be some who want what they are accustomed to doing. A shift like this is not easy for any campus because it depends on the dynamics of your discipline, and whether or not you have the time to make those changes. I think it's hard to argue with the data at a certain point. Now if the data showed miserable results, we can go back. Of course, it's not the only model, I think there are other things being looked at nationally. Maybe some are trying bits and pieces of it. We just know that there is a problem. It's the same as it was years ago. 7. We have a Title III evaluation specialist and that's allowed us to do extensive, time consuming, detailed data analysis that probably wouldn't be possible with just our own IR [Institutional Research] resources. I guess anything is possible but we'd have to put a lot of things on hold to do that. Our faculty has been so good at looking at data. We're very student centered.

Table 4.16 (cont.)

Faculty Reactions – Developmental Math	Examples of Responses from the Colleges
Unprepared	1. They're actually for it. They want to improve things to make sure students get ahead but they're frustrated that they're so unprepared.
Frustrated with K-12 Year Round Math Lack Basic Skills	1. Yes. Frustrated with what the DOE [Department of Education] is doing. It's hard to do anything else if you don't know your basics. We have to go back and redo what the DOE should have taken care of. 2. Have them take math all four years. And they have to memorize their basics, the multiplication table especially. I can't believe that they have a hard time. We have a few students, it seems that could have started in elementary. It's like putting on a band aid, when they come in to us. But you've got to start from elementary so when they come in to us we are not putting on band aids anymore. We can actually do problem solving because they have the skills.
Interest Concern Science Instructors	1. Some people showed interest in what we're doing. Some people again raised their concern. That concern has been very mellow. There was some strong concerns at the beginning but now I think their doubt has been cleared so we don't have as strong an opinion like before. 2. Actually, those people or instructors were teaching science classes. Because they give a pre-requisite to take their classes. Some people were concerned that their math skills will be weakened. Some people who share the concern probably thought that this was not going to work and students will not understand math but I hardly hear the same kind of concern these days. Maybe because they didn't see any difference. At least, they didn't see any students doing worse than before, or they could have given up.
Power Hours (office hours) Necessary Course	1. All of our full time faculty are over at power hour. We're doing group work. We're doing group discussion. We're doing about the same so our math faculty is very on board with changes that we have made. 2. View developmental mathematics as necessary courses to get students ready for the degree awarding 100 level math courses.

Table 4.16 (cont.)

Faculty Reactions – Developmental Math	Examples of Responses from the Colleges
Learning Center Second Chance	1. Right now our math and our learning center and our support services are kind of spread around the campus. One of the things we'd like to do is create a one-stop, general center where all of that could be located. I think college has done that already and we'd like to do that as well here so we're looking into that. 2. Providing students a "second chance" at learning the necessary mathematics in order to complete their college work.

Faculty Reactions to College Initiatives

For interview question 7, the college representatives were asked to share some general reactions of developmental mathematics faculties.

Table 4.17

Faculty Reactions to College Initiatives

Faculty Reactions - College Initiatives	Examples of Responses from the Colleges
Data Access Support Feel-Right Programs for Students	1. If it was easier to get data, then that'd be great. We could look at it and try to improve what we're doing. 2. I think most faculty in college, this is just an opinion, would go along with whatever the program people felt is right for our students.
Supportive Communication	1. I think they're supportive, it's just that it all requires change so that's the harder part. 2. If we make a change in the placement test then that filters the change down to the next level which would be the math faculty. So, making sure that everybody knows what's going on and what we're trying to do. But, sometimes adopting the change could be difficult for some.

Table 4.17 (cont.)

Faculty Reactions - College Initiatives	Examples of Responses from the Colleges
Domino Effect (on more than one course) In Favor of Trying New Methods Better Outcome to More Support Try New Method to Learn (vs. Old) Data Share Information More Temperament Develop All Round Skills for Students	3. Most instructors are in favor of trying something new. There were strong concerns from some people who believe that the traditional model is the best way. We had very healthy debates about it. In the end, we tried it and I think we are doing better. All of us have tried to teach a self-paced model so everybody understands now that the different method could work. Even if they don't agree, they at least know the different method could work. Yeah, I think it's a very healthy thing for both of us. They raise their concerns then we can learn from their concerns. 4. If you can show us that the change results in a better outcome for students, then we're going to support you. I think the campus feels comfortable in knowing that they can take risks, and that it's not like my hands are going to get slapped. We want you to try something new. That's the only way we're going to see if something is better. And if it works, then great, let's share it with others, let's support you continually and do what you need to do. I think the important shift was just kind of symptomatic of where the campus is today and people are willing to try new initiatives. We stress to them that it's not only about an initiative because I want to do something myself, it's really you've got to give us some kind of data that shows why you want to move in that direction. That's why we will support people for staff development, you come back different. We have a student success committee on campus which looks at people wanting to try initiatives and we support them financially. That's the mode we are in right now. 5. I think the sharing of information, what's working, is helping everybody, really forcing everybody to take a look at how they're doing business. 6. It requires a certain temperament to work with a diverse group of students with a great range of abilities. 7. You also work on study skills, and other non-math things to further develop the college student.

Other Factors Discussed

For Interview question 8, the college representatives were asked to discuss any other things they would like to share.

Table 4.18

Other Factors Discussed

Other Factors	Examples of Responses from the Colleges
Lecture Based Opposed to Computer-Based Combo Course Reduce Time	1. Offering courses in the same mode that were offered in the [name withheld] summer program (lecture-based rather than computer-based). Computer-based is currently being modified. Students have a choice of taking courses taught in a more traditional way as opposed to computer-based courses. 2. Include piloting "combo" courses which allow students to enroll in two courses during the semester. Offering students the opportunity to condense courses and shorten the time to complete their math studies.
Data Analysis	1. Through the Title III grant we were able to have a Specialist for data analysis. Without that we wouldn't be able to collect data and this would make analysis more difficult.
Multiplication Tables (Basics) Leaders Vocational Math Skills Need to Try New Initiatives Skeptical Data	1. We're all trying see what works best for the students. See if you can get the elementary folks to start requiring multiplication tables. Maybe the superintendent then has to come in. 2. Yeah, we are focusing on health science and nursing students because they trust that they need that skill a lot. 3. There was a lot of resistance from the general faculty when we were changing over to a [combination course] and stopped offering [traditional single] courses. There are still bad feelings out there. 4. I'm a big fan of data. I like having data to look at and having everybody doing continuous analysis to see if things continue to improve or if we kind of level off, or in a worst case scenario, it falls.

Table 4.18 (cont.)

Other Factors	Examples of Responses from the Colleges
Multiple Delivery Options Effective Instructor	5. We had a hard time with our division chair and maybe the vice chancellor before. But after seeing the results they were actually proud of it because they made a presentation to other vice chancellors about our combination course [2 levels of developmental mathematics as one course]. But in the beginning, they were skeptical. But I think we've passed that. Like I said, there's still some negative feelings out there but it needed to be done. When you have something that had to be changed dramatically, it's just gotta be done and then we look at the data and then we'll see. If we keep offering it as an option, how valid is our data? 6. But I think we always have to be mindful, especially since the learning styles of students have changed. The models of pedagogy that we used to use years ago are just not as applicable. I'm not saying they get thrown out, but I am saying probably a variety of modes of delivery. Maybe looking at how we have been, specifically in the remedial developmental situation that seems to be a difficult one for all campuses. 7. I'm not convinced right now that there's one answer to everything. Maybe there is a better method out there that we haven't found yet. Or maybe there is no perfect method, but maybe, at some point, we do different offerings and delivery. For some, this works best, for others not this way. Not everybody, for example, does well in a distance education course because that requires a little bit more independence, self-motivation. What we're trying to do is to offer students options which will help them to reduce their time to a degree and get them through faster. 8. What are the characteristics of an effective developmental math instructor? How does one assess an effective instructor? What can be done to develop an effective instructor? So much has been done with best practices, redesigning curriculum, etc. Should an equal amount of time and energy be focused on effective instructors in developmental math? How successful would a "best practice" curriculum be with a less than effective instructor? I recall a study by the Bill Gates Foundation on best practices in developmental mathematics a few years ago which highlighted the "effective instructor" as one of the greatest factors.

Summary of Results

The findings in Chapter 4 establish that colleges across Hawaii are not generally experiencing significant increases in student success rates in developmental mathematics and are still trying to find ways to improve their success rates in developmental mathematics. There were three main findings. First, the summer success rates are significantly greater, by approximately 20%, than spring or fall semesters. Numerous models are experimented with during the summer programs, including special programs, modified and traditional lecture styles, and special groupings, such as programs that target special cohorts, including ethnicity and previous math background. The finding of higher success rates for summer was not a surprise for any of the colleges. All of the colleges credited the higher success rate to student motivation, higher student investments, higher tuition, and to the accelerated model.

Second, analysis of placement test results (pre-test) correlated to students' final grades indicates that the Algebra placement test (COMPASS) is more consequential to student grades than the Prealgebra placement test. From the Ordinal Model, a point increase in the Algebra pretest increases the odds of passing/getting a better grade by a factor of 1.040 (4%) compared to an increase in 1 point on the Prealgebra pretest translates to an increased odds of passing by 2.3%.

Third, analysis of the interview transcripts indicates that colleges are trying and studying various models of teaching developmental mathematics. Student success data is a critical indicator to establish if these models are successful. While some are skeptical about redesign models without evidence that the new models are effective, many are venturing forward with the hope of attaining growth in success rate for developmental mathematics students. Importantly, the factors cited as making an impact on student success are student motivation, course load, and one-on-one support. The accelerated course model designs, where a standard course is delivered over less time, were consistently mentioned as key factors. This was established as a significant factor directly related to fresh memory and better performance in mathematics.

Chapter 5: Discussion, Conclusions, and Implications

Purposes and Overview of Study

Developmental mathematics poses one of the biggest challenges for college freshmen nationally. The placement exam is the first stumbling block for incoming college students and developmental mathematics can pose an even bigger barrier to a successful college career. Data from the Achieving the Dream project reported that only 20% of students referred to math remediation completed a gatekeeper course within three years and that 24% never enrolled in college (Bailey, Jeong, & Cho, 2010). Two year public colleges' in Hawaii play a critical role in preparing students and developing a strong mathematical foundation for more than 50% of college freshmen. Unfortunately, while enrollment in developmental mathematics is rising, the success rate is static. Like the rest of the nation, public colleges in Hawaii are tasked with finding effective ways to increase student success rates. The purpose of this study was to explore Hawaii's gateway level 2 developmental mathematics success rates, placement exam scores (pre-test), final grades, and college perspectives and initiatives to identify approaches that can inform developmental mathematics program redesign.

Each college in Hawaii is taking their own initiative and are approaching developmental mathematics in ways they feel are best for their college. In 2012, 1525 students attempted developmental mathematics gateway level 2 (2 levels below course level) and 52.72% of students were successful; that is, 721 students failed gateway level 2 mathematics for a single year in Hawaii public colleges (University of Hawai'i System, 2012). Developmental education at its best has shown limited success and progress is impeded because the structure is too complex, confusing, and ineffective (Bailey et al., 2010). The seven Hawaii public colleges in this study have experimented with, observed, and analyzed strategies and data to find ways to increase their student success rates. Their goal is to achieve 70% or higher success rate in developmental mathematics. The aim of this study is to examine all of the strategies deemed successful or important by these programs, and to provide insight for future redesign of developmental mathematics programs.

The sequential explanatory mixed method design was geared to use the results of the initial quantitative phase of the study to engage the colleges in reflection on the findings, then to share what is happening in their programs and what next steps they are considering. From program experts, to experts at the college level and state level, there is no consensus on placement, pedagogy, or almost anything to do with developmental mathematics (Bailey et al., 2010). Previous studies on models of developmental mathematics programs and placement exams suggest that collaborative efforts are needed to study the numerous projects to improve instruction and curriculum redesign undertaken by colleges. Also, there is a need to conduct studies of correlations of test scores with grades, and the reliability of placement decisions to determine if placement test scores are significant and are predicting success. Furthermore, the need is increasing for research to suggest strategies to help students with low placement scores (Bonham & Boylan, 2011; Boylan, 2011; Burdman, 2012; Ward, 1986). The findings in this study add to the pool of knowledge for developmental mathematics and placement exams, and narrow the research gap in two critical issues facing two year colleges; developmental mathematics and placement tests.

Discussion of Findings

This section includes a discussion of the findings structured around the three research questions:

1. What is the current success rate of developmental mathematics in Hawaii public colleges?
2. Is there a statistically significant difference (relationship) between students' scores on the Mathematics Placement Exam and students' final grades in developmental mathematics at the different colleges in Hawaii?
3. What are the colleges' administrator and faculty perspectives about the data trends (success rate, placement test scores, and grades), the effective aspects, the challenges or barriers, and the future vision for developmental mathematics?

Research question 1: What are the Success Rates Trends and Patterns?

Each college in Hawaii uses a different model for their gateway level 2 developmental mathematics programs (the content level is comparable to high school Algebra). A linear regression model was employed and the observed values were adjusted for the first predicted outcome. The success rate fluctuates each semester at all the colleges, but with no significant change over time for spring, summer, and fall semesters. A significant increase in success rate occurs over time for summer semesters when compared to spring and fall semesters. The mean success rate for spring is 53.00%, fall is 56.60%, and summer is 74.43% as indicated in Figures 4.8, 4.9, and 4.10.

Many of the colleges made substantial adjustments to their gateway level 2 developmental math courses with the goal of increasing success rates. While the success rates fluctuate from year to year for all the colleges, the statistical model predicts that there is no upward trend over time. This suggests that the programmatic redesigns and other curricular and instruction efforts are having no significant effect on success rates.

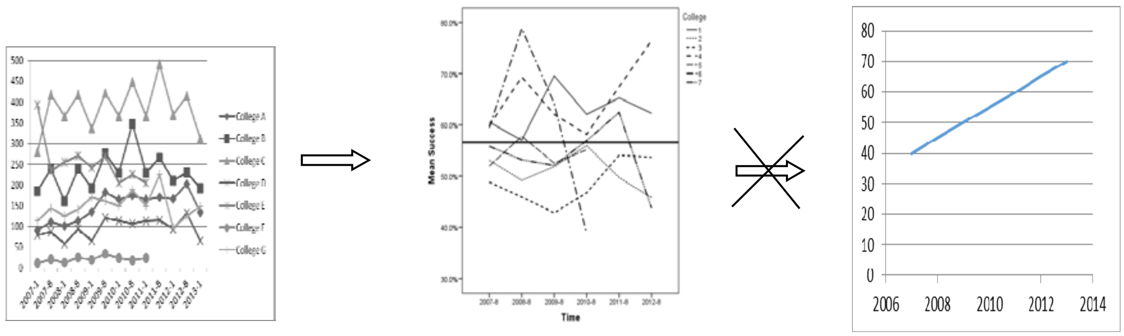

Figure 5.1. Success rates waver over time but do not show a steady upward growth

When success rates were compared over time (yearly intervals) for all the colleges, using College 7 as the reference college, the result in Table 4.2 indicates that all the colleges had a slight increase of 1% or less, except College 6 which had an increase of 4.63%. The 4.63% was not a significant increase over time because yearly intervals were examined and summer was included in the analysis. When the fall, spring, and summer semesters were analyzed, table 4.3, for success rate per semester over the total years, College 6 (with reference to College 7) is at an initial 3.65% (0 = year 1) and over total time (total time =1) a (-6.30). This indicates that the summer success rate for College 6 dropped by 2.65% (-6.30% - 3.65% = -9.95%). Over time, College 1 had a drop of 2.35% and College 5 had an increase of 3.41%. College 6 had the highest decrease of 9.95% over time and College 5 had the highest increase of 3.41%.

Through years 2007 to 2013, no college showed any significant increase in success rate for fall, spring, and summer. The only significant difference was that summer success rates were approximately 21.97% higher than fall or spring, that is, the average success rate in summer was about 70% over time. Relevant to higher summer success rates, the colleges respondents credited this to several factors including more motivated students, more special funding that allows for supplemental instruction/resources/programs, accelerated classes, smaller class size, lower course load, more (but not limited to) individualized instruction, and fresher/salient memory of content.

Research question 2: Is there a relationship between Pretests and Final Grades?

An ordinal (logit) model was employed to analyze the statewide college placement scores that assign students to gateway level 2 developmental mathematics in Hawaii. Student grades were scaled into four categories (Below C, C, B, A) and three thresholds. The model predicts the probability of the odds of an event occurring in the ratio of the number of students who experience higher grade versus combined lower grades. For example, A versus B + lower experience, or A + B combined occurrence versus C + lower experience. The model predicted that content assessed on the Algebra pretest is more consequential in determining success than measured by final grades than that for the Prealgebra pretest. Across the colleges, in general, a point increase in scores in the Algebra pretest increases the odds of the student passing by a factor of 1.040 (4%), whereas an increase in one point on the Prealgebra pretest only increases the odds of passing by a factor of 1.023 (2.3%). Although each test is a computer adaptive test, the ordinal model statistics test is indicating that using the Algebra Compass test (pretest) gives a higher possibility of passing with a better grade.

The ordinal model predicted that attending different colleges has a significant impact on final grades when compared to similar pretest scores. With respect to the correlation between placement scores and final grades, attending College 1(table 4.7), increases the odds of passing by a factor of 2.21 (or 121% increase) with $p < 0.05$, while attending College 5 decreases the odds of success by a factor of 0.39 (or 61%) with $p < 0.05$. This suggests that students with similar placement test scores will have a higher chance of receiving a better grade at College 1, and a lower chance at College 5. It should be noted that this correlation between placement test and final grade is not synonymous with College 1 having a better success rate than College 5. College 1 and 5 did not show any significant difference in success rate over time. However, students attending college 5 had a higher odds attaining better final grades than their peers with similar placement test (pretest) scores at the other colleges. The results from success rate (table 4.2) indicated that College 5 had a higher change in success rate over time (summer is included) but the percentage was less than 1% higher relative to College 1 (1.07-0.40 = 0.67) over time. However, table 4.4 shows that when the semesters are separated and analyzed over the years, with reference to College 7, College 1 had a 2.35% drop and College 5 has a 3.41% increase, but these changes are not statistically significant.

The differences in the colleges seem to have a greater impact on the final grades than the placement test scores. Evident from the interviewees' responses, all the colleges are tailoring their programs in ways they feel are best for their students and college. However, on one hand, College 1 is very cautious when it comes to making changes in the developmental mathematics program. While they are very selective in what they implement, they have integrated technology into their lessons and added peer tutoring, but each instructor still has leeway in integrating their own styles and strategies that they deem best for their classes. On the other hand, the developmental mathematics program in College 5 has undergone a major redesign compared to the other colleges and follows a more structured model, the Emporium Model.

Research question 3: What are the colleges doing to improve success rates?

Colleges have multiple perspectives on data trends, redesign efforts, and initiatives, but their singular goal is to increase the student success rate in developmental mathematics. The data trends on the success rate were not a surprise to the colleges' stakeholders and they acknowledged that summer is higher mainly due to greater student intrinsic and extrinsic motivation, and investment. Special summer funds also allowed for specialized programs or cohorts that cater to the needs of different groups, such as student ethnicity, and career interest. The accelerated nature of summer was also indicated as a major factor affecting student memory and retention of information. Accelerated developmental math classes are being explored at some of the colleges, but this is not giving as favorable of results as summer because the students' schedules for fall and spring semester are different, that is, it is a challenge when accelerated developmental mathematics classes are scheduled with 16 week classes. The increased semester load is another challenge for the students and a barrier to higher success rates.

When the placement test and final grade trends were shared with the college stakeholders, they noted the possibility of improving the advising of students with respect to the level they should select when taking the placement test. A few colleges mentioned that, for the sake of data validity, it makes sense to have all students start the placement test (pretest) at the same level, that is, Algebra instead of Prealgebra. This is better for data analysis purposes and because all high school students are expected to complete Algebra.

Data driven redesigns are clearly important to all the colleges. The developmental mathematics programs at some colleges have better access to data and analysis than others, largely due to grant funding requirements, and one even had an evaluation specialist. However, this is a challenge for many of the colleges as data and analysis are in such high demand that hinders immediate actions by the developmental programs. For example, compliance with accreditation or college program review data takes priority over the need to analyze data for the college developmental mathematics programs.

The majority of the colleges are in the process of implementing changes with the hope of increasing their success rates. One college remained skeptical about redesigning without any substantial data driven evidence that the changes will work. All the colleges have integrated technology into their programs and some have integrated commercially designed programs such as MyMathLab, ALEXS, and Hawkes Learning System for easier access and delivery of material to students. All the colleges are involved in professional development initiatives and are reviewing what other colleges, in Hawaii and nationally, are doing and how it is affecting the success rates. Several colleges mentioned that their most recent initiatives are examining modularized math curriculum, proactive intrusive counseling, cohorts, mandatory supplemental instruction, and finding ways to more effectively place students such as using high school data. Many colleges reported that it is a challenge to get high school data. While changes are being implemented, many colleges acknowledge that they have a long way to go towards improving the success rate. The goal is 70% or higher.

Implications for Future Practice

Despite the many programmatic changes made at most of the colleges, from the traditional model, to a hybrid model, to the Emporium model, no college shows a constant upward trend in success rate. From 2007 to 2013 the mean trend is flat. As such, implications for future practices are:

Program Evaluation:

1. Most of the colleges have no formal program evaluation in place to evaluate the effectiveness of their developmental mathematics program. Thus, a needs assessment factor should be included in all the programs to design and assess learning experiences and learning outcomes. It might be useful to consider the utility of creating a system wide program evaluation for developmental mathematics based upon a wide variety of student data.

Placement Tests:

2. The use of high school and college data for the placement of developmental mathematics students should be explored. A single placement test score should not be the lone factor to assess a student's mathematical skills. Colleges need to institute a more thorough and multifaceted prerequisite check for mathematics placement (Donovan & Wheland, 2008).

Program Design:

3. Math requires three layers of progression: first is memorizing the procedures to solve a question (that is not even the students own question but comes from a

book); second is understanding the importance and applications of this particular question; third is understanding how the mathematical concept can be applied to other problems or their life. The third layer demonstrates that a student understands the math and is not relying on a set of memorized procedures. Many developmental students never make it to this level and so they view math as memorization of a tremendous amount of procedures, and then not knowing where or how these procedures should be applied. This leads to student frustration, the major enemy of motivation. Curriculum should be designed for student sense-making. The multiple levels of learning and remembering mathematical skills, and the three layers of understanding should be explained to students so that they can see where they are and where they need to go.

4. Design more academic and career pathways oriented developmental mathematics courses. Collaborate with faculty that teach math intensive courses and tailor portions of developmental math to provide skills to help students in these courses (e.g., beginning physics, chemistry, astronomy, and economics). This would allow students to move into more interesting subjects and start their career path in academics instead of concentrating on "boring math" that does not have any immediate applications to their life, as supported by Knowles andragogy theory.
5. Redesign developmental mathematics so that students can map their progress and see their progress towards a set goal. Show them where they are in the layers of progression. Students need to know where they are and where they are going. If they are aware of this, they have a better chance of knowing how to get to and

reach their goal. Not knowing how much is going to be required and how far they have to go is discouraging.

6. Provide multiple methods of instruction for the students to choose from to match their learning style. While it is useful to incorporate technology, computer assisted instruction is not best for all students.
7. Long term memory retention is a major problem for student motivation. If a student cannot remember how to do a problem from the previous unit, how is the student going to do the next unit and what does this imply for the entire course? Refresher sections should be incorporated into developmental mathematics programs to aid retention of the sundry of basic mathematical skills that may have been forgotten or placed at the back of their memory bank. Show students that there are ways to increase long term retention. Building on previous learning to understand new concepts, rather than "forgetting one thing to learn another" help students make sense of their learning.
8. Consistently provide students review/refreshment for each previously acquired skill. This reinforces their progress and prepares them for long term retention. Integrate this into a picture of the entire course so they can see their progression.
9. Across the current redesign initiatives, a missing factor seems to be student perspectives; what students believe helps them learn should be a part of program redesign. Implementing a system to collect data on what students choose to be effective for them may provide insight not given by experts in redesign. There is a need to explore from the inside-out as well as from the outside-in.

10. The need to have a greater emphasis on competency instead of just performance because successful performance does not necessarily equate to competence.

Teacher Qualities:

11. New approaches –The results, especially from College 5, suggest that teacher effects may be more important to student success than program design. College representatives questioned: "What are the academic credentials, training, and personal attributes [of a teacher] that enhance student success? Has this been examined in a serious way? What are the best practices that specifically apply to developmental mathematics? What approaches do effective teachers take to relieve student anxiety and frustration, and to motivate students? Are there specific types of students that can be identified, and then appropriate strategies designed to help them learn?"

Recommendations for Future Research

Program Design:

1. In terms of the program structure, future studies should examine which is more effective: condensing time (accelerated) and having fewer exit points, or modularized instruction with constant success points?
2. More in-depth qualitative studies should examine the difference between summer and regular semesters to identify the factors that students and faculty identify as relevant to enhancing success in developmental mathematics.
3. Identify specific roadblocks that inhibit student motivation. Many of these are student beliefs and attitudes, self-efficacy, and anxiety such as:
    - Math is boring.

- Math doesn't make sense because students need to know why they are learning things, there are no immediate applications.
- Can I even do this ? Am I too old ?
- Concentrating on math problems is dwelling on the very problem holding students back. The idea that they are 100% remedial can be depressing and become a problem because of this. Students do not feel that they are really progressing into college, that this may take forever, and they did not even start college yet.

4. Identify factors that provide motivation to students,
   - Does success in a short and well defined math principle/unit that has applications to real world issues increase student mathematics efficacy?
   - If students were able to start college classes for their major/degree simultaneously with developmental mathematics, would it increase their self-efficacy and success?
5. Identify styles of learning that students can choose from. College 5 data indicates that student success seems to be related in part to the style of presentation. Design a study to identify various learning styles. Once the different styles are identified, a student could take a short questionnaire that would help them to identify the style best suited for them. A student could try different presentation styles, or use more than one. Possible methods are traditional lecture in small classes, online, computer-assisted, self-paced, group based instruction where students learn as a cohort with student interaction and with instructor participation, and hybrid models.

6. Study student perspectives on the factors that most critically affect their performance in developmental mathematics. What do they feel helps them in terms of the program, and what helps them with instruction, i.e., what instructor attributes help them learn?

Placement Tests:

7. Develop and collect data from an inventory of college preparedness, or something similar, that gauges student readiness for college.
8. Factors such as high school GPA, mathematics level in high school, Advanced Placement classes, and classes such as Physics and Chemistry that are math intensive should be studied with pathway oriented cohorts of developmental mathematics students to determine if it has an impact on more successfully placing students in mathematics.
9. Which is the greater hurdle, placement or course design?

Teacher Qualities:

10. Studying the students perspectives on what defines a good math instructor and math class
11. What qualifies an instructor to be an effective developmental mathematics instructor? Does formal education level, such as a Masters or a PhD in mathematics make the most effective instructor for developmental mathematics, or would more training in education be more effective? What are the other factors?

    (College Response: The idea that "anyone can teach it" is erroneous. It takes greater attention and understanding to help someone learn basic math skills. It requires patience and a greater knowledge of pedagogy. You are a "cheer leader" motivating students to do their best, to try again, to persevere. It requires that students be motivated to want to learn, to want to do well, and to continue their learning.)

Conclusions

The purpose of this mixed methods multiple case study was to explore the developmental mathematics programs at all the public colleges in Hawaii. Most of the Hawaii colleges are experimenting with a hybrid approach and/or, the Emporium Model. A common component of the developmental mathematics redesign effort was the integration of technology, such as MyMathLab and ALEKS, to deliver assessment and course material. Unfortunately, none of the course designs had any significant impact in increasing the success rate over time. While some research predicted that the integration of technology would have positive effects on learning, it has not been the "silver bullet" for improving success rate (Twigg, 2011). While the redesigns over the years have not produced any significant increase in success, summer continues to exceed fall and spring semester by a significant 20%, and participants from all the colleges mentioned that summer students are more motivated and invested so they perform better. This aligns to Bandura's social cognitive theory and Knowles andragogy principles that student belief about the value of their educational experience, and their own affective involvement and efficacy, are important factors that affect student performance, and this is evident in the summer (Bandura, 1977; Bonham & Boylan, 2011; Keegan, 2011; M. S. Knowles, 1990).

The Algebra Level Compass test scores are more consequential on final grades than the Prealgebra test scores. The placement test scores did not produce consistent results at all the colleges for students who appeared to have similar skills as predicted by the pretest. The differences in the college environment and instruction seems to have a greater impact on the final grades than the placement test scores. Students at the college with the least redesign had a better odds of getting a better final grade correlated to their placement scores than their peers at the other colleges with more redesign efforts. This suggests that colleges and programs have not found any method of delivery that consistently improves success.

This study shows that developmental mathematics is still struggling to increase success rate. Factors such as changes in curriculum, and pedagogy, and additional technology have not fixed the problem. The tendency is that the higher the enrollment, the lower the success rate. The results from the redesign changes have not significantly and consistently increased student success rate in any of the colleges and placement test results at different colleges have some significant impact on final grades. Further studies that focus on student involvement in their learning, and making sense of mathematics, as well as how instructors can facilitate this in addition to teaching mathematics skills, and processes might prove powerful in improving programs that result in greater student success.

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Appendix A: Interview Questions

Phase 2

Interview Questions

I have some findings from the analysis of the quantitative data for my research questions 1 and 2 and would like your thoughts. This is not a test, it is your opinion about the results/findings. For the interview, I would like your initial thoughts on what the quantitative data show. After the interview, I will be leaving the results with you and would appreciate if you would share any final thoughts that you may have with me, by email or phone, after you have some time to reflect on the results.

1. Preliminary findings success rate:

7 Colleges: Mean Success Rate (Spring 2007-Spring2013)		
Spring	Summer	Fall
53.00%	74.43%	56.60%

   Note: Per growth over time for each semester (spring, summer and fall) was flat.

   Question 1a: What is happening in summer to improve success?

   Question 1b: What are your perspective on the above findings on success rate?

2. Preliminary findings placement test/compass scores and students' grades:

   The Algebra Compass score is more consequential to student grade compared to the Prealgebra compass test.

   Ordinal Model: A point increase in the Algebra pretest increases the odds of passing by a factor of 1.040 (4%) compared to an increase in 1 point in the Prealgebra pretest translates to an increased odds of passing of 2.3%

Question: What are your perspectives on the above findings on pretest (Compass/Placement Exam) and grades?

Additional Question for one of the colleges:

In statistical test (ordinal model) one of the 7 colleges was used as the reference.

Attending your college have an increase odds of passing:

(i) by a factor of 2.21, that is, increase of 121% for students taking the Algebra Compass

(ii) a factor of 1.45, that is, increase of 45% for students taking the Prealgebra Compass

*Additional Questions for one College:

(2*) What are your perspectives on the above findings for the pretest(Compass/Placement Exam) and grades at your college?

3. What are the implications of the findings to the developmental mathematics program?
4. Any surprises?
5. What initiatives is your college taking in developmental mathematics?
6. What are the general reactions of your faculty to developmental mathematics programs?
7. What are the general reactions of your faculty to your college's initiatives?
8. Anything else you would like to add to the discussion?

Appendix B: Adult Consent Form

University of Hawaii at Manoa

Consent to Participate in Research Project:

My name is Bebi Davis. I am a graduate student at the University of Hawaii at Manoa (UH) in the College of Education. As part of the requirements for earning my graduate degree (PhD), I am doing a research project for my dissertation. The title of my project EXPLORING THE DEVELOPMENTAL MATHEMATICS PROGRAMS AT COLLEGES IN HAWAII. The purpose of my project is to explore the similarities and differences of college developmental mathematics programs at the public colleges in Hawaii. I am asking you to participate because you are a key member of the developmental mathematics program at your college.

Activities and Time Commitment: If you participate in this project, I will meet with you for an interview at a location and time convenient for you; this includes using distance communication, such as, Skype and telephone. The interview will consist of 8 structured and open ended questions, and will take about 60 minutes. Interview questions will include questions that are directly related to the developmental mathematics program.

Only you and I will be present during the interview. I will audio-record the interview so that I can later transcribe the interview and analyze the responses. You will be one of about 7-14 people whom I will interview for this study.

Benefits and Risks: There will be no direct benefit to you for participating in this interview. I hope, however, that the results of this project will help the colleges improve the Developmental Mathematics Program to benefit future students. I believe there is little or no risk to you in participating in this research project. If however, you become stressed or uncomfortable answering any of the interview questions or discussing topics with me during the interview, we can skip the question, or take a break, or stop the interview, or withdraw from the project altogether.

Privacy and Confidentiality: During this research project, I will keep all data in a secure location. Only my University of Hawaii advisor and I will have access to the data, although legally authorized agencies, including the UH Human Studies Program, can review research records. After I transcribe the interviews, I will erase/destroy the audio-recordings. In the final report of my research project I will not use your name or any other personally identifying information. Rather I will use pseudonyms (fake names) and report my findings in a way that protects your privacy and confidentiality to the extent allowed by law.

Voluntary Participation: Your participation in this project is completely voluntary. You may stop participating at any time without any penalty or loss. Your participation or non-participation will not impact your rights any services for the College of Education or University System.

As compensation for time spent participating in the research project, I will provide you with a $10 gift certificate.

If you have any questions about this research project, please call me at (808) _______or email me at_______. If you have any questions regarding your rights as a research participant, please contact the UH Human Studies Program, by phone at (808) 956-5007, or uhirb@hawaii.edu.

If you agree to participate in this project, please sign and date this signature page and return it to:

Bebi Davis, Principal Investigator

Thank you.

Bebi Davis

Signature:

I have read and understand the information provided to me about participating in the research project, *Evaluation of Services Provided via the Career Development and Counseling Program.*

I understand the procedures described above. My questions have been answered to my satisfaction, and I ________________________________ agree to participate in this study.

(***Print your name)***

Please check the box that applies:

☐ I **agree** to participate in this research project.

☐ I **do not agree** to participate in this research project.

☐ I **agree** to be Audio Taped

☐ I **do not agree** to be Audio Taped

My signature below indicates that I agree to participate in this research project.

Printed name: _________________________

Signature: ____________________________

Date: ________________________________

Contact: Telephone _____________________

email: _________________________________