A MIXED METHODS STUDY OF A STATISTICS PATHWAY FOR COMMUNITY COLLEGE STUDENTS PLACED INTO DEVELOPMENTAL MATHEMATICS

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by

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CERTIFICATION OF APPROVAL

I certify that I have read *A Mixed Methods Study of a Statistics Pathway for Community College Students Placed into Developmental Mathematics* by Pamela Marie Mery, and that in my opinion this work meets the criteria for approving a dissertation submitted in partial fulfillment of the requirements for the degree: Doctor of Education in Educational Leadership at San Francisco State University.

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Low completion rates for developmental mathematics sequences and in gateway mathematics courses prevent a majority of community college students from achieving transfer goals. This explanatory mixed methods case study examined an open-entry, accelerated, two-course mathematics sequence culminating in transfer-level statistics. Of the beginning cohort, nearly all of whom were Latino or African American, 86% successfully completed the sequence and performed well on questions from the nationally-normed CAOS exam. Student interviewees repeatedly attributed their success to growth mindset, consistent with their high scores on the Adult Dispositional Hope Scale. Observations substantiated ways that classroom interactions supported and reinforced students' new sense of competency regarding mathematics. With regard to contextualization, students' motivation seemed to derive from challenging statistics content rather than direct applicability or relevance. These findings have important implications for educational equity since lengthy developmental mathematics sequences have a disproportionately negative impact on underprepared students of color.

I certify that the Abstract is a correct representation of the content of this dissertation.

Dr. Helen Hyun, Chair, Dissertation Committee

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Chapter One: Purpose of the Study

A mixed methods, case study design was used to analyze a community college's implementation of an open-entry, two-course mathematics sequence culminating in transfer-level statistics. The initial pre-statistics course seeks to introduce students to mathematical concepts foundational to learning statistics, thereby preparing students to succeed in the second course which is transfer-level statistics. Enrollment in the sequence includes students placed into the lowest level of mathematics that the college offers (i.e. arithmetic); as such, the sequence attempts to support all students, regardless of initial placement or mathematics eligibility, in reaching college-level statistics by the end of the second semester. Moreover, 97% of sequence enrollees were underrepresented students of color, a large proportion of whom were first generation college students.

Problem Statement

Low completion rates for developmental mathematics sequences and in gateway mathematics courses prevent a majority of community college students from achieving their educational goal of transfer. Approximately one-third of students who enter community colleges with developmental mathematics needs advance to college-level mathematics (Bailey, Jeong, & Cho, 2009; Roksa, Jenkins, Jaggars, Zeidenberg, & Cho, 2009). Conversely, early completion of college-level mathematics is among the most salient variables contributing to community college student goal achievement and transfer (Adelman, 2005; Moore, Shulock, & Offenstein, 2009). Students who completed college-level mathematics within their first two years at a California community college were three times more likely to transfer or complete a degree or certificate (Moore, Shulock, & Offenstein, 2009).

To reach college-level math, many students must complete lengthy developmental sequences. The Center for Student Success ([CSS], 2005) indicated that over 70% of California community college students who took a placement test placed into developmental math, i.e. below advanced algebra or pre-calculus. The National Center for Education Statistics ([NCES], 2003) reported that in the U.S., public two-year institutions on average offer 3.4 remedial mathematics courses. Sequences of this length can be completed in two years, assuming continuous mathematics enrollment and successful completion of each mathematics course upon first attempt—yet only 17% of California community college students achieved college-level mathematics within two years (Moore, Shulock, & Offenstein, 2009). Some students do not even attempt the sequence. In the national study by Bailey, Jeong, and Cho (2009), 27% of students never enrolled in developmental mathematics after having been referred.

Research shows that African American and Latino students experience even less success than their white and Asian peers in lower-division math. Of those attempting elementary algebra in California community colleges, roughly 40% of African American and 47% of Latino students successfully complete the course, compared to

53% of white students and 55% of Asian / Pacific Islander students (CSS, 2005). These course completion gaps are mirrored by gaps in transfer rates. Moore, Shulock, and Offenstein (2009) reported seven-year transfer rates for Latino and African American students ranging from 16% to 18%, compared to 27% for White students and 30% for Asian students. According to figures from the state's longitudinal database, as of the most recent reporting year (2003-04), transfer rates have marginally improved by one to five percentage points, but achievement gaps in transfer have not changed substantially since 1998-99 (CCCCO Data Mart, n.d.).

Structures associated with lowering student success in mathematics and contributing to achievement gaps precede the community college level. High school mathematics curricula affect students' trajectories. According to national research, lower high school mathematics achievement corresponds to initial community college enrollment while higher achievement was associated with immediate four-year enrollment, as evidenced by a Pearson correlation of .7525 (p = .0001) (Adelman, 2005). Studies have shown that underrepresented minority students are less likely to attend high schools which offer advanced mathematics courses (Adelman, 2006; Orfield & Lee, 2006).

Current discussions about how to improve community college developmental mathematics sequence completion rates emphasize the potential importance of accelerating mathematics sequences through a variety of modifications including short-term “refresher” courses, self-paced courses, and shortened sequences (Asera, Navarro, Hern, Klein, & Snell, 2009a; Bailey, Jeong, & Cho, 2009; Biswas, 2007; Calcagno, Crosta, Bailey, & Jenkins, 2006; Wlodkowski, 2003; Wlodkowski & Kasworm, 2003; Zachry, 2008). In addition to the length of remedial mathematics sequences, there are concerns raised in the field about the effectiveness of approaches used for teaching developmental mathematics as well as the appropriateness of the focus of developmental content. In terms of the latter, researchers point out that very few students (roughly 5% - 20%) who enroll in algebra need or intend to eventually enroll in calculus (Dunbar, 2006; Herriott & Dunbar, 2009; McGowen, 2006). These researchers suggest that algebra content and course sequences should be examined for relevance and adjusted to fit the needs of students and the disciplines in which they intend to major. Mathematics leaders such as Steen (2004), past president of the Mathematics Association of America, urge colleges to focus on addressing students’ quantitative literacy needs, possibly through the use of statistics courses and other courses which focus more on applied use (see also Ganter, 2006; Snell, 2009a).

Advancing complementary arguments, distinguished researchers such as Grubb (2001) assert that an instrumental approach to developmental education hinders student learning. An instrumental approach views the subject matter as a means to some other ends, rather than valuable in its own right. Some believe contextualization, which relates subject matter to authentic, real-world situations, may become a preferred approach to teaching developmental concepts more generally, including developmental mathematics (CSS, 2009; Grubb, 2001; Office of Vocational and Adult Education, 2005). Other instructors have sought to further deepen the relevance of mathematics material for students by employing culturally relevant pedagogy (Enyedy & Mukhopadhyay, 2007).

From a discipline standpoint, mathematics is the most significant barrier to transfer that community college students face (Adelman, 2005; National Center for Education Statistics [NCES], 2003; Moore, Shulock, & Offenstein, 2009). Restructuring or reforming mathematics at community colleges so that it does not remain a roadblock would improve transfer numbers overall—and would undoubtedly go a long way toward reducing disparities in the rates at which different ethnic groups transfer. This study focused on a new approach to teaching developmental mathematics utilizing an accelerated sequence and contextualized statistics. Despite the broad interest in acceleration and contextualization, a limited number of published studies have investigated the effectiveness of these approaches. In fact, to date there are no published studies of developmental mathematics sequence acceleration utilizing statistics contextualization at community colleges.

Research Objectives

Quantitative Hypotheses

Quantitative hypotheses focused on course completion measures, sequence persistence rates, and sequence completion rates, as well as test performance for students in StatMode. (Note, StatMode is a pseudonym.) The primary hypothesis was that a large majority of students in StatMode would be able to complete the initial course successfully and persist to the second, transfer-level course—compared to a minority of similar students nationally. Quantitative analysis of items from the Comprehensive Assessment of Outcomes in a First Statistics Course (CAOS) test was used to examine the hypothesis that StatMode students' performance would be equal to their national peers on the post-test items. Demographic variables including ethnicity, gender, age group, and Puente status—as well as students' mathematics levels upon entering the StatMode sequence—were examined for potential relationship to student success in the sequence. Finally, the Adult Dispositional Hope Scale (ADHS) was used to collect students' self-assessed ratings regarding their individual sense of agency for and pathways to goal attainment. The primary use of the ADHS was to determine whether StatMode students may be atypical with regard to their hopefulness. The hypothesis was that StatMode students were not substantially different than their peers at other colleges regarding their sense of pathways and agency.

Qualitative Propositions

The qualitative data sought to explore, from the students' perspective, the reasons why StatMode might be effective. Collected primarily through individual student interviews, triangulated with classroom observations and discussions with the instructor, the qualitative data examined students' experiences in the pilot mathematics sequence. Data collection focused on the following:

- students' feelings and beliefs about mathematics and the nature of the mathematics concepts they are learning,
- perceived relevance of the content, including contextualization and cultural relevance, and
- shifts in students' sense of competency with regard to learning and using mathematics concepts.

Other aspects of StatMode were also investigated for conscious saliency to the students, including propositions that the following attributes contribute to students' willingness to persist through challenging mathematics material:

- caring relationships between the instructor and the students;
- early, encouraging feedback from the instructor; and
- peer support, particularly that derived from the learning community associated with Puente.

Finally, a potential criticism of StatMode was explored. This criticism reflects the conundrum that StatMode may be viewed as a tracking mechanism or a detracking mechanism, depending on one's perspective. StatMode can be viewed as a detracking effort, bringing developmentally-placed students rapidly into college-level content. Simultaneously, StatMode may track students away from mathematics-intensive and science-related majors. To better understand this issue from the students' perspectives, students' direct and indirect statements about mathematics sequences were analyzed. The related qualitative proposition was that college students would be inclined to view

StatMode as a detracking mechanism.

Conceptual Framework

Two primary concepts undergird StatMode. The first concept pertains to removing the structural barriers which currently impede students who place as low as arithmetic from completing college-level mathematics within one year. In order to accomplish the one-year timeframe, it is presumed that *challenging, conceptual mathematics content* must be incorporated even while remedial mathematics is being reviewed. The second concept pertains to providing a student-centered classroom environment utilizing an instructional approach which consciously facilitates students' sense of agency and competency in math, including incorporating *mathematics content which is relevant* to students. In addition, mechanisms for peer support are built into the cohort / learning community model leveraged by StatMode.

The length of community college developmental mathematics sequences and the practice of segmenting mathematics material between remedial and college-level (i.e. between rote, rule-bound material and more conceptual, intellectually challenging material) constitute a structural barrier. This barrier contributes to the inequitable achievement of transfer and other completion goals and also deprives many students of the opportunity to engage with rigorous conceptual content in math. The structural argument derives from landmark research by Bowles and Gintis in 1976 which showed that despite increasing education levels across various segments of the U.S. population, widespread equality of income and social status had not followed. In their analysis, schools largely legitimate rather than subvert inequities by providing a pretense toward equity and egalitarianism.

Subsequent influential research by Jean Anyon elaborated on the types of learning experiences associated with schools serving different student populations. As reported by Finn (1999), the working class schools which Anyon studied emphasized compliance and following instructions; there could only be one correct approach—the teacher's formulaic approach. In the middle-class school, students were expected to develop conceptual understanding, not just follow rules. However, in the affluent professional school, creativity, discovery, direct experience, and independent work were valued; power and control were negotiated between students and teachers. Finn noted several formal and informal studies in the 1990s which validated Anyon's findings and concluded, "When students begin school in such different systems, the odds are set for them" (p. 25).

Related studies of tracking find that even within institutions students can experience similar differences in teacher expectations of students (Burris, Heubert, & Levin, 2006; Watanabe, 2008a, 2008b). Watanabe (2008b) found that higher-tracked seventh-grade students received more instructor feedback (both in real time and in written format), practiced a broader range of skills, engaged in more socially situated learning, and considered topics which tended to be both more authentic and more challenging. Although tracking purports to place students by perceived ability level, the practice has been criticized for reinforcing inequities relating to ethnicity, class, and other demographic differences. Several detracking efforts in secondary education provide evidence that increased classroom heterogeneity (that is, a mixture of incoming skill levels) can improve student performance across ability levels when coupled with a variety of student-centered instructional approaches (Boaler, 2008; Boaler & Staples, 2008; Burris, Heubert, & Levin, 2006).

A second underlying concept of StatMode is that instruction should be relevant and engaging for students. Drawn from pedagogues ranging from Dewey to Freire, hooks, and Ladson-Billings, the concept of relevance reflects a fundamental belief that instructors must attend to the students' experience and relate the educational content to real applications which are meaningful to students. In his theory of experience Dewey (1954) emphasized the importance of being able to apply knowledge. He stated, "There is no such thing as educational value in the abstract" (p. 46). Dewey cited the need for what he referred to as an experiential continuum rather than planless improvisation. In addition, Dewey developed the notion of "interaction" whereby there is a mutual adaptation which takes the learning environment, the students' needs, and social conditions into account. Taken together, these notions are foundational to a constructivist view of education and the promotion of a democratic classroom which emphasizes the "freedom of observation and of judgment exercised in behalf of purposes that are intrinsically worthwhile" (p. 69).

Other theorists have built on Dewey's conceptions, arguing for learning environments and relationships with instructors which promote the development of students' independent intellect and agency. For example, Freire argued against "banking" where "the students are the depositories and the teacher is the depositor" (2009, p. 72). According to Freire, this form of instruction promotes passivity. Hooks argued that students "want knowledge that is meaningful…addressing the connection between what they are learning and their overall life experiences" (1994, p. 19).

Relevance can take on many meanings for both instructors and students. In her ground-breaking work, Ladson-Billings (1994) noted that cultural referents may be used pragmatically, simply as "bridges" to encourage student interest or help students understand a particular concept via cultural appropriateness, cultural responsiveness, or cultural compatibility approaches. While potentially effective for teaching students particular skills, Ladson-Billings argued that these approaches fall short. She argued that such cultural referents should be incorporated into culturally relevant teaching which "empowers students intellectually, socially, emotionally, and politically by using cultural referents to impart knowledge, skills, and attitudes" (p. 18).

Current theories of cognition support the importance of a meaning-centered approach to instruction rather than an exclusive focus on memorization and procedures (Bransford, Brown, & Cocking, 2000). For competence to emerge, facts must cohere into a deeper conceptual understanding. Researchers caution not to overlook concerns about students' ability to abstract and transfer knowledge. Retrieval and application of information learned in only one context may be limited to that context. Such knowledge is referred to as "overly contextualized" (p. 62). Use of multiple cases, "what-if" problem solving, and tasks which require generalization or abstraction were shown to increase flexible application and knowledge transfer.

The theoretical framework for this study is informed primarily by pragmatism and social justice concerns. A majority of community college students experience mathematics as a barrier, and this barrier currently serves to reproduce structural inequities which exist in the U.S. Rather than remain entrenched in historical and theoretical notions of the value of mathematics (e.g., mathematics teaches students to think deductively), it seems sensible to consider alternatives. The StatMode alternative would provide students with fundamental skills in mathematics (e.g., quantitative literacy) while allowing that fostering reasoning and other math-associated skills may be accomplished not only through mathematics but also through a variety of disciplines. Moreover statistics can be taught with academic rigor (Moore & Witmer, 1991). Preconceptions about the rigorousness of one course of study versus another—as well as the necessity of one subject area over another—must be examined closely when the impact is as influential over student outcomes as that of developmental math.

Key Constructs and Operational Definitions

Accelerated Program. By definition, these programs take less time to earn credits, certificates, or degrees than traditional programs. Wlodkowski (2003) indicated that the "core element" to an accelerated program is the accelerated course.

College-level Mathematics. Commonly defined as college algebra or a course transferable to a four-year college or university.

Completion Rate. An overarching term that variously refers to transfer rate, graduation rate, course or sequence success rate. The specific reference is defined upon use.

Contextualized Learning. Instruction that relates subject matter to authentic, real-world situations, especially foundation skills which may be linked to academic or vocational content (CSS, 2009). Includes the concepts of "integrated curriculum," "applied learning," and "cognitive apprenticeship." May use learning communities, lab assignments, or other instructional means to link foundational skills with contextual applications.

Course Success. Usually defined as completion of a course with a grade of C or better, particularly because many colleges will not allow students to take a subsequent course in a mathematics sequence with a "passing" grade of D. Depending on the context of its use, "Success Rate" may refer to "Course Success Rate" or "Sequence Success Rate".

Developmental / Remedial Mathematics. Generally refers to courses below college-level math. The numbers of developmental / remedial courses varies among community colleges (NCES, 2003). When possible during the discussion of a particular study, more specific descriptions are used (e.g., basic arithmetic, elementary algebra, intermediate algebra, algebra 2, et cetera). Although the term “remedial” is sometimes considered derogatory, it is used interchangeably with “developmental” in this literature review in order to avoid the overuse of either word (Bailey, Jeong, & Cho, 2009), as well as to more accurately reflect the varied use in the research studies.

<u>Gateway Course.</u> Usually refers to the initial college-level course in the sequence. Also referred to as “Gatekeeper” (Roska, Jenkins, Jaggars, Zeidenberg, & Cho, 2009).

<u>Quantitative Literacy.</u> This concept appears to be gaining prominence and is subject to completing definitions. One definition is the “uniquely modern blend of arithmetic with complex reasoning” (Steen, 2004, p. 3).

<u>Sequence Success.</u> Completion of all courses in a particular content sequence such as the mathematics sequence or English sequence, including completion of Gateway / Gatekeeper course. Depending on the context of its use, “Success Rate” may refer to “Course Success Rate” or “Sequence Success Rate.”

<u>Tracking.</u> An approach to instruction that sorts students by perceived ability level. “At the secondary level, tracking manifests itself in the form of honors, regular, or remedial classes by subject” (Watanabe, 2008, p. 672). Historically, two primary characteristics of tracking include lesser content provided to and lower levels of critical thinking

required of students in lower tracks. Thus, the longer a student remains in one track, the more difficult it is for that student to successfully move up to a higher-level track.

Delimitations and Scope of the Study

StatMode was selected for this case study because it is atypical. As Bogdan and Biklen (2007) caution, such selection limits the generalizability of the findings. A rich description of the research setting, including detailed descriptions of the study population, the instructor, the nature of the instruction, and the classroom climate, will allow readers to assess potential transferability of the findings.

A mixed-methods approach was employed due to the pilot nature of this curricular intervention. This design, drawn from a pragmatic research framework, focused on the urgent need to improve mathematics sequences for community college students. While there was not a sufficient sample size within the pilot for a full-scale quantitative study, the quantitative data were necessary to justify the importance of the qualitative findings. Qualitative data were vital to investigate the qualities within the StatMode sequence and instructional design which supported students' success and achievement. Due to the unique context and to counterbalance subjectivity, a variety of both quantitative and qualitative data were gathered for corroboration and triangulation in order to present the most complete picture possible of this particular case.

Significance of the Study

As described in the general overview, early completion of college-level mathematics acts as a catalyst to transfer for community college students, just as lack of mathematics completion acts as a barrier. The mathematics hurdle, as it is often called, impacts the number of community college students who become degree- or transfer-eligible. This is problematic for the students who seek to achieve their goals. It is also problematic for community colleges which may be increasingly funded based upon efficacy—either directly through performance-based funding or indirectly based upon legislators' perceptions of the colleges' effectiveness. Finally, the hindrance to degree production affects the social and economic health of individual states as well as the U.S. as a whole (Moore, Shulock, & Offenstein, 2009).

No other discipline has such a powerful effect on student outcomes. Yet there are no widely-implemented or widely-accepted remedies which ameliorate the mathematics hurdle. As will be discussed in the literature review, commonly-used interventions such as tutoring, Supplemental Instruction, and computerized software have not been found to both regularly and definitively improve student success rates in developmental math. More intensive mathematics interventions may be successful but are not considered scalable; they are resource-intensive for both colleges and students. Intensive programs such as MathPath (MathPath, n.d.) boast course success rates as high as 80% in beginning algebra, compared to success rates of 40% for students not in the program. However, enrollment in the program requires that students spend 30 hours a week on math—10 hours in class time and 20 hours outside of class.

StatMode represents a new approach to restructuring the developmental mathematics sequence and content. Growing national interest in the primary components of StatMode is reflected in the acceleration and contextualization themes cited in the literature review. Despite the broad interest in acceleration and contextualization, only a limited number of published studies have investigated the effectiveness of these approaches. There are no published studies of developmental mathematics sequence acceleration utilizing statistics contextualization at community colleges.

This study of StatMode seeks to show the potential viability of an accelerated, contextualized model in terms of student outcomes. It also seeks to reveal student experiences within StatMode. The demographics of StatMode students reflect some of the most underserved students in the educational system: roughly 80% of StatMode students are Latino and 70% are first generation college-going. In addition, 20% or more of StatMode students have completed only arithmetic or elementary algebra in high school, with an even higher proportion placing at or below elementary algebra upon community college matriculation. In part, the design of the research questions and the research protocol attempt to consciously leverage these demographics in order to focus findings on equity issues.

Conclusion

Low completion rates for developmental mathematics sequences and in gateway mathematics courses prevent a majority of community college students from achieving their educational goal of transfer. Moreover, research shows that African American and Latino students experience even less success than their white and Asian peers in lower-division math. In national debates regarding how to redress these issues, two frequently proposed modifications include shortened, accelerated sequences and contextualization. To date there are no published studies of developmental mathematics sequence acceleration utilizing statistics contextualization at community colleges.

Through an explanatory mixed methods approach, this study analyzed success rates of all 29 StatMode enrollees, including testing for statistical significance across several demographic variables. The study then used a close analysis of 11 student interviews—triangulated with four classroom observations and discussions with the instructor—to explain the success rates from the students' perspectives.

Organization of the Dissertation

The next chapter presents a review of the literature that guided this investigation. The third chapter presents the study methodology. Chapter Four focuses on the results of the quantitative analysis. Chapters Five and Six present the qualitative findings. The final chapter addresses the significance of and implications of the results, as well as suggestions for future research.

Chapter Two: Literature Review

Introduction

Low completion rates for developmental mathematics sequences and in gateway mathematics courses prevent a majority of community college students from achieving their educational goal of transfer. Most community college students begin their postsecondary education with a disadvantage in mathematics. A landmark national study showed that mathematics achievement in high school is strongly associated with the type of institution where initial postsecondary matriculation occurs. Lower high school mathematics achievement corresponded to initial community college enrollment while higher achievement was associated with immediate four-year enrollment, as evidenced by a Pearson correlation of .7525 (p = .0001) (Adelman, 2005). For the 1992 cohort of 12th-graders, 43.5% of students entering community colleges had not reached the level of algebra 2 in high school. In comparison, 11.4% of students entering four-year institutions had not reached algebra 2. Conversely, only 7.6% of community college entrants had reached pre-calculus or calculus in high school, compared to 40.0% of four-year matriculants.

Not only do a majority of community college students place low, but many students never make it beyond their first mathematics course. According to the Center for Student Success (2005), more than 50% of students attempting elementary algebra fail to achieve a passing grade of C or higher in California community colleges. In a simple demographic analysis, success rates were found to vary by ethnic group.

Roughly 60% of African American community college students in California fail elementary algebra, compared to 53% of Latino students, 47% of white students, and 45% of Asian / Pacific Islander students. Underrepresented students are more likely to place at the lowest level, a fact compounded by success rates which are also lower. Yet before attempting to fulfill college-level mathematics requirements, students must successfully complete not only elementary algebra but also intermediate algebra since the latter is a prerequisite for fulfilling quantitative reasoning transfer requirements.

Low placement and success rates in mathematics courses are a well known problem, but more recent studies have focused on the large proportion of students who never attempt mathematics after receiving a developmental placement, or who fail to complete the mathematics sequence even after having successfully completed all the mathematics coursework they attempted. Bailey, Jeong, and Cho (2009) in their study of Achieving the Dream schools found that 27% of students never enrolled in developmental mathematics after having been referred and 11% never failed a mathematics course yet did not complete the sequence. Taken together, this 38% is substantially higher than the 29% who failed at least one mathematics course and did not complete the sequence. It is also higher than the 33% of students who successfully completed the developmental sequence and reached transfer level.

Numerous studies and reports have suggested that community colleges currently do not transfer students in sufficient numbers—making both California and the nation less competitive globally as a result (Callan, Finney, Kirst, Usdan, & Venezia, 2006;

Shulock & Moore, 2007). From a discipline standpoint, mathematics is the most significant barrier to transfer that community college students face (Adelman, 2005; National Center for Education Statistics [NCES], 2003; Moore, Shulock, & Offenstein, 2009). Student transfer rates will improve only when student success in mathematics improves and/or mathematics requirements are changed. Restructuring or reforming mathematics at community colleges so that it does not remain a roadblock would improve transfer numbers overall--and would undoubtedly go a long way toward reducing disparities in the rates at which different ethnic groups transfer.

Further amplifying the importance of mathematics specifically is the increased need for greater mathematical skills among workers--skills remarkably consistent with those required for postsecondary education (Office of Vocational and Adult Education, 2005). Due to these pressures, mathematics requirements in states such as California, for example, have been increasing at both the K-12 and community college levels. Various interventions have, in some cases, improved mathematics success rates but only marginally. As a result, there is the potential for further widening current achievement gaps between ethnic groups if mathematics success rates are not substantially addressed. Simultaneously, among national, professional mathematics associations such as the American Mathematical Association of Two-Year Colleges (AMATYC), the Mathematical Association of America (MAA), and the National Council of Teachers of Mathematics (NCTM), there is a general agreement that the developmental mathematics curriculum needs to be revised to improve student success rates.

Specifically, mathematics associations recognize that a majority of college students, including community college students, do not require calculus to fulfill their major requirements—yet traditional mathematics pathways emphasize preparation for calculus over other mathematical skills (Hastings, 2006). Alternative mathematics pathways at community colleges are being investigated to determine whether they can simultaneously maintain a sufficient level of rigor, dramatically increase student success levels in math, decrease achievement gaps in math, and provide meaningful skills for a broad range of community college students. Possible pathways include an approach to teaching developmental mathematics and algebra concepts and procedures required as preparation for a college-level statistics course, rather than calculus.

Clearly these approaches (acceleration and contextualization) exist among many options for improving mathematics performance and sequence completion, particularly for underrepresented students. Given the growing interest in cultural relevance at community colleges, literature will be included to the extent that it specifically addresses cultural relevance used in teaching statistics material through a social justice lens. Cultural relevance may, depending on the approach, deepen the degree of relevant contextualization, but it may also divert students from statistics learning goals.

Finally, as a partially inductive, explanatory mixed methods study, the research remained open to the possibility that other frameworks and concepts would become important. As a result, a major framework which emerged during qualitative data collection has been incorporated into this literature review. The framework compares the implications of entity versus incremental theories of intelligence (TOIs) for learning. Popularized in the nonacademic literature as “fixed mindset” and “growth mindset,” these TOIs have been shown to be associated with performance when students engage with challenging material. The framework has also been used to address stereotype threat experienced by members of marginalized populations.

Scope and Search Criteria

An initial ProQuest search of Education Journals for (math* AND community college" AND statistics) yielded no empirical studies. Broadening the search to (math* AND college AND statistics) yielded more results; however, upon review the studies were nearly all university-based and seemed far removed from the community college experience. The search for "statistics pathway" references yielded no studies. Finally, results for subsequent, topical searches were also scant, including (math* AND "community college" AND (heterogeneity OR tracking OR ability-grouping)), which yielded one study.

Thus, the scope of the literature review was substantially broadened to investigate what is known about developmental mathematics instruction and course sequences at community colleges. A broad, initial search conducted using ProQuest, selecting for Scholarly journals across all databases, revealed a total of only 66 articles, of which 57 were published during the decade from January 2000 through December 2009. The search syntax used was as follows: (math*) AND (community college OR two-year college) AND TEXT(remedia* OR developmental OR basic skills). Adding

“OR algebra” and “OR junior college” to the search text did not reveal additional articles.

The 57 most recent articles were examined for empiricism and relevance. Opinion pieces were excluded. Others articles which did not focus on community college students were excluded – for example, articles focused on high school students concurrently enrolled at a community college. Several articles on assessment and placement were set aside in order to focus on student success in mathematics sequences, promising instructional interventions, and potential structural changes. Ultimately, 13 articles were identified for potential inclusion in the literature review. A similar search in EBSCO only added three more articles. These studies focus on success rates in mathematics sequences, the use of technology in mathematics courses, tutoring and supplemental instruction, and contextual learning.

Several education and mathematics experts were consulted regarding how to supplement the ProQuest and EBSCO articles. As a result, substantial articles were added from the following sources: The Community College Research Center (CCRC) and Achieving the Dream. Extensive branching was also used to locate relevant studies.

To further ground the researcher’s sense of the developmental mathematics field, articles and conference proceedings from the preeminent mathematics organizations mined, in particular the MAA and AMATYC. For example, 35th AMATYC Annual Conference was held November 12-15, 2009, in Las Vegas. For the latter, out of 149 individual sessions, 15 clearly focused specifically on developmental mathematics based upon their titles. Other foci ranged from the use of technology, statistics instruction, quantitative literacy, calculus, and approaches to professional learning.

Finally, as noted in the overview, two concepts were added during the course of this explanatory study based on preliminary findings. Additional concepts include theories of intelligence (i.e. incrementalist and entity TOIs associated with popularized notions of growth and fixed mindsets) and cultural relevance insofar as it is related to statistics instruction.

Structure of the Review

The literature review begins with a discussion of the particular role mathematics plays in students' trajectories. The landmark research study *Moving Into Town-And Moving On* by Clifford Adelman (2005), former Senior Research Analyst for the U.S. Department of Education, is probably the most extensive quantitative study of community colleges to date. At 175 pages, the study provides a complex view of community colleges using a larger array of variables than is available to most other researchers in the field. Due the comprehensiveness and complexity of the analysis provided by Adelman, the literature review devotes substantial attention to this study.

A synthesis of studies examining the effectiveness of developmental education follows the section on the particular role of mathematics in student trajectories and academic momentum. The relative effectiveness for diverse populations is also examined, followed by a discussion of the approaches used by community colleges to attempt to improve the effectiveness of developmental mathematics courses and sequences.

Finally, the additional concepts of entity and incrementalist TOIs and statistics instruction taught through a cultural relevance framework are all addressed.

Analysis of the Research Literature

Mathematics as Catalyst or Barrier

Early completion of college-level mathematics acts as a catalyst to transfer for community college students, just as lack of mathematics completion acts as a barrier. Adelman (2005) found that nationally, the completion of college-level mathematics during a student's first year at a community college was among five variables significantly associated with the likelihood of transferring to a four year institution. With each increase in mathematics level, the probability of transfer increased by 22.7%.

In their study of California community colleges, Moore, Shulock, and Offenstein (2009) found similar results: completion of college-level mathematics within the first two years of enrollment resulted in a three-fold increase of overall completion rates (i.e. transfer, certificate, or degree). College-level English within the first two years of enrollment was associated with a two-fold increase in overall completion rates. In their regression model, both completion of college-level mathematics and college-level English within the first year were significant. The difference from Adelman's findings in terms of English may be related to the relatively large proportion of nonnative English speakers in California.

Beyond mathematics and English, other variables associated with transfer included earning credits during a summer term, continuous enrollment and, negatively associated, the accumulation of withdrawal and repeats (Adelman, 2005). The final variable associated with transfer was "attendance in more than one state"—an unexpected finding Adelman suggested warrants further investigation. Like Adelman, Moore, Shulock, and Offenstein (2009) found that summer credits, continuous enrollment, and a low proportion of course withdrawals or course failures were positively associated with completion. In addition, they found that the number of credits earned during the first year also showed a positive, linear relationship with completion. Late course registrations, conversely, were negatively associated with completion rates.

Variables not directly associated with transfer included SES, ethnicity, and other student demographics (Adelman, 2005). However, the group of students Adelman identified as most likely to transfer and earn a Bachelor's degree was also disproportionately white, among the highest SES quintiles, and less likely to be first-generation postsecondary. Characteristics of the most successful group were as follows: they successfully completed 30 or more units, but less than 60% of those units were completed at community colleges, 77% earned a bachelor's degree, 43% completed college-level mathematics in their first year, and 84% were white. By contrast of students who earned fewer than 30 units at community colleges, just 5% earned a bachelor's degree, 7% had completed college-level mathematics in their first year, and 66% were white. To provide a fuller demographic picture, of the group of students more likely to transfer, 4% were African American, 7% Latino, and 5% were Asian; 29% were in the highest SES quintile; and 16% were first-generation postsecondary. Of the less successful group, 12% were African American, 24% Latino, and 5% Asian; 12% were in the highest SES quintile; and 31% were first-generation.

In a subsequent report, Adelman (2006) investigated the trajectories of all traditional-aged postsecondary students who attended a four-year institution at any time, thus may or may not have started their postsecondary studies at a community college. In this study he again makes the case that high school "curriculum counts," especially for African American and Latino students. "Differential lack of opportunity-to-learn was a major theme in the original *Tool Box* and is just as prominent a theme in this study of a cohort a decade later (p. 31)." African American and Latino students were less likely than white students to attend high schools which offered calculus, for example; the respective percentages were 51%, 45%, and 59%.

Adelman's reports (2005, 2006) focused on traditional-aged students using the National Education Longitudinal Study of 1988, which followed 25,000 U.S. eighth-graders through high school and was supplemented by postsecondary transcripts, as his primary data source. This represents a significant portion of the postsecondary student body, but certainly not all. Adelman (2005) reported that 58% of credit-enrolled community college students in 2001 were under 24 years old. In contrast, the study by

Moore, Shulock, and Offenstein (2009) included community college students of all ages. Again, these studies highlighted the importance of mathematics in the trajectories of community college students.

As a discipline, mathematics acts as a uniquely problematic gatekeeper in other ways as well. Skills in English, reading, and composition are critical to students' success in college. Underdeveloped skills in these English, reading, and composition contribute to students' lack of success in a range of college-level courses, for example psychology (Goldstein & Perin, 2008; Spurling, 2007). In comparison, many students placed into developmental mathematics either are not interested in math-intensive fields or are discouraged by their placement from pursuing math-intensive fields. They may not require mathematics skills for the majority of their coursework. These students may perform well in other academic areas, but the difficulty in completing college-level mathematics requirements can—by itself—obstruct transfer.

The Climb to College-Level Math

While completing college-level mathematics in the first year might be highly advantageous for a transfer-trajectory, many students entering community colleges cannot currently hope to achieve this feat. Approximately 44% of traditional-aged community college students left high school having completed a mathematics class prior to Algebra 2 (Adelman, 2005). Similarly, a survey of California community colleges showed that 47% of students entered at two or more levels below college-level mathematics (Center for Student Success [CSS], 2005). NCES (2003) reported that in the U.S., public two-year institutions on average offer 3.4 remedial mathematics courses.

Approximately one-third of students who enter community colleges with developmental mathematics needs advance to college-level mathematics (Bailey, Jeong, & Cho, 2009; Roksa, Jenkins, Jaggars, Zeidenberg, & Cho, 2009). For this one-third, mathematics remediation can be described as successful: students who complete remedial sequences tend to complete college-level coursework and persist to degree completion. In two statewide studies, researchers found that students who complete developmental mathematics sequences subsequently complete college-level mathematics coursework at rates similar to their more prepared peers who place directly into college-level mathematics upon matriculation (Bahr, 2008; Roksa, Jenkins, Jaggars, Zeidenberg, & Cho, 2009). Bahr's study examined the entire California community college system, while Roksa, Jenkins, Jaggars, Zeidenberg, and Cho investigated community colleges throughout Virginia. It might be considered encouraging that some developmental mathematics students—those who were successful—were able to reach parity with students who entered placing higher in math. However, in addition to the low proportion of students to whom this applied (one-third), neither study investigated ethnicity or other demographic variables to determine whether this success was experienced equally across various groups. Instead, the studies controlled for ethnicity and other demographic variables.

In a smaller-scale study, students who completed elementary algebra scored less than one-half point lower on the assessment test than students placing directly into intermediate algebra (Parmer & Cutler, 2007). Although smaller in scope, the study shows how detailed analysis can isolate particular areas for colleges to focus on, which in this case were absolute value, simplification, solving linear equations, involving fractions, and calculating percents. In these specific areas, elementary algebra completers scored ten percentage points lower. The study also shows how local perceptions may differ from statewide or national views due to temporal or institutional variation. The study was comprised of modest-sized samples *(*the *n* varied for each aspect of the study, ranging from 641 to 1,028) and was not longitudinal (only one instructional quarter was investigated).

Three other state-wide studies took a different approach to assessing the effectiveness of remediation by examining students at the margins of remedial placement--and found conflicting results. By examining similar students per ACT and SAT scores with different placements per local college policy, Bettinger and Long (2009) found public postsecondary students in Ohio who took remedial courses achieved better retention and degree completion rates. Specifically, they found that students placed into developmental mathematics were 15% more likely to transfer. Similar studies using quasi-experimental regression discontinuity analyses in Florida and Texas did not replicate the findings of the Ohio study. Martorell and McFarlin's unpublished study of the Texas system (as cited in Bailey, Jeong, & Cho, 2009; Calcagno & Long, 2008) concluded that students were neither helped nor harmed by remediation. Calcagno and Long (2008) found that remediation might promote early persistence, but only slightly. Furthermore, remediation was not associated with improved degree completion rates or improved transfer rates.

Looking at students "at the margins" of placement constitutes both a strength and a limitation of these three studies. The study designs approach a level of causality which is rare in educational research. However, the majority of students with developmental placements are not contained within the analyses, given that in all three cases only "marginal" students were included. Affects of remediation on students placing further down the developmental sequences cannot be assumed to be similar. Some other limitations are worth noting, particularly with the Ohio study since it found the most positive results. The Ohio study focused on full-time, traditional-aged students, raising additional questions of generalizability. Moreover, as with the other state-wide studies, ethnicity and other demographic variables are used as controls rather than explored for potential direct or indirect effects.

The most recent sequence studies have focused on the large proportion of students who never attempt mathematics after receiving a developmental placement, or who fail to complete the mathematics sequence even after having successfully completed all the mathematics coursework they attempted. Bailey, Jeong, and Cho (2009) in their study of Achieving the Dream schools found that 27% of students never enrolled in developmental mathematics after having been referred and 11% never failed a mathematics course yet did not complete the sequence. Taken together, this 38% is substantially higher than the 29% who failed at least one mathematics course and did not complete the sequence. It is also higher than the 33% of students who successfully completed the developmental sequence and reached transfer level. See also Roksa, Jenkins, Jaggars, Zeidenberg, and Cho (2009).

To summarize, many students who enter community colleges cannot complete the required developmental mathematics courses within the first year, a feat which is characteristic of the most successful community college students. Students who complete developmental mathematics sequences appear to do well in gateway courses. However, only one-third of students placed into developmental mathematics complete the sequence. Many students assessed into remedial levels never enroll in math, and a sizable percentage of students fail to complete the sequence despite being successful in all the mathematics courses they attempt.

Studies of Special Populations and Developmental Mathematics

Several of the foregoing studies selected for traditional-aged students (Adelman, 2005, 2006; Bettinger & Long, 2009) or otherwise controlled for age (Bahr, 2008; Calcagno & Long, 2008; Roksa, Jenkins, Jaggars, Zeidenberg, & Cho, 2009). Adelman cautioned that age is a critical variable for community colleges and should either be controlled for or investigated. To dramatize his point, he described traditional-age students and older students as coming “from different planets” (2005, p. 12). Partially in response to Adelman, a study of the Florida community college system investigated student success in terms of degree or certification completion by age (Calcagno, Crosta, Bailey, & Jenkins, 2007). They noted that lower completion rates of adults, defined as students between the ages of 25 and 64, have "been accepted as more or less conventional wisdom" but not explained (p. 218). Taking a simple view, Calcagno, Crosta, Bailey, and Jenkins found that 30% of younger students, compared to 19% of older students, achieve a degree or certificate within 17 terms. Using hazard models, however, older students were shown to be *more likely* to complete a degree (1.24 times as likely) after controlling for mathematics placement. Mathematics placement scores for older students averaged 328 compared to 415 for younger students on a scale of 200 to 800.

Investigation of the impact of community college remediation on Latino students is particularly important for two reasons: Latinos are increasing as a proportion of the U.S. population and, along with American Indian 12th graders, Latinos are much more likely to enroll at a community college. Nationally, roughly 55% of Latino students and 58% of American Indian students begin their postsecondary experience at a community college, compared to roughly 38% for white students, 39% African American students, and 37% Asian students (Adelman, 2005). Perhaps counter to common assumptions, these enrollment proportions by ethnic group have remained highly stable between 1972, 1982, and 1992.

A recent study focused on the factors affecting Latino students' community college success, defined as persistence, degree completion or transfer. Using the national Beginning Postsecondary Students dataset, Crisp and Nora (2010) found results similar to those of Calcagno and Long (2008): remediation was associated with near-term persistence. As with Adelman (2005), their analysis also showed a significant association between high school mathematics level and success in years two and three. Conversely, high school GPA was not associated with student success.

Given the importance of equity issues to the field and the limited number of published research articles empirically addressing equity in developmental sequences at community colleges, a few small studies warrant mention despite marked methodological shortcomings. These studies are characterized by small, locally-situated convenience samples and a relatively limited array of variables, both independent and dependent. Dozier (2001), for example, compared the academic records of documented and undocumented international students enrolled at an urban community college in New York during spring 1999 (n = 294 and 246, respectively) and found that more undocumented students were identified as requiring developmental mathematics (64%), compared to documented students (39%). A two-semester study of intermediate algebra enrollees (n = 1,318) at a Texas community college (Fike & Fike, 2007) found statistically significant differences in end of course grades, $F(2, 930) = 4.929$, $p = .007$. White students who comprised 66% of the sample had higher ending grades ($M = 2.20$, $SD = 1.423$) when compared to Latino students who comprised 25% of the sample ($M = 1.90$, $SD = 1.504$). Gender and faculty education level (graduate degree or no graduate degree) were also found to be significant, but the full-time or part-time status of the faculty member was not significant.

Overall, the community college literature on equity issues within developmental mathematics is limited. Some studies have identified differences in success measures by age, gender, or ethnicity. These studies are generally simplistic and do not include socio-economic and academic history variables.

Improving Mathematics Success Rates in Community Colleges

Use of technology.

The use of electronic interventions and approaches is a theme in the literature. Ancillary technological interventions are arguably more readily brought to scale than interventions which fundamentally change instructional practices. One study documented lower success rates of beginning algebra students enrolled in hybrid and distance learning sections of the course, compared to lecture sections (Zavarella & Ignash, 2009). Students were less likely to withdraw from the lecture sections: 20% withdrew from lecture courses versus 42% for hybrid and 33% for distance learning.

LaManque (2009) investigated the impact of computerized software. LaManque's sample was not randomized, but he makes the case that student self-selection probably was not a factor since students were unaware of the intervention prior to enrolling. Success rates in sections where the computerized software was used were significantly higher – 71%-75% for EnableMathematics sections compared to 55%-58% for the control sections (using Chi-Square, level of significance not reported). While potentially promising, LaManque reports local skepticism regarding these findings. Instructors were not randomly chosen; moreover, instructors were required to revise their lesson plans to accommodate the software. Also, in some cases success in subsequent courses was lower for the students who used the computerized software, drawing into further question the legitimacy of the higher initial success rates. One hypothesis was that the software allowed more “marginal” students to succeed in the initial course but the effects did not promote sustained success in subsequent coursework.

The use of technology as a form of delivering instruction or structuring in-class homework sessions can be distinguished from the inclusion of technological tools used specifically within math-related fields. The use of graphing calculators, for example, figures prominently in the MAA and AMATYC discussions. A study of one community college using graphing calculators in beginning algebra suggested that course success rates could be improved substantially (Martin, 2008). During each of the two semesters in which the calculators were used, students earning a B or better increased by ten percentage points. Grades of C or better increased between five and 12 percentage points.

Despite the interest in technology as evidenced by the 2009 AMATYC conference proceedings where 30 out of 147 sessions focused on some form of technology—by far the most popular theme—the robustness of the community college literature is again limited. Therefore, to augment the findings discussed above, a report is included which was prepared for the U.S. Department of Education. The Office of Vocational and Adult Education (2005) report summarized 15 studies investigating efforts to improve outcomes for developmental mathematics, of which nine focused on technological interventions. These studies were drawn from four-year and military settings, as well as conference proceedings; the latter included community colleges. The researchers concluded that the use of technology, relative to traditional instructional formats, "resulted in higher, lower, or no difference in pass rate, no difference or higher rates of persistence to higher-level math, and no difference in final grades" (p. 33). The largest improvement identified appears to have been a 12% improvement in successful grades in elementary algebra due to the supplemental use of technology via Computer-Assisted Instruction (CAI).

Supplemental instruction and tutoring.

Two popular interventions used by community colleges in efforts to improve success rates in developmental courses are peer tutoring and supplemental instruction (SI). SI is defined as "a form of peer learning which targets high-risk courses" rather than at-risk students (Phelps and Evans, 2006, p. 22; Zaritsky & Toce, 2006). Despite widespread use, according to ProQuest searches, only one published study to date has focused on SI for developmental mathematics at a community college, and one study on tutoring more generally. Phelps and Evans used an experimental design at Valencia, a community college in Florida to examine the effects of SI. Results were mixed. Found through EBSCO, Zaritsky and Toce (2006) also investigated SI for "high risk courses" at a community college. Targeted courses were not disaggregated, so the effect of SI on mathematics specifically is unknown, but the researchers reported an average increase in 1.24 letter grades over several semesters (spring 1993 through spring 2005). Longer-term affects were not investigated.

Although typically less structured than SI, tutoring also uses a peer learning approach. In their overview of “30 years of research” about remediation, Boylan and Saxon (1999) noted that the impact of tutoring for students in developmental courses has been widely debated. They suggest that the impact of tutoring depends primarily upon having a well-trained tutor. The study identified via ProQuest which focused on math-related tutoring at a community college found that tutoring increased GPA for students who placed into remedial mathematics by .38 points on average after controlling for ethnicity, gender, and course placement (Kostecki & Bers, 2008). Flaws in this study, however, include the fact that the study did not control for whether the student actually enrolled in a developmental mathematics class; moreover, as the researchers explained, at the community college where the study was conducted, grades were not given for developmental mathematics classes. Thus, it is unknown for which courses GPA increased.

For the SI studies as well as the tutoring study, student motivation was not controlled for, which leaves any positive findings open to an important counter-hypothesis: students who are more motivated may simply tend to perform better regardless of tutoring or SI. Perhaps in part because interventions such as tutoring, SI, and computerized software have not been found to both regularly and definitively improve student success rates in developmental math, several researchers have turned to structural considerations. These approaches will be discussed next.

Structural changes to the sequence.

Researchers point out that very few students (roughly 5% - 20%) who enroll in algebra need or intend to eventually enroll in calculus (Dunbar, 2006; Herriott & Dunbar, 2009; McGowen, 2006). These researchers suggest that algebra-related content and course sequences should be examined for relevance, and then the content should be adjusted to fit the needs of students and the disciplines in which they intend to major. Thereby, educators hope to promote greater student success in math.

One approach to structural change is “acceleration.” The term “acceleration” is borrowed from the K-12 (Bailey, Jeong, & Cho, 2009) and can be juxtaposed with community college notions of “intensification” (Asera, Navarro, Hern, Klein, & Snell, 2009). Intensification entails additional time on task during a prescribed timeframe. Intensification can be accomplished in a variety of ways including through paired coursework (as in learning communities or paired workshop courses), optional or required tutoring sessions (as in SI), or the use of technology. In terms of technology, for example, one rationale for the program LaManque studied was that the software would “assist” students with their homework; some faculty felt students were not spending enough time working on mathematics problems on their own. Intensification can be effective for some students, but it often requires substantial additional institutional resources and by definition requires more students’ time.

As with intensification, acceleration takes various forms. Biswas (2007) described several approaches being used by community colleges participating in the Achieving the Dream initiative, including mathematics classes which are modular and self-paced so students need to repeat only the portion which they had failed. Although the ProQuest search found no empirical studies of self-paced instruction for developmental mathematics at community colleges, Ironsmith, Marva, Harju, and Eppler (2003) examined self-paced instruction for remedial mathematics compared to lecture mathematics at a large university (n = 272). They found no significant mean main effect by class format for final course grade. Rather, they found that goal orientation (learning goal versus performance goal) was significantly associated with performance. The Office of Vocational and Adult Education (2005) report also cited several studies with the same finding: no difference in outcome by course format. None of these self-paced approaches were described as modular.

The effectiveness of self-paced instruction for mathematics may depend on the type of students enrolled. According to some researchers, accelerated approaches may be particularly appropriate for adults who need mathematics remediation (Calcagno, Crosta, Bailey, & Jenkins, 2007; Wlodkowski & Kasworm, 2003). Wlodkowski (2003) identified acceleration as a growing area of interest and indicated that 25% or more of adult, postsecondary students were projected to be enrolled in accelerated programs within ten years. However, Wlodkowski and Kasworm (2003) warned that there may be less “margin for error” in accelerated programs.

Another form of accelerated mathematics which Biswas described is a short, “refresher” course provided to students near a cut score on the placement exam. The success of these particular implementations has not yet been determined—only very preliminary data was available for some of the colleges. In an updated report, Zachry (2008) indicated preliminary, promising results for a “Fast Track Math” program utilizing a refresher approach. The sample receiving the intervention, however, was extremely small (n = 10).

A third approach to acceleration is to structurally change the course sequence rather than accelerate particular courses (Asera, Navarro, Hern, Klein, & Snell, 2009). Mathematics leaders such as Steen (2004), past president of the Mathematics Association of America, agree and urge colleges to focus on addressing students' quantitative literacy needs, possibly through the use of statistics courses and other courses which focus more on contextual learning and applied use (see also Ganter, 2006). Initial results from an accelerated, statistics-oriented sequence suggested a shortened approach may be possible, at least for some students (Snell, 2009).

Contextual learning approaches.

Approaches such as the aforementioned statistics-oriented sequence beg the question of contextualization. Contextualized instruction relates subject content—in this case mathematics content—to authentic, real-world situations (CSS, 2009). Contextualized learning is a growing area of interest at community colleges (CSS, 2009; Grubb, 2001; Office of Vocational and Adult Education, 2005). The CSS report identified the following learning theories as closely related to contextualization:

motivation theory, problem-centered learning, social learning, and learning styles.

Current theories of cognition support the importance of a meaning-centered approach to instruction rather than an exclusive focus on memorization and procedures (Bransford, Brown, & Cocking, 2000). Factual knowledge is important, but for competence to emerge these facts must cohere into a deeper conceptual understanding. By definition contextual learning is meaning-centered; however, researchers caution not to overlook concerns about students' ability to abstract and transfer knowledge. Retrieval and application of information learned in only one context may be limited to that context. Such knowledge is referred to as "overly contextualized" (p. 62). Use of multiple cases, "what-if" problem solving, and tasks which require generalization or abstraction were shown to increase flexible application and knowledge transfer. Metacognition, as emphasized in active learning environments, also has been shown to improve transfer.

Over time, contextual approaches, formerly referred to as "applied learning," became associated with low expectations (Bond, 2004). Applied learning can be taught in didactic, discrete skills-focused ways which are not learner-centered or engaging (Grubb, 2001). The current resurgence of interest in contextualization seeks to counter these negative associations by using learner-centered approaches and by coupling applied learning with deep conceptual and academic understanding (Bond, 2004; CSS, 2009). Thus, the preferred terms contextualization and cognitive apprenticeship reflect more current conceptions of teaching foundational content through applied relevance.

The pointed emphasis on contextualization may not be as prevalent in K-12 systems as in community colleges. Students enrolled in community colleges often major in a discipline, arguably making practical applications within that field a natural focus of students' interest, as well as a site of meaning. Moreover, the emphasis on contextualization within community college instruction is codified into law. The Carl D. Perkins Career and Technical Education Act (Perkins Act) requires that community colleges integrate academic and vocational education for improved student performance and outcomes (CSS, 2009). This emphasis was reinforced when the Perkins Act was renewed in 2006.

At first glance, contextualization may seem most appropriate for students enrolled in career technical education (CTE) courses, formerly referred to as "vocational." Indeed contextualized mathematics at community colleges was found to include a range of disciplines, including many vocationally-oriented programs (Grubb, 2001). Not coincidentally, mathematics departments have become concerned that they are not serving the present-day needs of other disciplines "where a deep level of conceptual understanding…is deemed more valuable than a very high level of facility in manipulating symbols" (Gordon, 2006, p. 276). Departments such as biology and business often create their own mathematics courses. A community college in Hawaii, for example, intent on diversifying the ethnic profile of students admitted into its nursing program created an elementary algebra course with context-relevant mathematics problems as part of a large pre-entry, preparation program (Noone, Carmichael, Carmichael, & Chiba, 2007). The implementation was still being piloted at the time of the study, with some initial positive results reported in terms of retention and success rates for the pre-entry curriculum as a whole.

Contextualization is not only appropriate for technical education courses. Some believe contextualization may become a preferred approach to teaching developmental concepts more generally, including developmental mathematics (CSS, 2009; Grubb, 2001; Office of Vocational and Adult Education, 2005). Developmental education is often seen as instrumental rather than valuable in its own right (Grubb, 2001). As a result, developmental content may be taught in ways that are not perceived as relevant or engaging. Contextualization may help to address these issues. For example, learning communities allow instructors to tailor mathematics concepts to the paired course. By some accounts, learning communities have resulted in longer persistence and in higher grades (Grubb, 2001).

In addition to enhancing student engagement and perceptions of relevance, there is recognized need for students to learn to apply mathematics concepts, particularly those related to quantitative literacy (Bransford, Brown, & Cocking, 2000; Ganter, 2006; Steen, 2004). Unfortunately, students are often unable to apply mathematical procedures in real-world contexts. In a study of university students, for example, Gordon (2001) found that absent explicit emphasis on practical understanding, students in traditionally-taught courses were, for the most part, unable to explain the concept of slope even though they were able to procedurally calculate it. Only a third were able to provide an adequate “plain English” description. The aforementioned accelerated, statistics-oriented sequence could encourage the development of real-world, quantitative literacy skills

Cultural relevance, social justice, and statistics.

Contextualization through statistics represents one avenue for making course material relevant to students; cultural relevance represents another; and, of course, the two approaches are not mutually exclusive. The scant literature on mathematics acquisition through cultural relevance provides some cautionary suggestions. Earlier studies on cultural relevance in mathematics focused on assessing increased student engagement through a social justice pedagogy, noting learning gains assumed to be concomitant (Gutstein, 2003; Noguera, 2001). Enyedy and Mukhopadhyay (2007) attempted to more precisely determine the relationship between the culturally relevant material and the degree of learning.

Using a mixed methods approach, Enyedy and Mukhopadhyay analyzed a “Community Mapping Project” designed to encourage urban high school students to “recognize how mathematics is relevant to their lives and their communities” (p.140). The summer project was targeted to working class students, primarily students of color, about to begin their senior year of high school and who were interested in attending college. The project utilized computerized mapping as a means for students to examine statistics relevant to their geographic communities. The researchers quantitatively analyzed students’ use of statistics to substantiate claims, and they qualitatively explored classroom discussions to ascertain students' beliefs about "what counts as adequate evidence" (p. 140).

The researchers found tensions between culturally relevant pedagogy and mathematics pedagogy. Often students approached inquiry assuming they already knew the truth, which led students to focus on finding supporting evidence for their claim; however, the academic goals and norms of statistics require skepticism. These conflicting norms created a tension surrounding "the project's overarching goal of advocating for a position" (p. 168). Within classroom discussions, students valued their learned experiences and observations over mathematically-constructed evidence. The researchers concluded, "As a result we saw conceptual growth around the statistical ideas they needed and hence talked about, but that growth had a ceiling" (p.168). Enyedy and Mukhopadhyay note in the study's discussion section that "cultural relevance" has multiple interpretations including the familiarity of the context of the material (i.e. content), the motivational value or application value of the material (i.e. purpose), and the familiarity of participation structures (i.e. norms). They contended that the project addressed only the first two without addressing the third component.

Unfortunately, no other studies were located which assessed the use of statistics and cultural relevance or social justice in mathematics instruction for college-level or nearly college-level students.

Learning Implications of Growth Mindset / Incrementalism

Growth mindset, as it is popularly known through nonacademic publications by

Dweck, draws from a body of research on Theories of Intelligence (TOIs; Dweck & Sorich, 1999). Nonacademic publications use the terminology "growth mindset" and "fixed mindset" to refer respectively to an incrementalist TOI (i.e. intelligence changes with effort) and an entity TOI (i.e. intelligence is innate and therefore fixed). Dweck's TOI framework has several implications for learning. The research in this area is extensive; therefore this section of the literature review was constrained to more recent exemplars, preferentially selecting for those pertaining to mathematics. In addition, studies which question or qualify Dweck's findings are also presented.

Research has shown that teaching students to believe that intelligence is malleable (i.e. not fixed) significantly improves their educational outcomes in mathematics. A study of 7th grade students examined mathematics achievement during this crucial transition period (Blackwell, Trzesniewski, & Dweck, 2007). Students with an incremental TOI expressed positive beliefs about the role of effort, were more likely to hold learning goals, and expressed less helplessness. Over four semesters, these students out-performed their entity-endorsing classmates in terms of mathematics grades. In a manipulation check, the study was conducted a second time, and an intervention was introduced whereby students were taught about TOI and implicitly encouraged to change their TOI orientation. For students whose TOI changed from entity to incrementalist, their mathematic grades improved. Students endorsing entity views evidenced declining mathematics grades.

In several studies, students with an incrementalist TOI have been shown to be more learning-focused (e.g., Mangels, Butterfield, Lamb, Good, & Dweck, 2006). In contrast, students holding predominately entity beliefs were shown to be more performance-oriented. In a social cognitive neuroscience model, college students with strong entity beliefs processed information differently than peers with incrementalist beliefs (Mangels, Butterfield, Lamb, Good, & Dweck, 2006). Students with entity TOIs had less sustained memory when corrections were provided. Perhaps as a result, their error correction was proportionally lower than incrementalist peers. The researchers assert this implies that incremental theorists may rebound better from occasional, error-related failures. Other recent research with college students has similarly shown that learning-focused students were more willing to take advantage of opportunities to remediate, compared to students with incrementalist beliefs who were more likely to defensively disengage and thereby forego the learning opportunity (Nussbaum & Dweck, 2008).

The TOI framework has also been used to address stereotype threat experienced by members of marginalized populations. According to Dweck (2006), a belief in incrementalism allows students to remain engaged with challenging material despite experiencing stereotype threat. Dweck theorized this as a shift from feeling judged to focusing on a learning orientation.

A recent study by Niiya, Brook and Crocker (2010) sought to qualify the findings by Dweck et al. Their study posed the question of what occurs when college students face increasingly complex academic tasks, and some students experience sustained or pointed failure despite high effort. Their research underscores context-dependence, as well as revealing a "magnifying" influence associated with contingent self-worth. The researchers found, for example, that entity theorists self-handicapped by listening to detracting music on both easy and difficult tasks, but incremental theorists were marginally (but statistically significantly) more likely to self-handicap on difficult tasks. However, incremental theorists who scored high on the Contingencies of Self-Worth Scale were the most likely of all groups to self-handicap in the difficult task condition. The researchers further investigated effort and found that highly contingent incremental theorists reduced effort when initial tasks suggested high task difficulty and potential failure. The researchers assert that "motivation is fragile" and suggest confidence in succeeding may mediate effort, even under the conditions of incremental beliefs (p. 294).

Another recent, longitudinal study evaluated the implication of TOIs for students enrolled in challenging college-level STEM subject-matter at an urban college (Cromley, Tanaka, Horvat, & Michel, 2010; Cromley, Tanaka, Horvat, & Michel, 2011). A majority of students in the study (60%) belonged to underrepresented ethnic groups. In examining dropouts after 18 months, the researchers found cognition (prior knowledge) and anxiety were strongly associated (large and significant differences) with whether students dropped out. However, TOIs, stereotype threat, and epistemological beliefs were not significant or appeared to have marginal impact on student retention after 18 months. This contradicted an earlier finding which suggested that incremental beliefs in chemistry (but not in biology) were associated with student retention through the first semester.

Qualitative analysis showed that instructors' implementation of pedagogical reforms at this urban college had limited scope and depth. Instructors "spoke about reforms in terms of relevance and interest [but] students emphasized their concerns about the pace, high expectations for independent learning, and the mismatch between the lecture and exams" (p. 7). The researcher included only selective student quotes. One quote highlighted how the pace undermined learning for understanding. Another said, "I just, I don't feel like I'm being taught. I feel like I'm being talked to and then I have to teach myself" (p. 8).

To summarize, TOI research has implications for college students engaged in studying challenging material. The implications are as follows:

- incrementalist beliefs about intelligence are associated with higher mathematics grades,
- entity beliefs can be altered and students can be induced to hold incrementalist beliefs which positively improve their mathematics performance,
- incrementalist beliefs are associated with learning goals, compared to entity beliefs which are associated with performance goals,
- students who hold incrementalist beliefs appear to process corrective information differently—this may be associated with their higher error-correction rate in subsequent performance,

- incrementalism may moderate the effects of stereotype threat, however,
- incrementalism alone is insufficient to guarantee student performance.

Regarding the last point, task difficulty and contingent self-worth both have implications for student performance, even amongst those students who believe that effort results in learning. Moreover, a recent study of students enrolled in college-level biology and chemistry suggest that TOIs do not always directly influence student retention in difficult courses.

Conclusions and Needed Research

Students entering community colleges are under-prepared in mathematics compared to four-year college and university entrants. Many students must successfully complete several mathematics courses before reaching transfer-level math. These “rungs” on the mathematics ladder substantially impact transfer rates. According to national research, each increase in high school mathematics level resulted in a 22.7% increased likelihood that community college students would transfer to a four-year institution (Adelman, 2005). Students’ placement on the community college mathematics ladder depends upon high school mathematics curricula--and high school mathematics curricula is associated with ethnicity (Adelman, 2006). For example, African American and Latino students are less likely than white students to attend high schools which offered calculus.

Remediation appears to work—particularly for those students who complete the mathematics sequence at their college. By many accounts, however, only one-third of students complete all the necessary mathematics courses. The failure of the majority of developmentally-placed students to complete their mathematics sequence results from a number of factors. Success rates for developmental mathematics courses are typically the lowest of any courses at community colleges. Moreover, recent research shows that many students (roughly one-third) never even attempt developmental math, perhaps discouraged by the length of the mathematics sequence. Further, even students previously successful in a developmental mathematics course do not always persist to the next course in the sequence.

The often unstated underlying logic behind extending mathematics sequences appears to be related to the concept of ability-grouping, with the assumption that more students will be successful if skills-focused instruction can be narrowly targeted. A related assumption is that ability-grouped students, having been more successful as a result of the targeted instruction, will be more likely to persist in the sequence. While it is true that successful students are more likely to persist than unsuccessful students, it is also becoming apparent that further extending mathematics sequences is not likely to result in more students achieving transfer-level math.

Lessons from K-12 may be particularly instructive for community colleges seeking to improve mathematics remediation rates by reducing remedial mathematics sequence length. Reform-minded K-12 educators have been moving away from ability-grouping. Studies have found that de-tracking efforts, which increase classroom heterogeneity, can improve overall performance levels when coupled with a variety of student-centered instructional approaches (Boaler, 2008; Boaler & Staples, 2008; Burris, Heubert, & Levin, 2006). Also, tracking has been shown to disadvantage underrepresented ethnic groups. Thus, an important rationale for de-tracking in K-12 is the provision of engaging curricula for all students.

Community colleges currently employ a variety of broadly-available, traditional interventions in order to improve mathematics success rates, including peer tutoring, supplemental instruction, and the use of technology. The limited research on these interventions in community college developmental courses and sequences tends to be deeply flawed, with small samples from one college or district, often comparing only two or four semesters, with few controls applied. Yet it seems reasonable to assume, as a whole and based on the evidence to date, that these interventions offer marginal improvements at best. Comprehensive interventions such as learning communities may be more successful but are difficult at best to bring to scale.

Given the number of students affected, the depth of the mathematics remediation problem at community colleges, and the lack of proven interventions which consistently result in substantial improvements in course or sequence success rates, the increased interest in attempting to find structural remedies seem sensible. Self-paced instruction is being piloted at several community colleges; however, research-to-date does not support the notion that self-paced instruction is likely to significantly improve mathematics sequence success rates for all students. Some suggest that self-paced instruction may be more effective for adult learners over the age of 25. Similarly, accelerated refresher courses are likely to be effective for a limited student demographic. A different structural approach is to offer alternative mathematics pathways for students with mathematics content contextualized to their field of interest. Social justice pedagogy could be used to augment such an approach to further engage underrepresented students, but this pedagogy presents particular challenges when paired with statistics instruction. Finally, students' theories of intelligence may have implications for their willingness to engage with challenging mathematics material.

Implications for Research

At community colleges nationally, new interventions and structural modifications are being developed and piloted to remedy low mathematics sequence completion rates. These interventions and structural modifications need to be examined, both in terms of success rates and implications for pedagogy. Such research should be especially attentive to underrepresented students of color who have been the most disadvantaged by lengthy developmental mathematics sequences.

In particular, research is needed to investigate whether and how shortened and accelerated mathematics sequences can be successful in retaining students, as well as successful in supporting the learning of rigorous academic content. In addition, contextualization has been proposed as means of motivating community college students enrolled in developmental mathematics, but there is limited research on the effectiveness of such approaches. One possible accelerated mathematics pathway consists of teaching developmental mathematics and algebra concepts and procedures required as preparation for a college-level statistics course, rather than calculus. This contextualization may be appropriate for students who are not oriented toward math-intensive fields, but who need quantitative literacy skills. The scope of procedural knowledge can be curtailed to those skills needed for statistics, allowing for deeper learning of fewer concepts. Contextualized learning may be particularly attractive to community college students who tend to be pragmatic in their views of higher education.

Chapter Three: Methodology

A mixed methods, case study approach was used to analyze a local community college’s implementation of an open-entry, two-course mathematics sequence culminating in transfer-level statistics. The sequence, called StatMode (a pseudonym), reduces the number of courses students need to take in order satisfy the mathematics requirements for transfer to a four-year institution. At the time the study began, the sequence was a pilot; during the timeframe of the study it was approved by the department. Enrollment includes students who placed into the lowest level of mathematics that the college offers (i.e. arithmetic); as such, the sequence attempts to support all students, regardless of initial placement or mathematics eligibility, in reaching college-level statistics by the end of the second semester. In addition to being open-entry, this sequence traditionally is comprised of a high proportion of Latina/o students (roughly 80%) due to a cultivated relationship with the college’s Puente program, with roughly 70% indicating they are the first in their immediate family to go to college.

Given the then-pilot nature of StatMode, the small number of participants, and the inclusion of a single instructor in the study, a quan → QUAL explanatory mixed-methods approach was selected. The primary quantitative research question posed by this study was whether underprepared students from underrepresented groups could successfully complete an accelerated mathematics sequence. Given the two semester sequence design and the demographics of the students enrolled in the sequence, this study was well positioned to respond to this question. A further strength of the study was the incorporation of results corresponding to a nationally-normed introductory statistics post-test. These quantitative results were used to confirm students' achievements in StatMode with regard to two specific introductory statistics domains: (a) data exploration and descriptive statistics, and (b) probability and inference.

Qualitative propositions were investigated to explain the quantitative findings. Through student interviews, triangulated with classroom observations and discussions with the course instructor, the researcher was able to ascertain and verify some aspects of this particular implementation of an accelerated mathematics sequence which seemed important to students. As with the quantitative data, qualitative data were examined for demographic differences in an effort to clarify potential transferability.

The remainder of this chapter describes the study design in greater detail and delineates each research question or proposition. The chapter also addresses standard areas such as the role of the researcher, ethics, and the treatment of data in terms of both collection and analysis. Due to the importance of questions about possible transferability and the emphasis on the qualitative analysis, the study context and participants are described in detail. The section describing participant selection outlines two groups of students which were followed through much of the qualitative analysis: (a) a younger, primarily first-generation Latina/o group, and (b) a smaller group composed primarily of African American women who were somewhat older than the young Latina/os.

Study Design

The mixed methods design utilized concurrent data collection; however, the data analysis followed an explanatory approach with an emphasis on the qualitative data. This type of explanatory approach, as described by Creswell and Plano Clark (2007), typically privileges the quantitative data (denoted by QUAN → qual). This case study, though, used a quan → QUAL analytic approach for the following reasons. The study focused on a new, pilot mathematics sequence with an instructor who is recognized within her field as highly effective and deeply invested in the pilot's success. In other words, the case for this study (i.e. the StatMode sequence) was selected because it is atypical. As Bodgan and Biklen (2008) caution, such selection limits the generalizability of the findings. More specifically for this case study, the strength of the study does not reside with the quantitative analysis due to severe generalizability limitations. In fact, the quantitative analysis was only necessary insofar as it showed whether such an approach is possible, i.e. whether it *can* be implemented effectively, not whether it is *likely to be* effective under typical conditions. Insight and potential for transferability emerged from the qualitative analysis.

Role of the Researcher

The researcher developed a working relationship with the StatMode instructor, beginning approximately one year prior to the commencement of the study. The researcher and instructor had several key acquaintances in common which facilitated the establishment of a working relationship. In addition, the relationship was facilitated by the fact that the researcher's coworker had published mathematics sequence completion findings several years ago which partially instigated and informed the instructor's local research leading to the creation of StatMode. As a result, it was clear to the instructor from the onset that the researcher is part of a research community which has an enduring interest in studying how student movement through mathematics might be improved. The researcher regularly apprised the instructor of study details. Continued trust between the researcher and the instructor was critical to the successful completion of the study.

The researcher maintained a reflective journal in order to track emerging understandings and in order to document preconceptions against which findings can be compared. Journal entries were either typed or audio-recorded after each data collection episode (student interviews and/or classroom observations) and after substantive conversations with the instructor. Pivotal changes in the researcher's observations were recorded. Equally importantly, and unexpectedly, the entries allowed the researcher to document triangulation (or disconfirmations) between her preliminary findings and the instructor's observations. This was unexpected as the degree of access to and rapport with the instructor was unanticipated. As such, the journal entries also provided a space for the researcher to regain more neutral intellectual territory. The enthusiasm of the students as well as the instructor regarding this pilot course sequence was palpable. Journal entries provided a conscious mechanism for the researcher to reflect on and examine personal biases. Critical colleagues, the faculty advisor, and dissertation committee members also assisted in reviewing the findings for credibility. In combination, these efforts allowed the data to be viewed more fully, from multiple angles.

Once data collection began, the researcher tracked interview data with an electronic cataloging system utilizing student pseudonyms. Dates and times for all interviews were recorded in the filenames. Classroom observations were logged using a standard observation format.

Research Objectives

Quantitative Hypotheses

Quantitative hypotheses focused on course completion measures, sequence persistence rates, and sequence completion rates, as well as test performance. The primary hypothesis was that a large majority of students in StatMode would be able to complete the initial course successfully and persist to the second, transfer-level course—compared to a minority of similar students nationally. A related hypothesis was that success rates will be proportionally reflective of the student composition in StatMode; that is, Latino and other underrepresented students would be as successful as their white peers. Due to the composition of the StatMode group, the research was unable to fully investigate this hypothesis; however, it was addressed to the extent possible. Quantitative analysis was used to investigate success rates for students entering StatMode with the lowest level of mathematics skills to those students who enter with higher level mathematics skills. Additional demographic variables of gender, age group, and Puente status were also examined for potential relationship to student success in the sequence

Quantitative analysis of items from the Comprehensive Assessment of Outcomes in a First Statistics course (CAOS) test was used to ascertain students' knowledge with regard to two specific introductory statistics domains: (a) data exploration and descriptive statistics, and (b) probability and inference. The hypothesis associated with CAOS items was that StatMode students would perform equal to their national peers on the post-test items. These results were examined by the aforementioned demographic variables.

A final quantitative data item derived from the use of the Adult Dispositional Hope Scale (ADHS). The scale is comprised of twelve statements total which students self-rated, including four statements regarding individual determination to meet goals (i.e. agency), four statements regarding individual ability to produce the means for attaining the goals (i.e. pathways), and four distracter statements. While initially presented in the quantitative section, this scale was used only with StatMode interviewees (a subset of the course). The primary use of the ADHS was to determine whether StatMode students may be atypical with regard to their hopefulness. The hypothesis was that StatMode students were not substantially different than their peers at other colleges regarding their sense of pathways and agency. While students' self-selection into StatMode cannot be fully accounted for, this analysis helps to investigate the potential impact of self-selection.

Qualitative Propositions

The qualitative data sought to explore, from the students' perspective, the reasons why StatMode might be effective. Collected primarily through individual student interviews, triangulated with classroom observations and discussions with the instructor, the qualitative data examined students' experiences in the pilot mathematics sequence. Data collection focused on the following:

- students' feelings and beliefs about mathematics and the nature of the mathematics concepts they are learning,
- perceived relevance of the content, including contextualization through statistics and cultural relevance, and
- shifts in students' sense of competency with regard to learning and using mathematics concepts.

Other aspects of StatMode were also investigated for conscious saliency to the students, including propositions that the following attributes contribute to students' willingness to persist through challenging mathematics material:

- caring relationships between the instructor and the students;

- early, encouraging feedback from the instructor; and
- peer support, particularly that derived from the learning community associated with Puente.

Finally, a potential criticism of StatMode was explored. This criticism reflects the conundrum that StatMode may be viewed as a tracking mechanism or a detracking mechanism, depending on one's perspective. StatMode can be viewed as a detracking effort, bringing developmentally-placed students rapidly into college-level content. Simultaneously, StatMode may track students away from mathematics-intensive and science-related majors. To better understand this issue, from the students' perspectives, students' statements about mathematics sequences were analyzed. The related qualitative proposition was that community college students would be inclined to view StatMode as a detracking mechanism.

Context

Martinez Community College (MCC) (pseudonym) is located in a suburban-commercial county that has been rapidly increasing in population density. Between 1990 and 2000, the population increased by 40% in the region where the college is located. The proportion of Asian and Latino residents has been increasing. Compared to the surrounding area, the city in which MCC is located has a low bachelor's degree level: 15% of adult residents had obtained a bachelor's degree or higher, compared to 38% immediate the county, and as high as 54% in neighboring counties. In addition, according to 2005 data, the college is situated next to one of the lowest performing high schools in the surrounding area. The proportion of underserved students was one rationale for selecting this site for the study.

The site was also selected because at the time this study began it was one of few colleges offering a two-course sequence to accelerate community college students to and through introductory, college-level statistics. Since the inception of the study, several colleges have begun employing similar accelerated statistics sequences—some collectively under the aegis of the Carnegie Foundation for the Advancement of Teaching and others through more localized approaches.

Another important aspect of the context was the situation of the StatMode pilot within the mathematics department. At the onset of the study, the sequence was a pilot. By the completion of the study, the sequence was voted by the department to be continued on a non-pilot basis. Students in the study were aware that this negotiation and discussion within the department was occurring. In order to gauge and control for the impact this had on students' perceptions of the sequence, a question was included in the study asking students directly about their experiences vis-à-vis being in a "pilot" class.

Finally, before revealing more about students' demographics in the next section, it is important to acknowledge that the instructor for StatMode was a white woman. At the time of this study, she was already a longtime mathematics instructor at MCC. She will be referred to by her pseudonym: Sylvia.

Student Demographics Pertaining to Quantitative Analysis

To better understand the study population, demographic interactions were investigated. Due to the small sample size ($N = 29$) and frequent occurrence of cells with zero cases, the Fisher's Exact Test was used rather than the Chi-Square Test for Independence. Also due to the small sample size, a higher *p*-value ($p < 0.1000$) was used for these significance tests--and all subsequent statistical significance tests throughout the study.

Just one interaction between the demographic variables was found to be significant: age group and Puente (Fisher's Exact test > 0.0000). All Puente students were under 18 or 19 years old. In comparison, only 25% of Non-Puente students were under 20. No other demographic crosstabulations even approached statistical significance.

The statistically significant relationship between age group and Puente status is particularly important to understanding rival hypotheses vis-à-vis the quantitative analysis. StatMode demographics were incorporated into the quantitative analysis and presented in Chapter Four. Due to the small sample, findings associated with Puente could not be subjected to age controls.

Participant Selection for Qualitative Analysis

In order to maximize the investigation of the broadest range of student experiences, no a priori sampling was used. All 29 students enrolled in StatMode were solicited for interviews. The instructor introduced the researcher to StatMode students during a normal class session. Due to the nature of the class, the instructor used the opportunity to briefly describe the dissertation process and study design to students. Students had already been introduced to the concept of designing studies. Students were informed that they would be solicited to participate on a voluntary basis. Volunteers placed their names on a sign-up sheet maintained by the instructor.

The face-to-face interviews occurred during three days in November 2010. Interviews took place during class time to minimize inconvenience and facilitate participation and ranged in length from 35 to 45 minutes. A private office was used to provide confidentiality. The interview dates were selected by the instructor in order to minimize any disruption of the class or the students' learning. The initial six interviews occurred on November 4. The subsequent five interviews occurred on November 16 and 18. Due to early saturation of emerging themes, the interviewees were limited to the initial 11 volunteers.

Eight of the students interviewed were Latina/o, of whom five were male and three identified as Latina. The other three interviewees identified as African American women, one of whom also indicated a bi-racial background. The ages and demographic backgrounds of these groups (Latina/o and African American) were relatively distinct, as will be described below. In addition, the representativeness of the interviewee selection will be discussed.

Interviewee Representativeness

The eleven interviewees were representative on all student demographics except gender. Interviewees did not differ significantly from their StatMode cohort with regard to ethnicity, age group, mathematics eligibility, or Puente status. The proportion of male students interviewed approached statistical significance (Fisher's Exact = 0.1081).

Although student performance in the sequence was not known at the time of interviewee selection, the instructor attempted to ensure that a range of students were included based on their performance to date. Indeed, per subsequent analysis, the interviewees did not differ significantly from their classmates on any of the course, sequence, or CAOS outcome variables.

Latina/o Group and Outlier

Of the eight Latina/o students interviewed, nearly all were still teenagers and in their first semester at MCC. Seven of the eight Latina/o students were 17, 18, or 19 years old. These same seven students had just matriculated into their first semester of college, except one of the seven who was in his second semester at MCC. All seven were enrolled in Puente. None had prior college experience (excluding in some cases concurrent enrollment as high school students).

Most of the Latina/o interviewees were first generation both in terms of U.S. citizenship and college education. None had a parent with a four-year college degree.

Four students had both parents with a high school diploma or less; the other four students indicated one parent with high school diploma or less, but the second parent had some college experience. Only one student indicated a parent who had achieved a college degree, which was from a community college. Regarding nationality, seven of the eight Latina/o students had parents who were educated outside the U.S., with Mexico the most commonly cited country. Four of the students indicated that both parents received their education in Mexico; other countries indicated were Belize, Nicaragua, and Peru.

One Latino student was a demographic outlier. Manny (pseudonym) was in his fifth semester at MCC. He was not enrolled in Puente. He was 25 years old. He was also the only Latina/o student who had both parents educated in the U.S., although neither parent had college experience. The self-selected pseudonyms of the other Latina/o students were as follows: Guss, Spaceman, Teavo, Davina, Jessie, Wolf, and Micky.

African American Group

When compared to most of the Latina/o students, the three African American women were older (ages 22, 32, and 35), had more previous college experience, and came from families with more formal education. Each of these students had one parent with a four-year degree, and in all cases, both parents educated in the U.S. All three had prior college experience themselves. In fact, all three had attended another college prior to enrolling at MCC. In addition, two were in their fifth semester at MCC. The youngest was only in her second college semester at MCC, but she had previously attended a four-year institution. Their self-selected pseudonyms for this study were Linda, SkyMarie, and Jackie. Figure 1 provides a summary reference regarding interviewee demographics.

#	Self-Selected Pseudonym	Age	Sex	Ethnicity (As Indicated by Student During Interview)	In Puente?	New* to College?	Parent(s) Educated in U.S.?**	Parent(s) College Degree?**
1	Guss	19	M	Latino/Hispanic	Yes	Yes		
2	Spaceman	18	M	Hispanic	Yes	Yes	Mother	Mother (CC)
3	Teavo	18	M	Latino	Yes	Yes		
4	SkyMarie	32	F	African American/ Caucasian	No	No	Both Parents	Father (4 yr)
5	Manny	25	M	Hispanic	No	No	Both Parents	
6	Davina	18	F	Latin	Yes	Yes	Mother	
7	Jackie	35	F	African American	No	No	Both Parents	Father (4 yr)
8	Jessie	18	F	Latina/Hispanic	Yes	Yes	Father	
9	Wolf	18	M	Latino	Yes	Yes		
10	Micky	18	M	Hispanic	Yes	Yes		
11	Linda	22	F	African American	No	No	Both Parents	Mother (4 yr)

Notes:

Light gray shading identifies African American students.

Darker shading with graduated fill effect identifies Latino outlier.

* New to College defined as first or second MCC semester, with no experience at another college.

** If neither parent, then blank.

Figure 1. Demographic overview of interviewees, ordered by interview.

Ethics and Protection of Human Subjects

The nature of the study required no deception of either students or the faculty member. Ethical considerations related to this study included risks to participants and to the instructor of the pilot. For participants, one potential risk was loss of privacy. This risk has been minimized by using pseudonyms and keeping all research data in a secure location. Each participant was assigned a pseudonym known only to the researcher. Academic records associated with this pseudonym were stripped of any personally identifiable information. For participants, there was also a psychological risk of discomfort during the interview process. Participants were informed that they could refuse to answer any question, stop the interview at any time, and withdraw from the study at any time.

The primary risk to the instructor continues to be the potential reflection of negative findings on her professional reputation. This serious risk largely results from the relative uniqueness of the pilot sequence. These concerns were mitigated by the instructor's own commitment to making data about the pilot public. Concerns were also mitigated by working closely with the instructor. Insights were shared with the instructor in order to triangulate findings but also in order to identify any potential differences in perspective which might need to be elaborated on in the analysis.

Data Collection and Instrumentation

This mixed methods case study utilized both quantitative and qualitative data.

Quantitative data were gathered by the instructor during regular instructional assessments. These data included standard course completion, sequence persistence, and sequence completion measures paired with de-identified demographic data. In addition, the instructor administered the Comprehensive Assessment of Outcomes in a first Statistics Course (CAOS) test as part of her regular instructional practice. Data were de-identified in accordance with IRB protocols prior to being made available for analysis. The nationally-normed CAOS exam is described in more detail in Chapter Four.

Qualitative data were gathered by the researcher primarily through semi-structured student interviews over a four week span during the fall 2010 semester. Interviews were augmented by and triangulated with classroom observations and discussions with the instructor. Interviews lasted roughly 40 minutes per student. Classroom observations lasted two to four hours each. Discussions with the instructor ranged from ten minutes to 90 minutes.

The qualitative interview instrument was initially developed by and used by the researcher with a previous group of ten developmental mathematics students engaged in an intensive mathematics program. Researcher-developed instrumentation was necessary because the StatMode pilot is unique and comprised of relatively novel components (e.g., acceleration). The instrument was modified for the current context. In addition, after the first day of interviews, two themes quickly emerged. To address these themes, two additional questions were added to the interview protocol and asked toward the end of the interview, if not already discussed. The ADHS was also deployed during the interview. This commonly available instrument has been described in more detail in Chapter Four.

Validity and Transferability

The qualitative data collection was limited by three factors in particular: the short timeframe of the collection, students' minimal exposure to the researcher, and the fact that the researcher differed demographically from the students. Regarding the first factor, logistically the short collection timeframe did not allow for techniques such as ongoing, modified analytic induction (Bogdan & Biklen, 2008). While some questions were added mid-collection, the timeframe did not allow for the in-depth analysis to occur between subject interviews in such a way that could inform more substantial modifications and refinements to the collection protocol. Regarding the second two factors, one clear distinction between the researcher and the students was ethnicity. The researcher is white and all the students interviewed were students of color. This coupled with the short data collection timeframe meant that some sensitive questions regarding race/ethnicity were only partially investigated since students could not be assumed to be forthcoming under the research conditions.

The qualitative data collection was potentially affected by another factor as well: students' knowledge about the pilot status of the program. This was both beneficial and potentially compromising. It was beneficial due to the fact that it made students keenly aware of the circumstances of the pilot and this made them more reflective than might otherwise be the case. It also meant that they saw themselves to some extent as advocates for the two-course sequence, possibly curtailing any negative comments. There was also a potential Hawthorne Effect from being in a pilot which was studied by this researcher, observed by other instructors, and, most pointedly, being evaluated within the college's own mathematics department. This was anticipated and questions were built into the interview protocol so that the potential impact could be investigated, i.e. students were asked directly about the experience of being in a pilot under scrutiny. Moreover, classroom observations were used to triangulate findings.

Three additional factors likely facilitated the richness of the qualitative data collection within the short timeframe of the study: students' relationship to their instructor, the instructor's vouching for the researcher, and the instructor's emphasis on students' metacognition within the instructional process. As the qualitative analysis shows, students expressed a certain gratitude toward and appreciation for the instructor. Since the researcher did not have sufficient time to develop rapport with the students, their respect for their instructor (who introduced them to the researcher) served to facilitate students' willingness to talk with the researcher. This also meant that students might be protective of the pilot due to loyalty to the instructor. This potential protectiveness was likely mitigated due to the nature of the class subject itself which emphasized analytical thinking and honest scrutiny. In addition, the instructor's general instructional approach encouraged students' willingness to be forthcoming. Moreover, questions were built into the interview protocol so that this potential impact could be investigated, i.e. negative perceptions were explicitly solicited, and classroom observations were used to triangulate findings.

Regarding the third facilitator of collecting rich qualitative within a short timeframe, the emphasis on metacognition was apparent as students discussed the instructional design. The researcher's prior experience conducting interviews with mathematics students in the initial design of the interview protocol was that students were often not especially articulate about the nuances of the learning experience; thus, many follow up questions were required to elicit well-rounded information. In contrast, StatMode interviewees were exceedingly forthcoming.

Threats to validity associated with mixed methods designs were minimized through the use of a single study population; in other words, the subjects for the qualitative and quantitative analyses were the same. Creswell and Plano Clark (2007) indicate this is particularly important for an explanatory mixed methods design. In addition, care has be taken, as urged by Collins, Onwuegbuzie, and Jiao (2007), to be mindful of issues pertaining to interpretive consistency between the quantitative and qualitative findings. As appropriate, negative case analysis, described by Caracelli and Greene (1993), was used to provide disconfirming evidence and to develop refinements in the researcher’s conceptual understanding.

Issues of generalizability and transferability remain pronounced due to the fact that the study focuses on a particular, self-selected cohort taught by a single, highly-invested instructor. Findings related to course content (e.g., statistics contextualization) and sequence acceleration are probably the most easily transferable. Structural changes to alternative mathematics sequences are not instructor-dependent. Any college could elect to create such a sequence and identify faculty to teach it. In addition, the proportion of students electing to enroll in statistics to complete their transfer requirements has been increasing—so student interest in shortened statistics sequences is likely to be high, making such a sequence viable institutionally. Results at other institutions might not be as positive as those presented in this study; however, for an open-entry model to improve upon the national figures for students reaching college-level mathematics, the completion rate for the pre-statistics course need only be higher than the 33% cited in the literature review. Note, this does presume that a substantial percentage of students could subsequently pass a transferable statistics course and perform competently.

In terms of student self-selection, the study design limits implications for overarching generalizability. There is no basis for claiming that *all* non-STEM students would benefit from this type of sequence restructuring. However, while the findings might not apply to all community college students, they likely apply to *some* students at all institutions. In other words, positive outcomes do not make a case for converting all non-STEM math pathways to a StatMode model. Instead, positive findings suggest that such an option should be provided.

To the extent that the data will allow, some suggestions have been made in the Chapter Seven regarding *which* students might be most likely to benefit from sequence restructuring. However, these implications are suggestive only since the study's findings were limited by the small sample size and general homogeneity of the sample. In this regard, the qualitative data were richer than the quantitative data and have implications for *how and why*, from the students' perspectives, an accelerated statistics sequence can be effective.

In terms of the instructional approach and classroom environment, any replication of this sequence would not, presumably, merely mimic the instructor's course design and instructional approach. Individual instructors must find ways to interact with students which are authentic to them and viable for them, and appropriate for their students. Affective characteristics of the instructor-student interactions and student-student interactions are likely to be the most difficult to genuinely replicate. Students' insights can be potentially instructive in this regard, suggesting what might be most important and why.

To promote transparency regarding students' voices, themes drawn from the qualitative data analysis were substantiated with multiple data points and detailed evidence. The intent was to ascertain not only what the instructor was doing but also how it impacted students. In addition, discrepant cases were often highlighted as counterpoints to provide further insight.

Data Analysis

Quantitative analyses were performed in SAS. The Fisher's Exact Test was used throughout instead of the Chi-Square Test for Independence due to the small sample size and frequent occurrence of cells with zero cases. Standard frequencies and percents were used to show the overall course success, sequence persistence, and sequence success rates. In addition, a categorical variable was created to examine the proportion of students who received a different letter grade in the second semester (i.e. "higher," "lower," or "same"). Letter grades were converted into mean GPAs and compared across groups using the Wilcoxon Rank-Sum Test. Note, *t*-Tests were not employed due to the small sample, large variances, and non-normal distribution. CAOS data were also analyzed using this approach. All data were subjected to tests to determine whether demographic variables appeared to be significantly associated with student outcomes.

Qualitative data were coded for themes, and then further summarized into broad categories (Bogdan & Biklen, 2008). Glossing was used to isolate and code emergent themes after the first day of interviews, and the interview protocol was amended as previously described. After all interviews were complete, the audio-recordings were transcribed professionally. To capture tone and allow greater authenticity, transcriptions were precise and included utterances such as “umm” and “yeah.” The accuracy of each transcription was verified by the researcher. Coding and theme analysis were conducted “by hand,” without the use of text-mining software, so the researcher could maintain close proximity to the nuances in the data collected. Apparent outliers were investigated further to ensure that key themes were not missed due to oversight or researcher bias.

Qualitative and quantitative data were mixed during several stages including question formulation, data collection and analysis. The final analysis incorporated triangulated quantitative data, transformed qualitative data, and qualitative quotes. The overall analysis emphasizes the qualitative findings including findings which appear to have the most explanatory power for the group overall, findings which distinguish between subgroups within the population, and findings which raise potent questions about students’ experiences.

Summary

A mixed-methods approach was employed due to the pilot nature of this curricular intervention. This design was drawn from a pragmatic research framework and focused on the urgent need to improve mathematics sequences for community college students. While there was not a sufficient sample size within the pilot for a full-scale quantitative study, the quantitative data were necessary to justify the importance of the qualitative findings. The qualitative analysis was vital to investigate the qualities within the StatMode sequence and instructional design which supported students’ success and achievement. Due to the unique context and to counterbalance subjectivity, a variety of both quantitative and qualitative data were gathered for corroboration and triangulation in order to present the most complete picture possible of this particular case.

Chapter Four: Quantitative Findings

As hypothesized, a large majority of StatMode students were able to complete the initial pre-statistics mathematics course successfully, persist to the transfer-level statistics course, and successfully complete transfer-level statistics. Of the initial cohort (N = 29) enrolled in the pre-statistics mathematics course, 93% (n = 27) completed the first semester with a grade of C or higher based on a 4.0 scale. All 27 persisted to the second semester statistics course, of whom 25 completed the statistics course with a grade of C or higher. Of the initial cohort of 29, the 25 completers represent an 86% completion rate for the two-course mathematics sequence overall.

Students from a range of incoming mathematics levels and diverse ethnicities successfully completed the full two-course sequence. Ten students entered at the lowest mathematics levels, i.e. eligible to enroll in arithmetic or pre algebra. Of these ten students, 80% (n = 8) completed both courses with a grade of C or higher. Of the initial cohort, nearly all students (n = 28) were students of color—primarily Latina/o and African American. The overall success percentage for students of color was 86% (n = 24). All 17 students concurrently enrolled in Puente successfully completed both semesters with a C or higher. Some differences in student outcomes were statistically significant when Puente students were compared to Non-Puente students.

At the end of the second semester, StatMode students performed similarly to or outperformed a national sample of students in a first statistics course. StatMode students were assessed using questions from a nationally-normed exam--the Comprehensive Assessment of Outcomes for a first course in Statistics (CAOS). The instructor divided questions into two broad learning domains: (a) data exploration and descriptive statistics and (b) probability and inference. For the descriptive statistics section, based on the eight questions with the highest level of discrimination (> .35), StatMode students from the initial cohort who completed the final exam scored somewhat better than the national average. On average, StatMode students answered 61% of these questions correctly, compared to 53% for students from the national sample. For the probability domain, five questions had discrimination level above .35. For these questions, StatMode students had a mean performance of 50%, compared to the national mean of 49%.

Finally, the students who were interviewed (N = 11) were asked to complete the Adult Dispositional Hope Scale (ADHS). These interviews occurred toward the end of the first semester, after students had significant exposure to the course. Students scored relatively high on both parameters of the ADHS: pathways and agency. Students met the criteria determined by the ADHS developer for having “high hope”: a score of 24 or higher (Snyder, 1994). StatMode interviewees had mean hope scores of 28, equally distributed between pathways (score of 14) and agency (score of 14).

The Quantitative Findings

Several student outcomes were examined, including success in the pre-statistics course by grade, success in the statistics course by grade, overall success in the sequence by average GPA, and the change in students' grades between the first semester and the second semester. For the latter variable, the categories were "higher," "same," or "lower." In addition, fall and spring grades were coded into "dummy" variables were "yes" indicated passed with a C or higher, and "no" indicated otherwise.

All student outcomes were examined by all demographic variables available, including gender, age group (divided into two groups--under 20 or 20 and older--since specific age was not known for all students), mathematics eligibility, and Puente status. Mathematics eligibility level was based upon students' score on the MCC placement test or their most recent successfully completed mathematics class. Note, at MCC there is no prerequisite for pre algebra, so at MCC the distinction between arithmetic and pre algebra is considered somewhat artificial. To further examine mathematics eligibility, this variable was recoded into "lower" and "higher" categories, where lower included arithmetic and pre algebra, and higher included elementary and intermediate algebra. All tests were run using both the four-category variable and the two-category variable. Student outcomes by age group, gender, and mathematics eligibility were not statistically significant; however, the relationships between Puente status and most student outcomes variables were found to be statistically significant. This significance testing for Puente will be presented in detail later in this chapter. As a reminder, there were no statistically significant interactions between the demographic variables, as described in the methodology chapter, with one exception: age group and Puente status.

The Fisher's Exact Test was used to determine statistical significance, rather than using the Chi-Square Test for Independence, due to the small sample size and frequent occurrence of cells with zero cases. To further example statistically significant results pertaining to Puente, the nonparametric Wilcoxon Rank Sums and Kruskal-Wallis tests were used to examine the combined GPA representing student performance in both semesters. These tests were used as an alternative to the *t*-test due to the extreme differences in the variances between the Puente and Non-Puente groups, the non-normal distributions, and the small sample size. Due to the small sample size, $p < 0.1000$ was used.

Due to the small N which limits the power of statistical tests, frequencies for student outcomes by demographic variables will be presented in the following sections despite the lack of statistical significance. The primary quantitative research question posed by this study was whether underprepared students from underrepresented groups could successfully complete an accelerated mathematics sequence. Even when not statistically significant, the data presented show the range of outcomes students experienced.

To reiterate, the reader should understand that the relationships between the demographic variables and student outcomes presented in the following tables were not statistically significant unless explicitly identified as such.

Pre-Statistics Course Success for Initial Cohort

An initial cohort of 29 students enrolled in the pre-statistics course in fall 2010, as of the MCC census date. Of those, 27 completed the first semester with a grade of C or better. Two students withdrew from the course and consequently received a W notation on their transcripts. Table 1 shows the final grades in the pre-statistics course by three demographics: gender, age group, and Puente status. Most students across all demographic groups successfully completed the pre-statistics course with a C or better.

Ethnicity is not presented in Table 1 as specific ethnicity was unknown to the researcher and the instructor for several of the students. However, all students except one were identifiably students of color—primarily Latina/o or African American. Only one white student enrolled in StatMode. The two students who withdrew during the first semester were both African American women and both more than 20 years old. Two other African American women, also more than 20 years old, remained in and successfully completed the pre-statistics course.

Table 1

Final Grade in Pre-Statistics Course by Gender, Age Group, and Puente Status

	Gender		Age Group		In Puente?	
Final Grade	Female	Male	< 20	20 +	No	Yes
A	15%	0%	5%	22%	17%	6%
B	50%	56%	60%	33%	25%	71%
C	25%	44%	35%	22%	42%	24%
W	10%	0%	0%	22%	17%	0%
N	20	9	20	9	17	12

Fisher's Exact for Pre-Statistics Final Grades by Puente: $p = 0.0472$

Given the small cohort, Table 1 will be discussed in broad terms. The data show that, in general, both male and female students successfully completed the course. However, female students represented all the A grades and the only Ws received in the pre-statistics course. Similarly, students from both age groups successfully completed the course. However, students in the 20 and older age group received more As and the only Ws. Finally, the difference in grade distributions between Puente and Non-Puente students was statistically significant. Both Puente students and Non-Puente students were generally successful in the course. However, students not in Puente received more As, more Cs, and the only Ws.

Table 2 shows the pre-statistics course success rates by students' incoming mathematics level, i.e. eligibility level.

Table 2

Final Grade in Pre-Statistics Course by Mathematics Course Eligibility

Final Grade	Arithmetic	Pre algebra	Elementary algebra	Intermediate algebra	Total
A	0%	0%	27%	0%	10%
B	33%	57%	36%	75%	52%
C	67%	43%	18%	25%	31%
W	0%	0%	18%	0%	7%
N	3	7	11	8	29

The data in Table 2 show that students from a range of incoming mathematics levels were successful in the pre-statistics course. Students with arithmetic placements did earn the largest percentage of Cs. When As and Bs are subtotaled, a potential pattern emerges: completions with A or B grades range from 33% at the arithmetic level, to 57% for pre algebra, 64% for elementary algebra, and 75% for intermediate algebra. However, this pattern is not statistically significant. Moreover, students with elementary algebra eligibility show the greatest spread in grades, earning the only As and the only Ws.

Statistics Course Success for Initial Cohort

All 27 students who completed the first semester pre-statistics course persisted to statistics, and 25 completed statistics with a grade of C or higher. The data in Table 3 and Table 4 show that students across all demographic groups successfully completed statistics with a C or better. Of the two students who received Ds, one was male, one was female, neither were enrolled in Puente, both were under 20 years old, and, both began the fall 2010 semester at the pre algebra level. Note, two students opted to take the statistics course with a different instructor. One student joined Umoja, a program which seeks to serve primarily African American and first-generation college students through culturally relevant curriculum and academic support services. Another, for convenience, selected a course section at a separate campus. The StatMode instructor continued to monitor their progress and their statistics course grades are included in the data that follows.

Table 3

Final Grade in Statistics Course by Gender, Age Group, and Puente Status

	Gender		Age Group		In Puente?	
Final Grade	Female	Male	< 20	20 +	No	Yes
A	33%	11%	20%	43%	30%	24%
B	50%	33%	50%	29%	20%	59%
C	11%	44%	20%	29%	30%	18%
D	6%	11%	10%	0%	20%	0%
N	18	9	20	7	10	17

Table 4

Final Grade in Statistics Course by Mathematics Course Eligibility

Final Grade	Arithmetic	Pre algebra	Elementary algebra	Intermediate algebra	Total
A	0%	14%	44%	25%	26%
B	67%	43%	44%	38%	44%
C	33%	14%	11%	38%	22%
D	0%	29%	0%	0%	7%
N	3	7	9	8	27

The data in Table 4 show that students from a range of incoming mathematics levels in fall 2010 were successful in the statistics course in spring 2011, with no clear pattern of students with higher incoming mathematics levels being more successful.

Two-Course Sequence Success for Initial Cohort

Of the initial cohort of 29, a total of 25 students successfully completed both courses--pre-statistics and statistics--resulting in an overall sequence completion rate of 86%. Students from a range of incoming mathematics levels successfully completed the two-course sequence. Ten students began fall 2010 at the lowest mathematics levels, i.e. eligible to enroll in arithmetic or pre algebra. Of the ten, 80% (n = 8) completed both courses with a grade of C or higher. In comparison, of the 19 students with eligibility for either elementary or intermediate algebra, 17 successfully completed both courses--an 89% success rate.

Of the initial cohort, nearly all students (*n* = 28) were students of color—primarily Latina/o and African American. The overall success percentage for students of color was 86% (*n* = 24). Females and males completed the sequence at a similar success rate (85% and 89%, respectively). Younger students were somewhat more successful: 90% of those under 20 succeeded compared to 78% of students 20 years old or older.

Several students (*n* = 6) improved their grades from the first semester to the second. For example, three students received a B in the first semester pre-statistics class, but improved to an A in the statistics class. Four students showed grades that declined from the first to the second semester. For example, two students earned a B in the first semester but dropped to a C in the second semester. Most students (*n* = 17) maintained the same grade from one semester to the next.

Perhaps the most striking result corresponds to Puente, shown in Table 5. All 17 students concurrently enrolled in Puente successfully completed both semesters with a C or higher—compared to 67% of those not enrolled in Puente. In other words, all four students who did not complete (two withdrawing the first semester, and two earning Ds the second semester) were not enrolled in Puente. While the small *N* should be kept in mind, this difference was statistically significant.

Table 5

Course and Sequence Success by Puente Status

	Fall 2010		Spring 2011		Full Sequence	
	Puente	Non-Puente	Puente	Non-Puente	Puente	Non-Puente
Successful	100%	83%	100%	80%	100%	67%
Not Successful	0%	17%	0%	20%	0%	33%
N	17	12	17	10	17	12

Fisher's Exact for outcome variable Full Sequence: p = 0.0208

Additional analysis regarding students' average GPA for the sequence (average of the two course grades) found differences between Puente and Non-Puente students which approached statistical significance when Ws were treated as zeros. The Wilcoxon Rank Sums test showed p = 0.1064 for the two-sided t-test approximation. Additionally, the Kruskal-Wallis test was statistically significant at p = 0.0908. To examine the degree to which the two Withdrawals by Non-Puente students from the initial semester were affecting the statistical analysis, these two records were removed and both tests were re-run. After removing the Ws, the Wilcoxon Rank Sums and Kruskal-Wallis tests no longer showed statistically significant differences between the Puente and Non-Puente groups. (The tests showed p = 0.3178 and p = 0.2962 respectively) This is consistent with earlier findings that students not in Puente earned more As (Tables 1 and 3); however, students in Puente earned more Bs and Cs, and overall were more likely to complete both courses.

CAOS Results at Sequence Culmination

At the end of the second semester, StatMode students were assessed using a nationally-normed exam--the Comprehensive Assessment of Outcomes for a first course in Statistics (CAOS). The instructor incorporated 26 CAOS questions, 25 of which she divided into two broad learning domains: (a) data exploration and descriptive statistics and (b) probability and inference. The 26^{th} question related to a third learning domain related to modeling. Since it was the sole CAOS question included from that domain, the question was excluded from this analysis. Also, additional questions designed by the instructor followed the CAOS questions in both Parts 1 and 2. These instructor-designed questions were also excluded from this analysis.

Student performance on the 25 questions was examined. Students included those 25 who began with the instructor in fall 2010, completed the fall semester, and re-enrolled with the instructor in spring 2011. Two students who took statistics in spring 2011 are excluded due to enrollment in different sections of statistics. While these students did successfully complete the introductory, college-level statistics course, they did not participate in the same final exam.

Regarding testing conditions, although StatMode students were allowed to retake sections of the exam within the two hour exam period, only the students' first attempts are represented in the data included in this analysis. The instructor used this approach to promote “productive persistence.” It is worth noting that many students did retake the exam sections. For example 21 out of 25 students retook Part 1 a second time. Many (16) took Part 1 a third time. It is possible that the fact that students knew they could retake the exam artificially suppressed their performance on their first take. Moreover, the instructor noted that student performance on final exams is not always the best representation of their learning. Despite these caveats, the data in this section show that StatMode students performed comparably to an unmatched, more privileged national sample, described next.

The national sample was comprised of 1,470 students from 39 classes at 33 institutions in 21 different U.S states. Of the 33 institutions, 82% were four-year institutions; just 18% were community colleges. Of the 39 sections, 41% had college algebra or calculus as a prerequisite. Of the 1470, 74% of the students were white. Cronbach's alpha for this sample was .82.

Figures 2 and 3 show the percent of students who answered each CAOS question answered correctly, as well as the average correct responses to all questions in the section (i.e. mean correct). Figure 2 corresponds to the first learning domain of data exploration and descriptive statistics. Most of the questions in Part 1 included histograms and boxplots and posed questions about data distribution. Figure 3 corresponds to the second learning domain of probability and inference. A few CAOS questions will be highlighted in the following section. For additional detailed information about CAOS items, see Appendix A in DelMas, Garfield, Ooms, and Chance, 2007.

PART 1: CAOS Item Number	15 Instructor-Selected Questions		8 Higher-Discrimination Questions	
	StatMode Students	National Sample	StatMode Students	National Sample
1	32.0	74.1		
2	56.0	56.0		
3	64.0	72.4	64.0	72.4
4	64.0	63.4	64.0	63.4
5	76.0	69.8	76.0	69.8
6	48.0	29.0	48.0	29.0
9	0.0	28.9	0.0	28.9
10	52.0	31.5	52.0	31.5
11	72.0	89.0		
12	88.0	86.1		
13	88.0	74.1	88.0	74.1
14	92.0	52.8	92.0	52.8
15	84.0	50.7		
33	8.0	41.2		
18	36.0	80.0		
Mean Correct	**57.3**	**59.9**	**60.5**	**52.7**
	N = 25	*N* = 1470	*N* = 25	*N* = 1470

Figure 2. Percentage of correct responses for questions about data exploration and descriptive statistics.

Figure 2 shows that StatMode students performed roughly similar to the national sample for Part 1, consisting of 15 CAOS questions related to data exploration and descriptive statistics. On Part 1, StatMode students answered 57% of questions correctly, compared to 60% to the national sample. The right columns show the data when only those questions with higher discrimination levels (> .35) are included. With this refinement, StatMode students outperformed the national sample. On average StatMode students answered 61% of higher-discrimination questions in Part 1 correctly, compared to 53% for students from the national sample.

Of the eight higher-discrimination questions in Part 1, StatMode students outperformed the national sample on five questions. StatMode students dramatically underperformed the national sample on only one item. Item 9, which pertained to a boxplot whisker, also elicited the fewest correct answers from the national sample. The CAOS developers described this item as testing student's "[u]nderstanding that boxplots do not provide estimates for percentages of data above or below values except for the quartiles" (DelMas, Garfield, Ooms, & Chance, 2007, p. 54). StatMode students performed particularly well on CAOS item 14. This item tests students' "[a] bility to correctly estimate and compare standard deviations for different histograms. Understands lowest standard deviation would be for a graph with the least spread (typically) away from the center" (DelMas, Garfield, Ooms, & Chance, 2007, p. 55).

Analyses of Part 1 found no statistically significantly relationships between CAOS scores and Puente status. Puente students scored 59% and Non-Puente 54% on all 15 questions. On high-discrimination questions, Puente students scored 63% versus 56% for Non-Puente.

PART 2: CAOS Item Number	10 Instructor-Selected Questions		5 Higher-Discrimination Questions	
	StatMode Students	National Sample	StatMode Students	National Sample
16	48.0	33.0	48.0	33.0
17	80.0	51.6	80.0	51.6
19	52.0	67.9		
25	44.0	57.1	44.0	57.1
26	60.0	60.1		
27	52.0	54.4	52.0	54.4
28	24.0	49.4	24.0	49.4
29	52.0	65.4		
30	20.0	47.5		
31	68.0	75.9		
Mean Correct	**50.0**	**56.2**	**49.6**	**49.1**
	N = 25	*N* = 1470	*N* = 25	*N* = 1470

Figure 3. Percentage of correct responses for questions about probability and inference.

On Part 2 (shown in Figure 3), StatMode students answered ten CAOS questions about probability and inference. StatMode students on average answered 50% of questions correctly, compared to 56% of the national sample. When just the five higher-discrimination questions are included, StatMode students perform roughly the same as the national average (50% versus 49%). Overall, StatMode students performed higher on two of the five higher-discrimination questions. StatMode students performed particularly well on item 17, “Understanding of expected patterns in sampling variability” (DelMas, Garfield, Ooms, & Chance, 2007, p. 55).

Analyses of Part 2 found no statistically significantly relationships between CAOS scores and Puente status. Puente students scored 50% and Non-Puente 50% on all ten questions. On high-discrimination questions, Puente students scored 49% versus 50% for Non-Puente.

Hope Scale Results for Interviewees

StatMode interviewees (N = 11) completed the Adult Dispositional Hope Scale (ADHS). According to its developers, the ADHS has a Cronbach's alpha ranging from .74 to .84 (Snyder, 1991). Interviewees responded to eight statements across two domains (agency and pathways). Four statements assessed students' sense of agency, i.e. individual determination to meet goals. A sample agency statement is "I energetically pursue my goals." Four statements assessed an individual's ability to produce the means for attaining the goals, i.e. create or identify pathways to goal attainment. A sample pathways question is "Even when others get discouraged, I know I can find a way to solve the problem."

All eight statements agency and pathways statements were framed positively such that a high score reflected a high sense of agency or pathways. Students rated each statement with "definitely true" (4.0), "true" (3.0), "false" (2.0), or "definitely false" (1.0). For each domain, agency and pathways, the maximum possible score is 16.0, based on the four-point scale, summing across four statements. The total hope score is determined by adding the two domains, with a maximum possible score of 32.0. A score of 24.0 or higher indicates “high hope” (Snyder, 1994).

StatMode interviewees generally agreed with all four statements in both agency and pathways categories, indicating either true (3.0) or definitely true (4.0). Fewer than half of the students disagreed with any of the statements: four students indicated false or definitely false to one statement. As a result, all interviewees had high hope scores. All students, across all demographics, scored high: the young Latino/a students, the somewhat older Latino student (Manny), and the three African American women. Interviewees had a mean hope score of 27.5, with individual scores ranging from 24.0 to 30.0.

The ADHS instrument also contains four distracter statements. These four statements, interspersed within the instrument, are all framed negatively. The statements include references to fatigue and worrying, with a high score indicating a high degree of frequency. Student rated the distracter statements low, tending to disagree with statements such as “I feel tired most of the time.” The maximum possible score was 16.0 (based on a four-point scale across four statements). The overall mean for all eleven students combined was 7.5, with individual scores ranging from 4.0 to 10.0. The fact that students responding differently on the distracter statements, compared to the pathways and agency questions, indicates a thoughtful response to the instrument.

Table 6 shows interviewee responses for pathways, for agency, and for the combined total. While slightly different on the subscales, the Puente and Non-Puente subgroups had similar totals, rounding to 27 and 28, respectively. Compared to the aforementioned “high hope” cutoff of 24, these students evidenced high hope. An additional comparison is provided in Table 6. Snyder (1991) surveyed college students for several years and found mean hope cores ranging from 25 to 26 (lowest and highest years respectively).

Table 6

Hope Scores for StatMode Interviewees and Comparison Groups

	N	Pathways	Agency	Total[b]
		StatMode Interviewees		
All Interviewees	11	13.9	13.6	27.5
Non-Puente Subgroup	4	14.5	13.3	27.8
Puente Subgroup	7	13.6	13.9	27.4
		Comparison Groups		
College Students - Highest Year[a]	955	12.8	12.8	25.6
College Students - Lowest Year[a]	875	12.5	12.6	25.1

Note: Maximum Total Score = 32.0.

[a] Published by Snyder (1991).

[b] Per Snyder (1994) score >= 24.0 indicates "high hope."

Summary and Synthesis

Most StatMode students completed the initial pre-statistics mathematics course successfully, persisted to the transfer-level statistics course, and successfully completed transfer-level statistics. Overall, 86% of the original cohort of 29 students completed the full, two-semester sequence. All but one of the students were students of color—predominately African American and Latina/o. Gender, age group, and incoming mathematics eligibility level were not significantly related to the course and sequence outcome variables.

While both Puente and Non-Puente students were generally successful in completing the two-course sequence, findings suggest that Puente students were more likely to remain in StatMode. Specifically, three different outcome variables showed statistically significant differences, or differences which approached statistical significance. The first semester grade distribution differed between Puente and Non-Puente students: Non-Puente students received more As, Cs, and Ws; Puente students received more Bs. The overall two-course sequence completion rate defined in terms of yes (completed with a C or higher) or no (D, F or W) was statistically significant by Puente and Non-Puente status, with a larger proportion of Puente students (100%) completing the sequence. Moreover, this finding approached statistical significance when using the Wilcoxon Rank-sum test to evaluate combined GPA across the two terms—as long as withdrawals were included as a zero GPA. Once withdrawals were excluded, the difference between the GPAs of Puente and Non-Puente students was no longer statistically significant.

Quantitative findings suggest that StatMode students performed comparably to, and perhaps somewhat better than, the national average on the Comprehensive Assessment of Outcomes for a first course in Statistics (CAOS). Scores were assembled for two learning domains—(a) data exploration and descriptive statistics and (b) probability and inference. Based on questions selected for discrimination > .35, StatMode students from the initial cohort scored somewhat better than the national average within the first domain, averaging 61% of questions answered correctly, compared to 53% for students from the national sample. For the second, probability domain, StatMode students had a mean performance of 50%, compared to the national mean of 49%. Based on this data, StatMode students not only completed the two-course sequence at high rates, but students also performed comparably on a post-test when compared to national peers who were primarily white, primarily from four-year institutions, and most of whom were required to have higher mathematics prerequisites before beginning the statistics course.

Finally, the StatMode students who were interviewed ($N = 11$) were asked to complete the Adult Dispositional Hope Scale (ADHS). Students scored relatively high on both the pathways and agency parameters of the ADHS. Students met the criteria determined by the ADHS developer for having "high hope."

Chapter Five: Qualitative Themes about Math Attitudes and Growth Mindset

Qualitative data collection focused on students' perceptions of mathematics and their experiences in StatMode. Interview questions elicited students' feelings and beliefs about mathematics, both historically and in the StatMode sequence. Historical experiences were gathered for comparison purposes and are discussed in the first theme titled *Initial Mathematics Attitudes and Backgrounds.* Subthemes include (a) best math experiences, (b) worst math experiences, and (c) fixed mindset and limited effective encouragement. This line of inquiry showed that students' prior mathematics experiences were overwhelmingly negative, and frequently characterized by their own fixed mindsets, coupled with limited effective encouragement from instructors and other adults. However, many students did describe relatively recent positive mathematics experiences.

The second theme, *Perceived Power of Growth Mindset*, is also presented in this chapter. Shifts in students' sense of competency with regard to learning and using mathematics concepts were investigated. Students spontaneously and enthusiastically discussed "growth mindset," a concept the instructor introduced early in the fall semester. Subthemes include (a) the critical importance of mindset, (b) caring about learning, (c) involving each student (and related uses of group work), and (d) thinking differently about errors and risk-taking.

The third and final theme from the student interviews, *Motivation through*

Intellectual Engagement, will be presented in Chapter Six along with data from several classroom observations.

All qualitative data in both Chapters Five and Six are presented in abundant detail. For example, where one illustrative quote from the interview data might suffice, several students' quotes are provided. It is hoped that these detailed qualitative data allow nuances to be transparent.

Note, in this chapter "math" is used more frequently than the more formal "mathematics," since this was the verbiage used in the interviews and observed during classroom observations.

Initial Mathematics Attitudes and Backgrounds

When asked to describe previous feelings about math in one word, ten of the eleven student interviewees provided a range of negative associations. Four students chose words such as confusing, complicated, or difficult. Another four simply indicated horrible, hate it, or extreme dislike. One student said boring, another said anxiety. The only student who indicated a positive disposition toward math (Davina) said she previously liked math but that her feelings about math varied according to the degree of patience shown by the instructor.

Despite these largely negative associations with mathematics, nearly all interviewees were also able to identify a "best math" experience--typically a relatively recent experience. However, these best experiences were often relatively isolated and few spoke enthusiastically about anyone encouraging them or supporting them regarding their math performance prior to StatMode. Students generally characterized their prior best math experience as either a time when they learned math readily or when they were willing to work hard to learn, the latter being aligned with growth mindset principles.

The remainder of this section on math attitudes is separated into three subthemes: descriptions of best math experiences, descriptions of worst math experiences, and a theme regarding historically fixed mindset approaches coupled with limited effective encouragement.

Best Math Experiences

Only two students failed to identify a best math experience. Not coincidentally, these were two of the older students who had both consciously delayed taking math: SkyMarie and Manny. The other nine students indicated that their best math experience had been relatively recent. Six indicated freshman or sophomore year in high school, two indicated middle school, and one indicated a previous college class. Most often these "best math" courses were identified as pre algebra or elementary algebra.

Students typically related their best math experience to their performance, with five students (Davina, Jackie, Jessie, Wolf, and Micky) implying an ease of performance by offering descriptions such as "I was actually really good at it" (Wolf), "I performed at my max and I really enjoyed it" (Micky), and "Completing homework was like playing, it was fun" (Jessie). These students all indicated that they not only performed well in terms of grades but that they were able to *understand* the material and this was why they enjoyed that particular class. Jessie, for example, emphasized the degree to which she understood the material by describing how she was able to assist other students: "I don't know, I just got it, I loved it um, I helped other people that didn't get it and got them to get it because you know, to me it was simple."

While describing these "best math" experiences, these same five students (Davina, Jackie, Jessie, Wolf, and Micky), plus Linda, focused on the subject matter in ways that implied they had ascribed limits to their mathematical abilities. They described their best experience as characterized by "basic" or "simple" math. For example, one student (Linda) described Geometry as "simple measuring" where she "had the formulas" compared to algebra where "complex formulas" were required. Another (Davina) described elementary algebra as "basic math" taken in middle school and juxtaposed it with "harder things" she encountered while taking math in high school. Wolf provided this caveat, implying that his good experience was an aberration: "Math was never my strong point [but] I understood the concepts a lot better [in Algebra 1] because it was simple math such as numbers and stuff, not graphs and all that are not my best experience."

The other three students (Guss, Spaceman, and Teavo) indicated that their best math experience occurred because they had worked hard or decided to "try." Their responses implied that this willingness was limited. One student (Guss) asked for help and "studied like for a week intensively" for a particular test, which he "aced." He described this as an isolated occurrence. Another (Spaceman) said, "I guess when I tried, I got an A but when I didn't, I just, I failed the same semester." Teavo described an isolated instructor who consistently encouraged him: "He always told me…if you really think about it and work on the problems, you'll understand it… but then he retired and so it became a little more complicated…I never had the courage with other teachers to ask for anything else."

Five students, including Teavo (above), noted particular instructor characteristics in their best math experiences which varied from fun and energetic, to patient, to encouraging. Three emphasized the instructor's ability to provide good, simple, or detailed explanations. Only one student highlighted the structure of the best math class which relied heavily on group work.

The remaining two students, Manny and SkyMarie, failed to identify a "best math" experience in school. Manny stated, "Yeah, well to be honest, math was to me, was the same from elementary, junior high, to high school… I never took math because I feel like I was wasting my time or I wasn't going to do good in it." SkyMarie also indicated that her prior experiences had all been bad, stemming from early race-based pressure to perform. She was one of the few interviewees who referenced race, and she explicitly associated it with her pronounced math anxiety, which she initially described then further clarified.

> My worst math experience is um, I grew up in a mixed household, so I'm a black/white mix believe it or not, and um, my mother um, did our math and homework with us because my father worked, and she was under a lot of stress, so screaming was all we got, so [my sisters and I] got math anxiety. And she was a math whiz, so, um, with us not catching on quickly, it created huge problems, like anxiety and yelling and, and for us um, it, she'd always say if you don't learn math, you're going to work with your hands. So, math became a huge, huge anxiety… so that's my worst.
>
> [Researcher: you mentioned that your parents were uh, one black one white, which was which?] My mother is African American and my father is white, and because my mother is African American, she taught us that everything is going to be a struggle, so if you're not really smart, or you don't learn how to be really smart, then, you know, this is going to be your struggle, so the psychological [pressure] mixed with the math anxiety, it just didn't pan out… (SkyMarie, 11/4/2010, Question 3)

In addition, despite indicating a recent "best math" experience, Teavo also described difficulties with math which began very early in his education.

> When I was in elementary school, the teacher would give us small quizzes, you know to make your additions and then you pass your additions, then you get your multiplications and I was always struggling …and everyone was ahead. They got fractions and I didn't understand what was going on so I was always two steps behind in math. I think that's why I became discouraged. (Teavo, 11/4/2010, Question 4)

Worst Math Experiences

Of the nine students who indicated both a best math experience and a worst math experience, six indicated a worst math experience that seemed to symbolize a turning point for them after which they described largely negative math experiences. For three students, the turning point was high school Geometry; for the other three it was Algebra 2 or pre-calculus.

In describing their worst math experiences, students referenced feeling discouraged and disinterested. For two students (Spaceman and Jackie), this disinterest pertained to school in general, not just math. For others, it was specific to math. While many were frustrated with themselves, they also expressed frustration with instructors:

> I didn't get any of it at all, I never liked doing graphs or like finding shapes' radiuses and so I completely gave up then I would barely turn in homework, I would slack off in class and I know it was mostly my fault but… my teacher really didn't pressure me as much as the other one did so I was missing that part too. (Wolf, 11/16/2010, Question 3)

Interviewees described teachers who seemed impatient, covered material too quickly, and did not seem to care whether students were learning. In particular, students expressed that instructors did not "explain" the material or answered questions in ways that were not helpful, as the following quotes from Davina, Jessie, and Teavo illustrate:

> Some teachers do not know how to teach…, they don't know how to interact with a student or like they're not patient enough. I've had a lot of impatient teachers during high school. (Davina, 11/4/2010, Question 1)

> It was dreadful. Teachers went very fast…. Obviously, it's their job so they just do their job but it was more like I'm getting paid, so I'm just going to do it, like a sloppy way, you know? And not caring if the students understand or not, it was more like, I already taught, it's up to you if you want to go and actually get it, I already did my part. That was the most dreadful part, was like going home and like oh my god, I don't get it, I don't get it, I don't get it…. I didn't even know what I was doing, what I was learning about, I couldn't tell you what I was learning about. (Jessie, 11/16/2010, Question 3)

> The teacher would want this, this and this like she didn't explain thoroughly what we were learning. She would just assume that you would know it and I

> know I felt frustrated because I asked questions too but she just responded in simple sentences, like she assumed that you knew it and it was just frustrating. I had an F, and then I had to retake it—just frustrating like, I don't know, that year, I felt like it was the worst for me in my math experience. After that, I just never liked it or enjoyed math in any way. I just felt that it was not for me. (Teavo, 11/4/2010, Question 3)

Students did not spontaneously elaborate on their worst math experiences beyond what is described above. Only one mentioned a parent's reaction (withheld allowance money), and only one mentioned a desired instructional technique which was absent (group work).

Fixed Mindset and Limited Effective Encouragement

When asked "Have you ever questioned your ability to be good at math?" all but one student indicated this was true for them. (Jessie's response was the exception. She said, "It's not about how smart you are.") Their responses often echoed their initial one-word description of math. Students often described feeling confused by the assortment of numbers, equations, and formulas. In the students' words, "I think a lot of it was just confusing items of where they went in the formulas" (Linda). "Like in my head, to me, when the teacher is talking numbers and equations, all I heard was 'blah, blah, blah', and it's hard to get focused" (Teavo). "I feel like in every other subject, I'm pretty good at it, and like math, I don't know why, it's hard to like, it's all those equations and it's confusing to me" (Manny).

Many students described how they internalized this difficulty, particularly when comparing math experiences to their experiences in other subject areas (see Manny above), or when comparing themselves to their peers, to their teacher's expectations, or to their parents' perceptions. Related comments include the following: "My math grades were always lower and my frustration level would be way different like, I would get frustrated so easily with math than I would any of the other [subjects], even if they were more complex" (Linda); "It looked foreign and I just thought I couldn't do it" (Jackie); "When other people get it, I feel like there is something wrong with me" (Spaceman); "I was always two steps behind in math. I think that's why I became discouraged" (Teavo); "I was like I'm never going to get this… I guess I was questioning [my ability] because, the teacher, I would think that the teacher knows what he's doing and he's teaching, right? And I'm not getting it" (Davina); and "I was always pressured to be good in math and my parents would always make fun of me, saying how come I'm not as good at math" (Wolf).

When asked whether anyone had ever made them "feel more confident about doing math," only two students—Guss and Teavo—described prior instructors with conviction. Teavo described a "very influential" ninth grade instructor who "never gave up on students" and who told him "not to give up." This instructor not only encouraged Teavo but also offered him individualized support: "He was like one on one."

Guss described an energetic and demanding instructor. This particular 11th grade Math Endeavors instructor confronted him directly about his engagement in the class:

> She talked to me straight, she was like you know what you're a pretty smart guy, you've got this down, but you've just got to put more effort into it. She was like straight up like talking to you straight you're just lazy. I was like damn. I didn't know that teachers could do that, you know tell me that straight. (Guss, 11/4/2010, Question 5)

In addition, while Guss did not emphasize this instructor's helpfulness per se, Guss provided a clear image of this instructor's engaging classroom, using words such as "dynamic" and "fun" and described other students as "involved into the class." Finally, Guss also indicated this class was more practical than other math classes: "It's not like just rules and what not. You actually get to put it, you could say like to work. Like an architect. Like angles and whatnot."

Other students provided more tepid responses with regard to their experiences with prior instructors. For example, Spaceman described a seventh grade instructor who spoke in encouraging aphorisms and was "kind of motivational." Spaceman provided this example: "One of his favorite [quotes] was always, 'The only two things you need to do in life is learn to learn and learn to think.'" Linda also provided a qualified response: "One teacher kind of made me feel a little better." Additional students provided vague responses or simply said they had not been such an influence on them. Related comments include: "Yeah, um, maybe a teacher" (Davina); "Probably around…6th grade" (SkyMarie); and "Not when I was younger. Um, they probably didn't even know that I struggled because I was never one to ask questions. I just sat there and didn't ask questions" (Jackie).

Four students identified other sources of encouragement beyond instructors, including parents and counselors. Micky and Linda both identified their parents as providing encouragement: “You know, you can do this, your ability to do math is more than what you think” (Micky).

While the first half of the interview was clearly framed to elicit math experiences prior to StatMode, several students seemed eager to describe their current math experience. Two students (Manny and Jessie) identified a current college counselor (in one case a Puente counselor) who encouraged them to be confident about enrolling in StatMode, particularly due to the counselor’s description of the instructor.

Other students (SkyMarie, Davina, and Guss) also inserted unprompted comments about their current StatMode experiences. In response to the second interview question, all three spoke about how their best math experience has been in StatMode. Guss commented, “She took us like to the front and … she wanted us to present it to the class and… I felt good about myself because I actually knew what I was talking about, you know what I’m saying?” SkyMarie spoke about the class as a “confidence builder” that was helping to move her past her anxiety. Davina said, “The teacher, she goes step by step so if you don’t understand it, like, she’s there for you.” It’s plausible that many of the other students also would have classified StatMode as their best math experience; however, students were asked to “think back to some of your earlier experiences in math” for this portion of the interview.

Perceived Power of Growth Mindset

The second half of the student interview protocol focused on StatMode. Several themes emerged vis-à-vis StatMode, most strikingly the theme of mindset. In fact, even before interviews shifted to focus on StatMode, the theme of mindset quickly emerged, including concepts of “fixed mindset,” “growth mindset,” and “open minded.” As shown in this section, students spontaneously raised the issue of mindset and many spoke about it with a distinct level of intensity, indicating that understanding mindset had changed their approach to the course material and potentially to mathematics more generally. Students indicated that growth mindset and related concepts were regularly referenced by the instructor, by other students, and internally as they self-regulated and continually readjusted their attitude toward math. This finding was utterly unexpected, particularly since the researcher had no way of knowing the growth mindset concept had been introduced to students.

By having students read and discuss an article titled “Transforming Students’ Motivation to Learn” (Dweck, 2008), the instructor concretely exposed her students to several interrelated concepts. The article was also revisited mid-semester. To aid in the understanding of the mindset theme, each subtheme includes a thread from the Dweck article read by StatMode students. This ex post facto mapping of the subthemes with the article followed initial data analysis. The fact that it was possible to map subthemes with the article likely reflects not only the salience of the article but also the degree to which the instructor built concepts from, or deeply compatible with, growth mindset into the course.

Four mindset subthemes will be highlighted in this section. First and foremost, the article underscored the critical importance (according to Dweck's research) of obtaining and maintaining a growth mindset. Initially this first subtheme may seem tautological; however, as the introduction to the subtheme explains, students' reflections on the importance of growth mindset were particularly striking. Believing in growth mindset seemed to foster a new or renewed approach to the mathematics material. The researcher came to think of this as hitting a metaphorical, internal reset button where students thought, "Let's try this again, this time believing I *can* master the material."

The other three growth mindset subthemes include caring about learning (thus counteracting performance-orientation), involving each student (thereby reflecting the inclusive applicability of growth mindset), and thinking differently about errors and risk-taking (taking opportunities to deepen understanding). To reiterate, these three subthemes were initially assembled outside the context of growth mindset. As the qualitative findings were revisited during the final analysis, correspondence was noted between these subthemes and key threads in the growth mindset article to which students were exposed.

Critical Importance of Growth Mindset

Students appeared to have absorbed the sense of the importance of growth mindset promoted by the Dweck article. The article emphasized that intelligence grows with effort and that believing this—i.e. having a “growth mindset”—results in higher academic motivation, learning, and achievement. The article relayed particularly relevant findings regarding a study of mathematics grades: students with a growth mindset were “propelled ahead” of peers who maintained a fixed mindset. The article not only discussed the benefits of growth mindset but also portrayed problems associated with fixed mindset. In other words, the article made growth mindset seem essential.

The degree to which students emphasized growth mindset provides the first, most simple measure of how important it was to them. Overall, nine of the eleven students interviewed made an unprompted reference to mindset. During the first day of interviews, four students out of six spontaneously used this terminology. The remaining five interviews occurred two weeks later, at which time four more students spontaneously referenced these concepts. Two references were oblique, but most students were direct and reasonably detailed in their descriptions.

Another measure of growth mindset saliency is the degree to which it permeated the interviews. References were not made in response to any particular question; in other words, there was no apparent single trigger which prompted students to discuss mindset. Mindset was initially raised by students in response to various interview questions, including questions 2, 4, 5, 6, 7, 9, 12, 15, 16, and 17. In fact, four students

(Spaceman, Teavo, Manny, and Micky) included mindset in their response regarding the most important aspect of StatMode. Since mindset came up at different points during the interviews, the researcher's question is often included to provide context for students' responses.

Only Guss and Wolf did not spontaneously use mindset terminology. Guss was the first student interviewed. Since the theme had not yet arisen, he was not prompted to speak about it. The instructor recalled that three students, including Guss and Wolf, and also SkyMarie, had likely missed the class meeting when mindset was originally discussed. Despite this, when prompted, Wolf spoke about mindset readily and with feeling:

> I was freaked out.… I always had an open mindset when it came to other things, but when it came to math, I had a fixed mindset, and so that kind of surprised me a little bit. I never thought about it that way because I always used to tell myself, oh, I'm not good enough. I never did well in math, but when it would come to video games or reading or English, any other things, I [told myself] 'Let's learn more, let's learn a little more.' So when she showed me that, I thought, I can't continue like this, I can't keep telling myself I'm horrible at math, I'm not doing well at math, it's only going to bring me down even lower, and so it just made it pretty … and so it opened my eyes to the fact that every time I said I'm not so good at math, that boxed me in, in my little math worthlessness bubble, to put it in a simple term. (11/16/2010, Question 18)

Another measure of the importance of growth mindset was the emotions students used when speaking about it—and the personal transformations they described. Several students stated directly that reading the mindset article transformed their perceptions of themselves with regard to math. As in the previous quote from Wolf, nearly all the students directly or indirectly indicated that they previously or occasionally had a fixed mindset, specifically with regard to math. The sole exception was Guss. This exchange with Teavo (11/4/2010, Question 12) describes his transformation (note, the term "growth mindset" had not yet been used during this interview):

> *Researcher*: What kinds of things are you learning in StatMode?
>
> *Teavo*: We're learning about, first of all, explanatory data and categorical data, sorry, I have an accent. It's categorical data and explanatory data, what else? We did a lot of means and finding average deviation. We did a project right now by using a lot of means and medians, average deviation, you know, explanatory data as well…. I didn't understand it at first, but then I got it.
>
> *Researcher*: When you started getting it, what do you think changed for you?
>
> *Teavo*: Before that, she made us read an article it's called 'People Having Fixed Mindsets or Growth Mindsets.' Those people who are fixed mindsets, those who are closed in and say 'I'm not good at math, so I'm not even going to try' and those who are growth are open-minded and observe what they learn and so, I think at the beginning of the year, I was a fixed mindset because I was like 'I don't need this class, I'm just here to try to get a good grade and pass it' and actually, I became a more open-minded person now….. With this class, I always came at the beginning of the year with like 'another day in math, what am I going to do to get distracted,' but now I come to learn actually. I want see what's next, what challenges she brings us and so, I find it very rewarding that she is always trying to challenge us and when she challenges us, I find it very rewarding when I can answer the question. So the thing that's changed… my attitude towards math now, I find it more fun, which I never thought it would be, but I found it more fun.

Teavo's use of the word "distracted" struck the researcher as particularly illustrative of how students talked about previously avoiding mathematics material and enduring mathematics classes. Juxtaposed with the words "challenged," "rewarding," and "fun," Teavo clearly described a fundamental shift in his affective approach to the material. He also described shifting from a performance focus ("get a good grade") to a learning focus. This shift toward learning will be discussed more in the next subtheme.

Some students had particularly strong reactions to the mindset article. Per the prior quote, Wolf used the words “freaked out” and “surprised.” Jessie said she “loved the article.” Jackie felt the article was “eye opening.” Linda referred to the article as “eerie.” The following series of quotes from Linda show the enthusiasm with which she discussed mindset and the degree to which reading the article transformed her relationship to math. This first portion of the quote below describes her previous, fixed mindset and associated math-avoidance:

> It was kind of eerie because it, it like rang true for me, I was in a fixed mindset as I said before, I did not like math, I didn’t want to touch math, I didn’t want to deal with it. Just every time I say it, ugh, I would just start getting a little frustrated like, uh here we go with math, we’re done with English, we’re done with science, but here we go with math. And it would just be a whole little mood I would have on it like it’s going to be hard, I’m not going to be able to understand this, I don’t get it, and that kind of hindered me because I was putting myself down and being my own hurdle instead of thinking of it as something I could do, I could understand. It was always just a negative thought when it came to the math instead of a possible positive thought. (11/18/2011, Question 17)

Linda continued by describing how her new, growth mindset allowed her to “try” and “put effort into it,” and the positive results she began to see after making that mental shift. She also distinguishes her current efforts in mathematics from “effort credit”:

> And after reading that article, I was kind of like, yeah, it’s true, and then seeing when you kind of think of it as something that in a better light, you do kind of tend to do better at it because you don’t think of it as something that’s going to stop you. You try, you try harder to do it because of the fact that you think you can, whereas if you already off the bat have a thought that you’re not going to be able to do it, you’re just going to be like, oh well, let’s look at this problem, I’m, I’m not going to get it anyways so I’m just going to write a random number.

> I'm not going to really try at it. Whereas if you think, okay, there's a possibility that I can do this, you kind of try to put more effort into it, and you tend to see that you can actually do it. Where it's just the negative, you're just like I don't even want to [try], just, here, I just did it, give me effort credit, don't even just try to break it down for me, just give me the A for doing it or whatever. (11/18/2011, Question 17)

Linda concluded by describing how visible this shift was to others around her, and how she felt that she was understanding the material as a result of this mental shift:

> So, yeah, and then it was kind of eerie because I was in a fixed mindset. But I'm feeling better about math now and this is like, I even told a student today that I've never been this happy about a math class, ever. And I'm like really excited about this class because I'm understanding it, I'm like, yes, I'm getting A's on the quizzes, I'm getting A's on my papers, I'm understanding it, I can apply it on the board, I'm explaining it to my classmates. Before I would just shrug my shoulders and say, I don't know, ask the teacher. But, I'm actually seeing myself grow and expand and I'm enjoying it, I'm liking it so, it's a change and even my parents have noticed, they're like, you're a lot more happier. I'm like, yeah, I'm taking a math class and I actually get it. So, it's, it's, I think it's a good thing, I like it. Whenever someone asks me about it I'm like, yeah, I'm in this one math class that just explains everything and like, you usually hate math, and I'm like, I know! What does that tell you? So, it's a change that a lot of people can see, just, not even, just know I'm in a math class puts a little, ugh it's a math class. It's, it's a math class! We're learning this, this, and this. I can actually tell you what I'm learning and be happy about it and excited. (11/18/2011, Question 17)

Not all students were equally articulate about growth mindset. Manny and SkyMarie were among the older students. They were also the two students who had no prior positive experiences with math and who had described the most deep-seated math aversions. Their understandings of mindset were less fluent (Manny) or less accurate (SkyMarie). Manny was able to describe both fixed mindset and growth mindset, but at first he struggled with his explanation. SkyMarie conflated fixed mindset with rigidness in general, using the example of pre algebra:

> When you're learning math in school, it's fixed. I tell you 2 + 2 = 4, you take it in and then I test you and you come back with the same thing that I taught you… Lecture, you write it down, I test you, you either got it or you didn't … but with Sylvia's class, it's critical thinking, you know, um, adults can do it, and, you know when I say adults, I mean the later, 30+ crowd like me, can do it and then the kids coming in from high school can do it, you know. (11/4/2010, Question 6)

It seems possible that Manny and SkyMarie's deep-seated math aversions played a role in the limited effect growth mindset seemed to have for them (although both students did complete the sequence successfully). Age also seemed plausible as a factor; however, both Linda and Jackie were also among the older students (22 years old or older) and both were affected by growth mindset. Linda, who in the earlier quote had described the mindset article as "eerie," related early exposure to the general concept of mindset in sixth or seventh grade; when she did well, that particular instructor encouraged her by saying "it's not as hard as you thought." She indicated that her parents also identified her mindset as a hindrance: "They'd always say, like, you make it harder, and your mindset of that you don't like math makes it harder for you, too." It may have been this early "priming" that made the Dweck article so impactful for her.

Jackie was the oldest student at 35. She did not describe the article as pivotal, but she did describe it as helpful. She explained the history behind her mindset / frame of mind regarding school in general and mathematics in particular. "Um, well, I wasn't a good high school student, I think I graduated by the skin of my teeth." She characterized her lack of effort as a problem in college: "I did go to junior college a year or two after I graduated [from high school], but I just wasn't in the frame of mind to even try." She attributed her lack of understanding the material to "a 10 percent effort." She recently returned to college after 14 years and described herself as "mature," "focused," and "driven." She had taken pre algebra at MCC before enrolling in StatMode, and that had been a positive experience for her ("I probably had close to 100 percent in the class.") Despite her new focus, and the positive experience in pre algebra, math still posed a particular barrier for her: "I still had a fixed mindset about math and so the article kind of helped, and it's only about math that I had a fixed mindset about."

To summarize, most of the interviewees believed growth mindset was critically important. Several described a transformation resulting from reading the article and shifting their approach to mathematics. The possible exceptions were Guss who did not reference growth mindset at all, SkyMarie and Manny who showed limited or superficial understanding of it, and Jackie for whom it was helpful but not pivotal.

Caring about Learning

Caring about learning emerged as an especially strong subtheme within the student interviews. In the Dweck article, caring about learning was presented as fundamentally characteristic of growth mindset and epitomized by embracing learning opportunities viewed as challenging. This orientation toward challenges was juxtaposed with performance orientations associated with fixed mindset in which students selectively apply themselves only to tasks at which they believe they will excel. Thus, caring about learning is not only an individual orientation but requires coping with and navigating external expectations. “Many students had seen school as a place where they performed and were judged, but now they understood that they had an active role to plan in the development of their minds” (Dweck, p. 4).

Instructors, who are in some ways an embodiment of external expectations, can facilitate a shift toward growth mindset (Dweck, 2006). In this scenario, the instructor serves as a collaborator who focuses students on learning goals and creates an environment wherein learning goals are reinforced. Judgment is still present, of course, but is not central. This collaboration between the instructor and students is reflected in the quotes contained in this section: caring, helping, and the learning focus were described as intertwined.

An initial, overall indication of the instructor’s relationship with the students was the fact that most students spoke about “Sylvia” by first name. In general her name was intoned with warmth and, perhaps most notably, appreciation. Even the few times when students spoke with annoyance about something in particular (e.g., too much group work, not enough group work), it was coupled with indications of affection and respect. Note, the researcher purposefully did not refer to the instructor by name until the student had done so; instead, the researcher would refer to her as “your instructor.” Only two students did not refer to her by first name during the interview, possibly out of respect. Wolf referred to her as "Professor [Last Name]" and Manny as "the professor." Clearly this was not a classroom where students felt invisible. Instead, students felt they had a tangible relationship with the instructor.

StatMode students frequently described the instructor as caring, but this description was always qualified. In other words, she wasn't viewed as simply kind or nice. Students specifically described how she challenged them to learn, how she cared about their understanding of the material, how she focused on concepts that she wanted them to understand, and how she was responsive, patient, and detailed in her explanations. To students, these were all components of and evidence of her caring.

Some students explicitly associated this type of caring about learning with growth mindset. Spaceman, for example, described the instructor's encouragement of growth mindset as the most important quality of the StatMode program and as evidence that the instructor cared about each student.

> *Spaceman*: I think [StatMode is] good because you don't need to go through extra math classes and it, well the way that Sylvia teaches, I don't know how other people teach it, but she really gets into the, she really cares about us so, it's not really StatMode but Sylvia in general, she's a good person, she wants us to pass, she wants everyone to pass, she wants everyone to get A's. She wants everyone to be in a growth mindset.
>
> *Researcher*: Does she talk to you about that? How do you…?
>
> *Spaceman*: Yeah, she's always, you need to have a growth mindset to understand, because if you're in a fixed mindset, you won't, you'll just, you'll, you create your own limits and you'll stop learning. (11/4/2010, Question 15)

Teavo and Davina also described the instructor's reinforcement of the growth mindset concept and its relationship to their understanding the mathematics material. Davina emphasized the relationship between growth mindset, the instructor's support, and her own confidence. Teavo referred to this as "influencing" students and ultimately encouraging increased understanding and confidence.

> My Algebra 2 teacher, she was kind of influential and my Algebra 1 teacher, like I said. But right now, my recent one has influenced me to be more open minded about it. And I actually became a little more open minded to it, well, not a little bit, I became more open minded towards math and so, I'm with it right now, and I don't struggle because I understand it now. I know what she is doing and what she is teaching us, and for the first time I feel happy because I get what she is saying. I don't hear a teacher going 'blah, blah, blah,' I hear a teacher explaining the answer or problems, and so I feel more confident about it. (Teavo, 11/4/2010, Question 5)

Several students, including Spaceman, Manny, Davina, and Jessie, used the word "cares" or "caring" specifically. They described this as different from their past experiences and often exceeded their expectations. When asked if the course was what he expected, Manny was very affirmative: "Yes, yes, yes, yes. Especially the professor she's very nice, helpful, and she really, she's a genuine person, she, she, uh, cares a lot about her students and wants to see them succeed." When asked to explain what caring means, he expanded: "That she's always looking out for us, checking our work to see if we're doing good, and she's always asking us not to be afraid to ask questions and that she's there for us." Davina said the course was better than she had expected: "I think the teacher, she's more, she's more into you learning than just handing you something, just like she cares, she cares if you pass math." Jessie's description below (11/16/2010, Question 8) was similar and more expansive:

Jessie: Because I previously took a math class here, I thought the teacher would

> be, no this is the way you do it and not really caring but, Sylvia actually is. She's really, she takes her time, she, she wants us to understand it, you know? She, she's doing her job. She's caring. Like, she cares about her students, so it wasn't what I expected. I expected it to be not, not, her not so nice about it, you know? About math.
>
> *Researcher*: So, so when you say she's, she's caring, can you tell me a little more what that means to you?
>
> *Jessie:* It means her teaching, her teaching like the concept that she's doing and asking are you ok, you know do you guys get it? If not, we can go over it again, and she does go over it again if, oh, we need a little bit more explanation. And also on her practice quizzes online, she'd do, um, if you get it wrong, she gives you a whole explanation like why this is the way it's supposed to be, so actually explaining it to us, not just leaving you confused [because] oh I don't have time to answer your questions. It's like, oh yes, I have time to answer your questions. That's more caring.

Other students did not use the word "caring" specifically, but this essential quality came through with different adjectives. Linda, for example, identified the instructor as "the most important aspect of StatMode" and described the instructor in this way: "She's just, she's just always nice and polite, she just, she's always willing to help. She'll never tell us 'no' if we ask a question or if we ask for help." These types of perceptions were echoed many times by all students interviewed: the instructor was caring / helpful / patient / nice – all of which meant she cared about their learning.

In addition to describing an atmosphere permeated by students' questions and a variety of explanations, students described being asked for their ideas and sensibilities—and being encouraged to put explanations in their own words. Guss and Spaceman mimicked the open-ended of questions posed by the instructor such as "What do you guys think?" and "How are you guys doing?"

Involving Each Student

On the opening page of the 2008 article, Dweck described fixed mindset as a reason “bright students” often fear challenges and avoid learning opportunities. In addition, the article described stereotypes as “typically fixed-mindset labels” which “imply that the trait or ability in question is fixed and that some groups have it and others don't” (Dweck, 2008, p. 4). Dweck described studies where stereotypes were found to negatively affect student mathematics performance. Obviously, the instructor’s use of this article suggested to students her own belief in growth mindset. Moreover, within the growth mindset framework any student in the class might fit this description of the bright student who had given up on learning mathematics or succumbed to internalized stereotypes about mathematics. In any case, within the growth mindset framework the instructor takes the resolute view that all students have the potential to learn.

The StatMode instructor’s interest in *each* student’s learning appeared to be both evident to and important to many of the students. The capacity for success in mathematics resided not just in them alone, but in their peers as well. Within the noncompetitive classroom environment created, students were encouraged to believe in each other’s potential, to encourage each other, and to learn from the successes and challenges of others. Although the students themselves did not always frame these observations within growth mindset, they described a classroom setting that differed from other experiences—where student engagement was central and each student's learning mattered. One student spoke specifically about stereotypes. Several students spoke about the importance of group work in supporting growth mindset and motivation. Group work is analyzed at some length given its central role in the structure of StatMode and the degree to which students talked about it. Notably, while most students felt the group work was beneficial, the older women were unenthusiastic about it.

Student interviewees were consistent in their descriptions of a typical day in class. Students described the first portion of class as particularly interactive and collaborative, focused on concepts, data, questions, and explanations. This portion of class lasted from 9:00-11:00, and included what Spaceman and others termed "the lesson." SkyMarie succinctly described this portion of class as comprised of "new concepts… a lot of brainstorming… a lot of group work… and a lot of analyzing."

Within this typical class framework, each student was engaged and each student's learning was central. As Spaceman described it, "On a typical day I walk in and Sylvia, she'll take roll and she'll, you know, she'll get involved with us…. She makes sure everyone is involved." Teavo described it this way: "[We] come in. We discuss what we did for homework and if there are any questions to ask… we don't move on until everyone gets it. Until we get it, that's when we move on." When asked "how do you know" that the class is ready to move on, Teavo clarified, "Everyone participates in class, everybody talks, and that's when you can tell people are understanding what we are doing, what we are working on." Teavo's emphasis on "we" in "until we get it" indicates that peers were also involved in making sure all students in the class comprehended the material.

It was not only the Puente students who felt this way—that everyone was included. While the Puente students were encouraged by the Puente program to support each other as *familia*, Non-Puente students also felt connected to their classmates within StatMode. SkyMarie, a Non-Puente student said, "This class is different than any other class. It's a more social setting, it's a supportive class…. It's not student versus teacher, it's actually a community." Jackie, also a Non-Puente student, described how material was revisited during the first half of class through lecture, group work, and question/answer: "She'll ask if anybody has questions, and she'll make sure that everybody understands it." Linda, another Non-Puente student, elaborated that going over the homework was not about checking to see who got it right but rather deepening everyone's understanding:

> On a typical day, um, we start by looking at the homework, … figuring out what differences people had or what similarities, and we come to a conclusion and a general basis for every one of why this was the answer or why this wasn't the answer or what outward ideas make you think that made the answer probable. (11/18/2010, Question 10)

In other words, the emphasis was not on the right answer or how many students got it right; rather, the emphasis was on collectively determining *why* an answer was correct.

Jessie's exchange with the researcher (below, 11/16/2010, Question 17) indicated that students frequently encouraged their peers to regain or maintain a growth mindset. In addition to highlighting the role of peers, Jessie was one of the few students who raised the issue of stereotypes. SkyMarie also obliquely talked about stereotypes when she described race-based pressure to perform in math. (SkyMarie's reflections on race and math were included in the conclusion of the "best math experiences" subtheme earlier in this chapter).

> *Researcher***:** What would you tell another student about StatMode?
>
> *Jessie:* If you don't like math, definitely take StatMode because it got me to change my way of math… like oh yes, I can do it, you know it's… it got me again to like it, to like kind of love it. Going home and actually knowing what I'm doing, so maybe if you take StatMode, it will change your way of thought and get you ready into going to different, harder maths and not going with a fixed mindset that you're not going to, oh you're not smart, I'm not going to learn, it allowed me to open up again.
>
> *Researcher*: So, you said fixed mindset. Is that from the article? How was that article for you?
>
> *Jessie*: Yeah, it was. I loved it. To me, it was great because everything it said was something that I didn't know. That fixed mindset and growth mindset, I didn't know about and stereotype how maybe like an Asian person's smarter at math and a Latino person is dumber at math, you know, but it's more of your, the way you think, the way you open up to things like if you keep thinking I'm not smart enough for this, then obviously you're not going to be smart, you have to be open and think, 'I am going to learn, I am going to learn this, I am going to be good.' That's more of a growth mindset like, you're letting yourself, your mind grow not just putting a wall in front of you and saying 'I'm not going to pass this.' So, to me, I love the article. It was something that got me thinking all over again.
>
> *Researcher*: Have the students talked about it much in the class?
>
> *Jessie*: Yeah, we always use those two words: 'You have a fixed mindset right now…. I have a growth mindset right now.'

Micky also referenced the role of peers in reinforcing growth mindset when he described the importance of group work. According to Micky, group work was the most important aspect of StatMode, in part, due to fostering a growth mindset:

> I think working in a group definitely makes the answers come out like, correctly and it, it makes the class flow a little easier as [opposed] to sitting in your desk by yourself not talking to anybody [which] kinda makes it hard for you, so I think working in groups really gives you an open mind, open in a open mindset. (Micky, 11/18/10, Question 15)

Many students spoke about the prominence of group work in the morning class sessions. While no specific question within the interview protocol asked about group work, the researcher often asked students to further describe the group work when they mentioned it, typically with this question: "So, what do you think about the group work?" Some students particularly liked the group work, others had mixed or more negative feelings about it. Only one student (Guss) did not discuss group work.

Micky was the strongest advocate for group work; however, other students spoke strongly in favor of it as well. The four students who spoke most strongly in favor of group work included Spaceman, Manny, Davina, and Micky. Jessie and Wolf expressed less overt enthusiasm, but also spoke favorably about group work. Manny described the group work as "perfect," both because "we motivate each other" and also because students supported and assisted each other through uncertainty. He clarified, "Because she's only one person, she can't help everybody at the same time, we help out each other and stuff." Spaceman's response also implied that group work was one way students motivated each other and that it improved the pace and direction of class:

> It's good. It's a good way to see the other people how they're doing in the class. And because there are some people who are like, 'I don't get it,' and some people are really into it [so] they're asking Sylvia a million questions, when they mix with these people then everyone else kind of rubs off each other and we all go ahead in the same direction, so we all learn a lot at the same pace. (Spaceman, 11/4/10, Question 16)

Other students who spoke strongly in favor of group work explicitly noted their own approach to learning. Davina said the instructor "does a little bit of everything"; as a result, Davina explained, each student could benefit particularly from their preferred instructional approach. Davina then clarified why group work was particularly effective for her.

> So if something doesn't work for you, we have other things that do work for us. Such as, to me, the group work is what helps me. The other students say it's when the teacher's giving a lesson, that's when they learn, so I guess she does that, a little bit of lessons, a little bit of group work, and a little bit of practicing by yourself.... [Researcher: "What do you like about the group work? What seems helpful about it?"] The different ideas that come in and you realize what you're doing, if you're doing it wrong, you realize what you are doing wrong. And if you're not [wrong], you realize, you get confident. To me, every time I'm in a group, I realize how good I am and like, 'Oh, I got it right!' (Davina, 11/4/10, Question 9)

Some group work references implicitly or explicitly reflected growth mindset concepts. These included comments by Spaceman, Davina, Jessie, Micky, Wolf, and Teavo. For example, when Spaceman spoke about students asking "a million questions," he was referencing students' interest in seeking deeper understanding over correct answers. Jessie's response even more clearly articulated the relationship between group work and growth mindset:

> Because you know what helps that I never thought would help was, um,

> sometimes your answer is wrong and like, 'Oh, I get, I get why she's saying this,' but I was thinking at home that I was right like, 'Oh this answer has to be right, I'm right.' But when you get into groups, you hear other people's explanations towards it, towards their answer, and it starts to make sense so it gets you, it opens your mind a little bit more. (Jessie, 11/16/10, Question 10)

While Teavo saw the connection between group work and growth mindset, his endorsement was tepid: "I think group work helps you a little bit more better to understand the subject or problem, so it kind of helps with the group work." He clarified his tepid response as follows, implying some mindset-related benefits:

> Sometimes it is very confusing because a lot of times people are confused of it, and so sometimes I have to explain a little bit and then they are still a little bit confused, and so it's kind of hard. And sometimes the group work is very good because most of the time, people know what we are talking about and we figure it out together. We answer the problems together, we share ideas and you know, people understand a little bit more and if you do it as an individual--instead of working with three other people that you can share ideas--it would just be one close-minded person. (Teavo, 11/4/10, Question 12)

Teavo's feelings about group work were distinctly mixed, which set him somewhat apart from his peers. However, the responses of the three older African American women (Jackie, Linda, and SkyMarie) were vastly different from the other students. Both SkyMarie and Linda had marked reservations about group work, although they acknowledged the communal feelings it created within the classroom. Of all the students, Jackie spoke most negatively about group work. Her comments echoed the concerns about confusion and occasional lack of focus during group work noted by Teavo, but she stated her concerns less ambiguously. In addition to highlighting potential problems with group work, Jackie's comments suggest an age difference which she has observed:

> Um, the group work I don't really like because it's usually the blind leading the blind and so I work better on lecture first and um, if she lectures it and tells us what we're doing with it, then we can get into groups and I'm ok with that… although there's still um, most of the class, I would say are high school students, so they're all friends and they sit in the groups and they chit chat about facebook and they're not focused, so the group work, um, is hit or miss I guess. (Jackie, 11/16/10, Question 10)

Linda noted the affective support provided by the groups. She indicated that there were "icebreakers every day" at the beginning of the first semester "so we were able to feel comfortable interacting with each other and working together." She mentioned the occasional lack of focus of some students, "but nine times out of ten, everyone's determined to get the work and understand it." She described at some length the ways that students could "gauge each other's emotions or mood" in order to work more effectively with each other, particularly when someone was not "feeling it today." She noted the valued in learning to explain things. She also described how students sometimes seem to learn better from their peers than from the instructor, "because we're more on the same wave length." She further described,

> And sometimes they just tune out the teacher... It's completely just, [the instructor is] talking and they're just shut down and go visit Pluto and Mars and [then they] get together with the group and realize we have stuff to do now, I wasn't listening, what, what do we have to do now? (Linda, 11/18/10, Question 17)

The researcher frequently asked students to compare their experiences with group work in StatMode with other group work experiences by asking students, "Is it similar?" This question was primarily posed to Puente students since Puente students were engaged in group work within their concurrent English class. However, one of the strongest reactions about group work came from SkyMarie who emphatically stated that the group work in this class was “different than any other class” due to the degree to which students supported each other.

When students compared the group work in StatMode with group work in the Puente-related English, most students noted some differences. While Spaceman characterized Puente groups or *familia* as “comfortable,” he preferred the StatMode approach which constantly shifted which students were working together based on card color, number, or letter. He said this way interpersonal emotions did not “get in the way of work.” Teavo saw group work as less central to Puente English: “Mostly you have to do individual work.” He clarified, “[In English] we just have a small share together [regarding] what we read.”

A few students found some general similarities between the Puente group work and StatMode group work. Davina noted the utility of group work for “discussing, exchanging ideas.” Jessie also said “you do get to listen to other people’s points of views.” Micky noted the similar use of worksheets. But by and large, students did not see the StatMode group work as typical of other group work they experienced. Nor did they describe the Puente group work as creating the same degree of classroom community.

Wolf compared the StatMode group work with his high school experience. He recalled that during high school math classes, group work was approached as a way to complete homework: “We just let the smartest guy do the work, and then we copied off of him.” He contrasted that with StatMode:

> In this group work, she makes us think. She makes, she, either she separates the questions among the groups or she makes us think in our own different way on how to tackle the problem, so in my opinion, the group work here is a lot better because we become closer, we don’t just, ok, this guy is the smartest in our group, we’ll let him do it and then we’ll copy it. Instead, we’re like, ok, so you’re really good at making the graphs, you’re really good at solving the problems and I’m really good at analyzing the numbers, ok, we’ll all work together and we’ll come up with a concrete answer and that way, and that way we can double check with her before we turn it in that way, we know we did it right and if we did something wrong, we go back through it again. So, we work more as a group than as you know, the one smart guy doing all the work for us. (11/16/2010, Question 10)

Wolf did observe some influence from Puente in the group work:

> Well, the majority of the students … are also in Puente so we’re already friends. So the few people who aren’t in Puente, we’re kind of still little iffy with, but we’ll still get along with them. But if they put us all with Puente groups, we’re all already together, we know our ways of thinking, we know who will work and who will sit back and stay quiet and we’ll have to coax the answers out of them so, it, it makes things a lot easier that the people from the club are in the same class, that way we get each other a lot easier. (11/16/2010, Question 10)

As the preceding sections have shown, both the instructor and peers reinforced the growth mindset concepts and encouraged all students to participate in the learning process. Indeed, the structure of the class itself reinforced growth mindset through the use of group work (including not only small group discussions but also dyads, poster sessions, and other forms of group work and student interaction) which allowed students to expose and re-conceive ideas. This type of risk-taking (discussed next) is important to learning and foundational to Dweck's characterization of a healthy growth mindset.

Thinking Differently about Errors and Risk-taking

The Dweck article asserted that students with growth mindset were more resilient in the wake of setbacks and more able to learn from mistakes. Within growth mindset, failure presents as an opportunity to reflect on what worked and what did not work--then readjust one's approach to the material. Errors are "interesting" and "informative" and represent a normal--indeed welcome--part of the learning process. "Students with a growth mindset understand that mistakes and effort are critical to learning" (2008, p. 56). This seems especially counter to the traditional mathematics experiences students described where small errors are as problematic as large errors.

The admission of errors as a learning device within StatMode came from not only the students but from the instructor herself. The students found this to be liberating, as did the instructor who spoke about it during a discussion with the researcher. The instructor still guided the classroom, of course; however, students were permitted a degree of latitude that was unfamiliar. Guss poignantly described this as "letting students fly":

> I mean it was beyond my expectation, because you know for me it was ok math, you know, like dang, it's going to be like all over again, like sitting down listening to the teacher talk and me falling asleep and. But not. [This course is] dynamic. Especially [the computer graphing]. Ok, she's like, we're going to analyze this data and what do you guys think, what do you guys see? It's like, she actually gave us the control to go this direction, but she was always like

> directing us back and forth. She let us do the work, you know what I'm saying? And if we had a question, or so, we didn't know what to do, she would take over control. Giving us clues, making us think, actually. [In most other classes] you know like just the teacher, this, this, this, and this; this is how you're going to do it and there's no way else. (11/4/2010, Question 8)

Davina referenced how maintaining a growth mindset refocused her on learning and allowed risk taking. Her noteworthy description of StatMode "allowing" students to "learn more" was juxtaposed with high school mathematics.

> It's definitely true about how students tend to have fixed mindsets during, well to me, during high school, like everything was a struggle and I felt like I couldn't do better, but in my classes now, I feel very grow, growing. Sometimes like, I step back to fixed mindset but as I motivated myself so, I try to always have a growing mindset. I always try to learn more. In this class you're allowed to do that. The teacher is always there to, to help you grow or um, or for any work you do, she's there to, to give you the confidence when she tells you like what you did right and what you've done wrong and how you can fix that, and so that gives me a growing mindset. (11/4/2010, Question 17)

Notably, while students were allowed to "fly" and take risks, the observations by Teavo and Davina both include the notion that the instructor was never too far away and always available to assist.

The allowance for errors was not the only thing different about StatMode for students—and it was not the only opportunity for risk-taking. The statistics subject itself provided new and unfamiliar latitude to students, a change from prior mathematics. In statistics, a range of answers is often acceptable, and the concept of approximation is embedded within the subject. Several students (Guss, Spaceman, and SkyMarie) noted that statistics is not "black and white." Other students alluded to this as well, but not as succinctly. Guss described statistics as providing an opportunity to “play”:

> You can play around with it. It’s not like just straightforward like 2 plus 2 is 4. We’re looking at variables, we’re looking at dates, we’re looking at hecka stuff that in math, normal math, you wouldn’t see. It’s either this or this, it’s either you’re right or wrong. But here, like I told you, you can actually play around with the data. (11/4/2010, Question 9)

For Guss, this was the most important aspect of StatMode and it affirmed his intellectual abilities:

> Well, it would be the handling of data, most of all, you know. Because she gave us certain data and she tells us look at it and see what we see, you know what I’m saying? Like to tell her really what the data can tell us, you know. That would be like the most important thing. (11/4/2010, Question 15)

Spaceman made similar observations about StatMode and statistics:

> It’s not really like any other math class I have ever taken because StatMode is different, it’s not all about the text book, it’s not, it’s not like more, it’s not black and white, it’s kind of like they’re telling you to see different ways of analyzing information and thinking through different things. (11/4/2010, Question 9)

In comparison, Spaceman described his other math classes as “just, go to the text book and do this and that.”

Students characterized the latitude afforded by StatMode as engaging their “critical thinking” and allowing for a “point of view,” versus mathematics epitomized by a predetermined series of steps required by the instructor. SkyMarie said, “There’s more variability and there are more pathways to the answer you know? It’s not a rigid type class. That’s why I like it.” SkyMarie contrasted this with earlier mathematics experiences:

> It’s not an ‘I don’t want you to think for yourself’ type of process, you know,

> [where the instructor] wants you to know how to line this up [and] when you line it up, you better get what I get. [Then] I give you a good grade on your test. (11/4/2010, Question 6)

In addition to SkyMarie, critical thinking and having a point of view was emphasized by Teavo, Davina, Jessie, Wolf, Micky, and Linda. Davina described it as “It’s more thinking in your mind,” which appeared to be contrasted with rote performance where students “do everything step-by-step.”

Thinking critically and having a point of view were not seen as solitary efforts. Students engaged in risk-taking where their ideas were examined, discussed, and evaluated by their peers. Their explanations might be right or wrong, but discussion deepened understanding.

> [W]e get into groups and discuss the answers, why we got them, there’s disagreement, there’s agreement, then finally we just, if we disagree, we’ll just say just see what Sylvia says. [We say] let’s see, let’s see who’s right because we both have explanations to our answers and after we’re done discussing it with groups, because you know what helps that I never thought would help was um, sometimes your answer is wrong and like oh, I get, I get why she’s saying this but I was thinking at home that I was right like oh this answer has to be right--I’m right--but when you get into groups, you hear other people’s explanations towards it, towards their answer and it starts to make sense, so it gets you, it opens your mind a little bit more. (Jessie, 11/16/2010, Question 10)

As with other subthemes, a few students (Manny and Jackie) did not appear to be deeply affected by the allowance for and opportunities for risk-taking and opinion-sharing. Jackie casually described enjoying a writing assignment that was “pretty interesting and fun to do because I’ve never done anything like that before,” but this comment was overshadowed by the bulk of her interview which showed her to be among the most highly pragmatic of the interviewees. This pragmatism may be related to the fact that she was the oldest of all the interviewees and was especially determined to complete the course regardless of the material.

Like Jackie, Manny was one of the older students. Along with SkyMarie, he could not identify a "best math" experience. Moreover, throughout his interview, Manny made several statements which suggested a strong risk-aversion. Conversations with the instructor as well as comments throughout the interview confirmed that Manny failed to embrace a growth mindset and resisted risks. Several of his comments emphasized a desire for external validation. Manny described wanting to be seen as "not dumb and confused" within the class. "I feel like I could tell someone oh I'm in statistics and they'd be like, 'Oh wow statistics.' Like, it makes me feel like I'm getting smarter."

To summarize, both the instructor and the subject matter itself were permissive of errors and exploratory latitude which allowed students to take risks. This seemed important to nearly all the StatMode interviewees. This relationship between latitude (what SkyMarie called the "gray" of statistics compared to the "black and white" of other mathematics) and intellect will be discussed further in the next section which addresses StatMode students' motivations for learning statistics.

Summary

Student interviews revealed three major themes, two of which were covered in this chapter. The first theme, *Initial Mathematics Attitudes and Backgrounds,* showed that students historical mathematics experiences were largely negative, characterized by fixed mindsets and limited effective encouragement. However, most students described at least one positive, recent experience prior to enrolling in StatMode.

The second theme, *Perceived Power of Growth Mindset*, revealed students' new sense of competency with regard to learning mathematics in StatMode. Students spontaneously and enthusiastically discussed "growth mindset," a concept introduced by the instructor early in the fall semester. Students were not merely exhorted to maintain a growth mindset. Rather, they were exposed to information about the relevance of growth mindset for learning in general and for mathematics in particular, as well as for addressing stereotypes. Students described a classroom atmosphere and pedagogical approach where all students were actively included. Students were asked to care about their own learning, as well as each others' learning. Moreover, students were clearly aware that the instructor cared about their learning, and they contrasted this with prior mathematics experiences. Finally, students were encouraged to take risks and allowed to make errors within the context of a pre-statistics class where answers are often not "black and white."

Chapter Six: Student Motivation and Classroom Observations

The final theme from the student interview data was *Motivation through Intellectual Engagement.* As shown in the prior chapter, a majority of students attributed their success in StatMode to a new frame of mind typified by a willful decision to embrace a more confident attitude when approaching the mathematics material. However, this *willingness* to engage does not fully explain students' underlying motivations for continued engagement.

Motivations for engagement are explored in this chapter, including students' responses to prompts investigating contextualization, an anticipated source of motivation. The motivation-related subthemes presented in this chapter are as follows: (a) overwhelming enthusiasm yet enduring pragmatism, (b) limited views on applicability, and (c) deep engagement with challenging material. The latter subtheme in particular expands on the growth mindset theme presented in Chapter Five.

Student interviewees were overwhelmingly enthusiastic about their StatMode experience and the instructional approach. Any suggestions for changes to the sequence were almost entirely logistical, and several students reported they were encouraging peers to enroll. This enthusiasm, however, was consistently counterbalanced by an enduring sense of pragmatism regarding their need to "get through" math in order to achieve their transfer goals. Students spoke frankly about the mathematics requirement as their chief motivation not only for enrolling but also for striving to do well. Many continued to question the broad utility of mathematics.

The researcher had proposed that statistics contextualization would figure prominently in students' motivation such that students would begin to view statistics as highly relevant and applicable either to their chosen fields or to their everyday lives. However, this was only weakly evidenced through the interviews. Beyond a class-related cereal project, only a few students cited specific examples of how they had applied their new knowledge. Students spoke of those instances as an unexpected boon, not a crucial motivator.

In addition, other forms of relevance, e.g., cultural relevance, were not found to figure prominently. While this was not fully investigated due to limitations of the context and study design, it is worth mentioning that students did not make any unprompted references to desires for more meaningful or more relevant course subject matter. Social justice issues were raised by one student. He made a positive statement regarding the degree to which the course has allowed him to become more critical of potentially biased statistics, particularly those statistics which might reflect negatively on his ethnic community.

Instead, students' descriptions implied that their ability to reason and think critically was not only affirmed (per growth mindset) but continuously solicited and engaged (through interaction with the instructor and through the pedagogical cycle). Students described feeling motivated by and excited by their ability to seek out and build deeper understanding. They characterized the instructor as not only responsive to their questions but actively solicitous of and interested in their questions. They explained that the instructor responded to questions in detail, providing not just solutions but thorough explanations. These detailed explanations seemed profoundly important to nearly all the student interviewees as they sought deeper, more conceptual understanding.

Finally, this chapter depicts several StatMode class sessions. Four separate class sessions, consisting of two hours each, provided windows into the students' classroom experience, including pacing, range of activities, and student engagement. The first class session is presented in full to most clearly illustrate pacing. Excerpts are included from the other three class sessions. Student interview data was triangulated with classroom observations and informal discussions with the instructor. This triangulation is presented in the next chapter.

Motivation through Intellectual Engagement

This third and final theme from the student interviews explores what appears to be most important to students during their first semester in the StatMode sequence. Students' enduring pragmatism is noted, reflecting the fact that their primary reason for enrolling in StatMode is to fulfill a mathematics requirement and move further toward transfer. While enthusiastic about the sequence, students did not tend to be wholeheartedly excited about practical uses of statistics or the meaningfulness of the subject area. Instead, students were motivated by the learning process itself, grappling with challenging material, and seeking deeper, more conceptual, understanding within a responsive and supportive classroom environment.

Overwhelming Enthusiasm Yet Enduring Pragmatism

Students were overwhelmingly enthusiastic about their StatMode experiences. Students' positive feelings about the class were evident from their responses to "What would you change about StatMode?" Most students (six of the eleven) declined to identify anything they wanted changed. This included Guss, Spaceman, Teavo, Manny, Jessie, and Micky. Moreover, many students took the question as an opportunity to reiterate the aspects of the class they liked, as exemplified by this student's response:

> Um, I would change... I wouldn't really change anything really. You have to go to class for math, she really breaks it down, she does her lessons, she doesn't make it too long, she makes sure everyone is involved, she does a lot of group work, the class is over before I know it. It's like, it goes really fast because I'm involved a lot, and then we have computer time in class. (Spaceman, 11/4/10, Question 16)

Five students had suggestions for changes; however, all but one of the suggestions related to duration, location, or the availability of course tools. SkyMarie had the most suggestions: three. She wanted the class to meet three days a week for shorter sessions rather than the current arrangement of twice weekly for four hour time blocks, she wanted classes to be offered in the evenings so that it could be available to more students, and she wanted the computer graphing program to be available for home use on a temporary license. Jackie and Wolf were even more emphatic about the class length and described the four hour time block as "way too long." Linda also felt the four hours was too long but took the opportunity to highlight in some detail the aspects of the class she would *not* change:

> Ooo, that's a good question. Um, the only think I can really think of would be the times, just like the length of class a little bit. I would kind of, instead of having it, I don't know, it would be weird, I would kind of say instead of having it be eight hours, kind of cut it in half where it's like hours a week where you do one hour for each day of the in class teaching and then an hour of computers for the tinker plots just because sometimes it can interfere with other classes and work schedules and it's kind of a lot, but other than that, I wouldn't change the teaching style, I wouldn't change the work or the way or the rate or the timing of how we are learning the different things--how they integrate this new concept but still apply it to the old ones. I think that's really working with us because it's relatively fresh in our minds to where we could actually still make the connections ourselves and see where things are going instead of having to think way back to five or six months ago when they first introduced this one concept and now they're connecting it to this one which has been months later and you have to kind of think back, whereas with all of these, it's smooth, even flow of information and concepts being that we're learning. (Linda, 11/18/10, Question 16)

Only Davina had a substantive critique of instruction, and she noted it at several points during the interview. She wanted less time on "lessons" which she defined as "when the teacher's speaking and talking." She said the instructor "can lesson for like 20 minutes and then I need to practice it, and like if it's 30 or more [minutes] I don't really need that for myself but some other students do." In addition, as noted in Chapter Five, the older women expressed reservations about the extensive group work.

It should be noted that students were keenly aware that the class was being observed not only by the researcher but by others as well. They were aware that, as a "pilot," it was being considered for either expansion or termination. Manny's response reflected the concern several students expressed regarding their perception of the need to have such as pathway.

> I wouldn't change anything, I like how it's going, yeah. I feel like it's a perfect scenario for uh, people to uh, grow and uh, to, I feel like this class needs to stay because I feel fortunate for this class and, and I would feel bad for the other students who, who don't have this, don't get this opportunity because they'll, they'll just probably drop out of school. (Manny, 11/4/10, Question 16)

As this section shows, students described being extremely satisfied with the StatMode material and the StatMode approach. Despite these positive feelings about StatMode and despite the mindset changes students posited as essential to their successful learning, students remained primarily pragmatic regarding both StatMode and mathematics.

Enduring pragmatism and detracking.

Students revealed their pragmatism many times over in the interviews, including how they characterized StatMode to their peers, their sense of whether they would need math in the future, and their continued resistance to "the importance" of mathematics. As an example of this pragmatism, when asked what he would tell other students about StatMode, Spaceman's said, "I would say it's a good class. It's a good way to get your, most of your math out of the way." When asked if he would need math in his target profession of criminal psych, he replied, "I don't think so." For Spaceman, despite his praise for StatMode, mathematics remained first and foremost a requirement.

Spaceman's responses were typical of the interviewees.

The following responses similarly focused the appeal of StatMode down to the most essential necessity, which was "getting through":

> Cuz that's like hecka stuff that I might need but I might not. But this is a straight shot… one teacher and that's it. (Guss, 11/4/2010, Question 7)
>
> You get your math over with and quickly and you don't have to worry about it for the next semesters of college. (Wolf, 11/16/2010, Question 17)
>
> It's very important because without mathematics, you can't [transfer] anywhere else. (Manny, 11/4/2010, Question 13)
>
> I've been telling everyone about it. I would tell them if your goal is to transfer, don't give up, because there is a course that can help you with your frustration. (SkyMarie, 11/4/2010, Question 17)

Students' overarching pragmatism about the accelerated sequence should not be surprising since it was the reason many enrolled. The emphasis on the value of a two-course sequence suggests that these adult students did not feel they were being tracked away from opportunities. If anything, they felt fast-tracked toward opportunities.

Jessie was a rare counter-example regarding the importance of acceleration to the students. She actually enrolled in order to take *more* mathematics. Her presumed major requires her to complete calculus; however, she wanted to enroll in StatMode in order to overcome her negative feelings about math. She emphasized that an additional math class or two "doesn't hurt."

Beyond pragmatism.

Beyond simply getting through, several students said they would tell peers about being able to understand the material, being less frustrated, and being more confident (Davina, Jessie, Jackie, and Linda). Micky was the only interviewee who focused on the course content in response to what he might tell another student: "[I]t will definitely help you in your, in your uh, in real life. And out in the real world, it will definitely help you." He also provided an example of how he used his new knowledge outside of the classroom (beyond cereal analysis which had been a class assignment and which seven students referenced when prompted for an example of relevance):

> I'm learning how to read data. Scatterplots and like, I really like the scatterplot. So I can go into a daily newspaper and just look at you know, sometimes I look at the stocks, and I see how like there's a lot of similar graphs that I see in StatMode so I know how to read that, like positive or negative associations, and I think it's really, like really cool that I can read that because back then, I just used to say that's just a bunch of numbers, what does that have to do in my life? (11/18/2010, Question 12)

Note, the question about what interviewees would tell another student about StatMode was preceded by questions about the relevance of the course material, not questions about sequence length. There were no direct questions about sequence length in the protocol. Yet this was the response from most students, except Micky. Students' limited views regarding current and anticipated applicability are presented next.

Limited Views on Applicability

Students were asked about the importance of math to them personally, for their anticipated careers, and in everyday life. In response, most students spoke about statistics in a perfunctory way. In other words, they spoke of statistics as a requirement for their major or a requirement to graduate rather than a set of skills they were likely to need in their careers. While some were willing to concede that statistics *might* be important, perhaps *marginally* important, they were not especially enthusiastic about its applicability. That statistics or mathematics might be important or necessary at some future point did not appear to be a primary, secondary, or even tertiary motivation for their learning.

Direct challenges to utility.

In fact, more than half of the students interviewed explicitly questioned and resisted utilitarian arguments for mathematics in general, while making occasional concessions for statistics, including Teavo, Wolf, Manny, Jackie, Linda, and SkyMarie. Wolf phrased it simply: "[I]f math is what you need [for your major], of course that is going to be important, but if it's not what you need, then why take it?" Manny said for him math was a "waste of time," but "I feel like statistics you need it more in life than algebra. I think algebra is for like if you're going to get like a science major or math major and statistics helps you in the long run." An older student and one of the two students with the strongest math aversion and no "best math" experiences, Manny said that he refused to take math at MCC until he heard about StatMode.

The three older African American women, along with Manny, were the most unabashedly dismissive of the mathematics requirements beyond statistics. SkyMarie said as if speaking to someone who had tried to convince her of its import, "And I think a lot of the times it's unnecessary because you don't really use too many algebraic equations in life, you really don't." She did foresee "using a lot of percentages and things like that" in her career. Linda also commented, "[W]e don't use the calculus type, trigonometry type, um, mathematics in everyday life, we do use basic math… [but] not as much as you would think when they say it in like classes." Jackie asserted, "I don't really know that for my specific field of work that I would need to know the other kind of math, like calculus and geometry and stuff like that, so I think [math is] really important based on the career focus and how you're going to use it and why." When asked about statistics she said it is "probably" important and cited being able to read articles "…and be able to relate to it and know the vocabulary and know what the study meant and why they were doing it and how they got the percentages they did…."

Teavo expressed a willingness to remain open to the possibility that math might become more useful to him. It seemed to be a concession he was struggling with internally:

> I don't think it's important to me but I think I'm still going to have to use it in life, but I mean, other people who want to use it, it's available to you, but for me it's not important. I haven't used it a lot, and so I can't say it's not important and [that] I'm never going to use it because actually some of the lessons that she has taught us, some of the work she has taught us, I have used in some of my classes. (Teavo, 11/4/10, Question 13)

In the subsequent question, Teavo was asked to cite an example of using his new StatMode-derived knowledge in your his everyday life. He selected an example of using statistics for a paper in another class, and he seemed pleased about it the response he received from the instructor, but he reiterated that math was "was important" to him.

> An example, find the percentage of people who… I had to use equations or categorical data that we had learned in this class and I used it in my criminology class to write a paper and it actually came out pretty good because my criminology teacher appreciated that I used some math in my paper. And she kind of figured it out, 'Oh, so I understand what you are trying to convince me with [the data]…..' I think you could see that [math is] not important to me but I have to learn it so I can use it in the outside world, you know? (Teavo, 11/4/10, Question 14)

Breakthroughs in understanding leading to usage.

Teavo's example suggested percentages and proportions were something he felt comfortable enough to use and was able to apply "in context." Jackie also talked about percentages (see prior quote). Along with Teavo and Jackie, SkyMaria, Davina, and Linda spoke about breakthroughs in their understanding of proportion and/or the importance of having an understanding of proportion. SkyMarie anticipated "using a lot of percentages and things like that" in her chosen field of public health. She described a breakthrough she had in understanding the importance of proportion during a class assignment analyzing cereal ingredients.

> So I have learned in my everyday life that um, a small number does not mean that it is a small fraction in other words when I say, oh it only has like 18 grams of sugar, compared to what? You know? And so that's like a big deal that I have taken away from this course is how to analyze and how to find out, um, is this information biased at all. (SkyMarie, 11/4/10, Question 14)

Davina's breakthrough was similar:

> I think right now [math is] important because everything I am learning, I am putting it into my life outside of school like, I find myself like, well in the beginning I found myself putting fractions into what I'm talking about, like this is percent… It would be whatever I was talking about like 20 percent… I would just be talking about it, so it's important, it's important because it's another way of thinking, I guess. (Davina, 11/4/10, Question 13)

When asked about the math she would need for her chosen field of nursing, Linda also focused on proportions (expressed in terms of dosages), although her sense of mathematics applicability seemed broader than SkyMarie and Davina (including rates and conversions):

> I'm going to need to know how to convert different types of um, liquid measurements… I'm going to need things not only for the medicines I'll deliver, but how much of this will affect the measurements within the body and how fast it will circulate through so it has, it plays a very heavy role in, in nursing because everything is kind of built on numbers and distributions like weight and height, age, all that plays a factor in how much of a dosage someone can get or whatever their ailment is so, it has a, it has a lot to do with it. (Linda, 11/18/2010, Question 13)

Beyond proportion, there were few concrete examples of current or anticipated usage. A rare example was Micky's description of reading scatterplots in the newspaper.

A classroom project with everyday relevance

One "everyday life" usage was cited by several students: the cereal project. Seven interviewees (Spaceman, SkyMarie, Manny, Jackie, Jessie, Wolf, and Micky) referenced and described this project, which was a class assignment. Jackie's comment suggested a reason why this novel project remained prominent in students' minds: "Our first real assignment was writing a paper on cereal data and so that was pretty interesting and fun to do because I've never done anything like that before." SkyMarie highlighted how the cereal project differed from math projects she had worked on in previous classes:

> I'm a mother of two children and for instance, we've been working on cereal data analysis and it's not just about math, it's almost not about math, because

> now I, you, can determine nutritional facts. We had to learn how to read the ingredients, read the labels, take out that categorical information--sugar and fiber--and put that into quantitative. So how much of this is good? How much of this is not good? (SkyMarie, 11/4/10, Question 14)

Manny became particularly animated in discussing the cereal project:

> [StatMode] makes me more aware, like everything I look at, it reminds me of StatMode because I compare data to see if… for example, the cereal data got me aware of how children's cereal has more sugar than adult cereal and I grew up on cereal and I was like, wow, and that's what causes children to be obese because of the sugar and all of that so now in the future, when I become a parent, after analyzing that data, I'll be more aware of not feeding my children, uh, like sugary cereal. I want them to have less sugar cereal for example. [It] just makes me aware and I would want to see stats in everything. (Manny, 11/4/10, Question 14)

Manny's quote strongly suggested that he has begun to see the world differently through statistics. Two students, Wolf and Jessie, described more pointedly how the cereal project was merely an *example* of seeing the world differently.

Wolf comments (below) were a rare reference to social justice issues. Notably, throughout the interview Wolf remained resolute in questioning the importance of math, including statistics (e.g., "Statistics is something that I don't mind learning… but if it's just 'Oh cool, I can look at stats a lot more efficiently now…,' then why do we need to learn this?") Despite this resistance, Wolf suggested that class assignments like the cereal project made him more analytical.

> Every day I see new statistics…I didn't realize how blindly I was looking at them before. I just saw them and accepted them… but now I see the drop-out rate and all that stuff and I go more in depth with them and that way I can, instead of just basing my opinions on what those people think, I can create my own opinions and say these guys are wrong because they're saying if 50% of Latinos and 20% of the African American community are the most that are

> dropping out, I find that wrong because… there are other African Americans that don't go to school, there are Latinos who have just moved in from Mexico and can't get into school, and so on a so forth. We can look at the other factors so, I can make my opinions a lot more intelligently with what I'm learning here than I could if I didn't take [statistics]. [What's most important is] learning how to take those statistics and look at the outliers or the other variables that come in question and it helps you base, it helps you make your own opinion a lot better, it helps you build your own answer instead of just blindly accepting what they say, oh, 50% of Latinos are dropping out of high school. That means that half of my family is going to drop out, no. Gotta take into account other variables, it can't just be what they say. (Wolf, 11/16/10, Questions 14 and 15)

Jessie also stressed that the cereal project was one example of "learning how to observe," provoking a way of seeing the world from a more critical perspective. Jessie noted, "It is important because you're using it in your everyday life, not just once and you're forgetting about it. It sticks with you."

Summary of applicability.

As this subtheme shows, some students were able to put their new mathematics knowledge to use, even during their pre-statistics semester. Occasionally students were excited about this. However, students continued to resist the notion that mathematics, including statistics, was or should be particularly important to them. Interest in the subject matter and its perceived practicality were *not* foundational to their motivation for learning.

Nor were cultural relevance or social justice primary motivations, perhaps due to the fact that the course did not focus on these issues. In private conversations the instructor was clearly committed to social justice issues. For example, she spoke about students' varying levels of cultural capital with each other in the classroom and how she tried to increase the social capital of lower-status students through her responses to them during group work. However, she believed putting emphasis on social justice topics within the classroom would likely distract from the statistics-related learning. While this area could not be fully investigated for reasons noted in Chapter Three, there was no evidence that students wanted more culturally relevant material.

Deep Engagement with Challenging Material

Ultimately, beyond fulfilling mathematics requirements for transfer, students seemed to be motivated by their own ability to learn; more specifically, they seemed motivated by their ability to engage critically with challenging material. Several students described statistics as a challenging subject and something they felt proud to learn. Many students felt able to face this challenge (statistics) specifically because it allowed them to bring their reasoning skills to bear—it wasn't just numbers and equations. Students' responses implied that as they experienced increasing competence within the sequence, the learning itself became rewarding. This sense of competence appears to have been nurtured and sustained at least in part through students' sense of being able to learn the material more deeply (i.e. more conceptually), rather than just "get through."

Statistics as legitimately challenging.

In her conception of growth mindset, Dweck asserts that learning is associated with a willingness to tackle *challenging* material. Through tackling challenging material and succeeding, students experience the value of effort for learning, i.e. for increasing intelligence. While StatMode students were not necessarily convinced of the broad applicability of statistics, they believed it to be a "real" and challenging subject. Statistics does not have a reputation for being "easy." As Wolf said, "I had one friend, she graduated a year ahead of me, so she's been here a while um, and she told me that statistics was the hardest thing she's ever taken…."

Students appeared to be excited by and motivated by the fact that they were *already* learning statistics in the pre-statistics class (Guss, Teavo, SkyMarie, Manny, Davina, Jackie, Jessie, Wolf, Micky, and Linda). Spaceman was the only student who did not describe the pre-statistics course as already comprising statistics. However, he did characterize it as emphasizing "different ways of analyzing information and thinking through different things," and he noted that it was unlike any math class he had taken previously. The fact that students felt thoroughly and explicitly prepared for statistics as of November in the fall semester may partially explain the high student re-enrollment rate in the spring. Teavo said that StatMode "...turned out to be something nice for me… I understand it [and] I'm getting to know what is going to be Statistics next semester."

In fact, this sensibility of already being immersed in statistics material was so strong that several students referred to the pre-statistics class as a statistics class. They based this assessment on what they were learning, the vocabulary they were using, and comparisons they made when talking with peers who were already taking statistics. For example, SkyMarie called StatMode "our statistics class" and clarified, "I'm learning to analyze data, like scary data, like um, to put them into categories, to know the difference between categorical and quantitative data…." Jessie expressed a similar sentiment:

> We're learning, the majority is analyzing data and um, right now we're actually learning, we're doing scatterplots, the Y axis, X axis, she gives us A, B and C in different small prompts and see which one matches the um, scatter plot. And, it is difficult because you say, oh this could match this one or this could match this one, but that's basically what it is--observing, knowing which one is which, collecting data. To me it's statistics already because don't you learn that in statistics? (Jessie, 11/16/2010, Question 12)

The following quote by Linda shows her excitement about learning a challenging subject and feeling comparable to her peers in statistics classes:

> There's, um, friends and they have math or they're talking about something in math, and they're like in statistics or above, and I'm like looking at the paper and it's like, 'Oh well, break it down this way,' and I'll like show them how we've done it in this class and they'll be like, 'Are you even in statistics yet?' and I'm like, 'No I'm in an intro class and I can do it,' and they're like 'Wow.' (Linda, 11/18/2010, Question 14)

Bringing intellect to bear.

A majority of StatMode students expressed how statistics "exercises reasoning" or critical thinking, including analyzing data and problems, and providing explanations (Guss, Spaceman, Teavo, SkyMarie, Wolf, Micky, Jessie, and Linda). Many of these students directly asserted or clearly implied that they believed these reasoning skills were more important than general mathematics or statistics knowledge per se. Spaceman said, “StatMode is a lot of analyzing and problem solving… I think that’s what I need also in life….” Guss described it as learning to look “at both sides of the story.”

Related to reasoning and explanations, several students noted that statistics was not “just about numbers.” These students (Guss, Teavo, SkyMarie, Manny, Micky, and Linda) articulated how the use of words and reasoning made the subject more approachable than other mathematics.

> I had a lot of anxiety because the word ‘statistics’ is scary. Just that word. And um, when I finally met [Sylvia] she broke statistics down in to something that was doable. It’s a critical thinking and psychology course and I could do it. (SkyMarie, 11/4/2010, Question 3)

> Like, when [the instructor], when she talks, like, it’s an easy flow, it goes into my head, the vocab, so she uses vocab and then numbers, and it’s, they all just fit in the same. They’re organized in my head and I understand it really good. (Micky, 11/18/2010, Question 8)

Linda compared it to math classes where she was expected to mimic the instructor versus being asked to reason and explain why a particular approach is preferred:

> [The StatMode instructor] actually makes us kind of go through each problem and figure out why we have to use that formula or why it’s this way and not this way and we have to think about the other variables and problem as well so, she has us doing not just math, but other elements of um, different subject like you know, thinking and problem solving and just as, it makes it more easier for us to understand why, because when you understand why you’re doing something, you’re able to complete it better, I think, so. (11/18/2010, Question 9)

Perhaps partially as a result of this intellectual engagement, students described being interested in understanding the material more deeply.

Seeking deeper understanding.

The instructor promoted learning as described in Chapter Five by showing that she believed each student to be capable of learning the material and that she cared about their learning. These were not idle assertions but rather palpable beliefs which appeared to be built into every class, from the onset of each class meeting. The instructor immediately “got involved” with students (per Spaceman’s characterization), engaging them in a regular review of their understanding, actively encouraging them to ask questions, and patiently responding in detail to build conceptual knowledge. Triangulation between the classroom observations and discussions with the instructor further revealed this emphasis within StatMode. However, the students’ words also suggested they were conscious of as well as appreciative of the instructor’s attempts to facilitate deeper understanding.

In describing the “the first half of class,” students emphasized explanations, either that the instructor provided or that they shared within their groups. Explanations might be related to specific variables and data more generally, as well as statistics-related concepts and vocabulary. This was a particular manifestation of care which the students noted and contrasted with previous experiences where math instructors were impatient or responded in ways that were not helpful (e.g., “simple sentences,” “three steps ahead,” “very fast and sloppy,” not really understanding the students’ questions).

Students particularly emphasized the degree of detail or comprehensiveness of the explanations. Teavo stated it simply: “Sylvia goes through all the problems with us.” Davina noted the step-by-step approach. Spaceman said, “She really breaks it down.” Wolf (and others) indicated the same process, “So, usually we get to class, we pull out our papers and she comes… checks the work and then she goes over the homework…she goes into it in as much detail as possible.” While Wolf was the only student who openly complained about the degree of detail by saying sometimes it was “boring” and sometimes the instructor was “too nice,” he also acknowledged, “That’s one of the qualities that I enjoy, that she’s always there for us regardless of our level of statistics. He then added, “And it’s cool because she makes us question our original answers.”

As Wolf implied, the focus was not exclusively on checking whether homework was complete and accurate, or whether students had questions. The instructor also sought to promote conversations where students tested their knowledge and understanding by comparing answers and explanations. This was already presented earlier in this chapter, within the growth mindset subtheme related to errors and risk-taking. Several quotes in that subtheme portrayed how students would discuss and test each other’s ideas. Linda’s description was similar:

> On a typical day, um, we start by looking at the homework, going over the homework if we had any problems, figuring out what differences people had or what similarities and we come to a conclusion and a general basis for every one of why this was the answer or why this wasn’t the answer, or what outward ideas make you think that made the answer probable, and then we segue into the lesson for the day, which generally has something to do with the worksheet.

(Linda, 11/18/10, Question 10)

Thorough discussions and posing questions were not the only means used to deepen understanding. Several students noted the instructional cycle used to deepen students' understanding through "revisiting" and "connecting" material within a class period and between class periods, and using multiple approaches to cover the same material. Regarding within class cycles, a student provided this description:

> She'll lecture the concepts of it or she'll put us in groups with the paper and we'll, you know, work on the lesson amongst each other and then she'll revisit, she'll give us time in group to go over it and then she will revisit the idea, and kind of explain, you know, what's happening in the paper, and she'll ask if anybody has questions. (Jackie, 11/16/10, Question 10)

Jessie also noted how the instructor revisited material, although her response focused on the variation of approaches.

> The way the teacher explains it, definitely helps you more to learn and to grasp and to stay with me. Um, the variation she does, group work, she'll explain it on the board, and if you don't get it then it's like a one-on-one personal level. (Jessie, 11/16/10, Question 10)

Micky said of the variation in approaches, and the overall structure of the class sessions, "I think it's really, it's a really cool process."

Students seemed less aware of and less articulate about between class cycles, but Linda was especially perceptive:

> Each week we learn something new and so for those two days, like the first day will be the intro and the next, and the following Thursday will be like the follow up and so it makes it easier because it connects … it draws connections to what we've done Tuesday or last Thursday or last Tuesday so that [we're] constantly reminded of what we're learning and how they all are connected. (Linda,

11/18/10, Question 10)

Students further tested their ideas and explored their understanding through the second half of class which was occurred in the computer lab. Students who spoke about the lab described being able to directly manipulate the data in order to study the data and test ideas. This second half of class also included group work, pair work, and other forms of interaction questions and answer activities.

Summary of Motivation Theme

Overall, students appeared to be motivated primarily by a sense of pragmatism regarding "getting through" college. Their sense of the relevance of statistics seemed constrained, and in fact several students persistently asserted that mathematics was not important to them. As a source of student motivation, statistics contextualization seemed nascent at best in terms of practical application either in career or everyday life. However, the statistics sequence appeared to be motivating insofar as it represented challenging material which students were proud to be learning. Notably, although still characterized as a difficult subject, several students described statistics as more approachable than other mathematics material due to an emphasis on reasoning and use of words. Finally, the fact that students were deepening their understanding of statistics concepts appeared to be additionally motivating. Students described regular classroom activities emphasizing students' questions and thorough explanations, which they attributed to Sylvia's patience, care, and concern for their understanding. Student contrasted this with prior mathematics experiences in which they felt their questions were often unanswered and they felt frustrated by not understanding the material.

The classroom observations and discussions with the instructor substantiate and clarify how the instructional approach emphasized conceptual understanding. Classroom observations are presented next.

Classroom Observations

The following four classroom observations exemplify and broadly substantiate the students' observations about the nature of the classroom environment. Students are denoted by gender and presumed ethnicity, e.g., LF for Latina and Female. For each activity, students were further denoted using numbers (e.g., LF1, LF2); however, these numbers do not uniquely identify individual students. For example, LF1 during the first small group breakout and LF1 during a subsequent class activity were not necessarily the same person. Note, specific ethnicity was unknown to both the researcher and the instructor (both of whom were white and female). While in most cases ethnicity could be assumed, the researcher acknowledges that the classifications used in this chapter do not necessarily represent students' own racial, ethnic, and national origin identities.

During the fall 2010 semester of StatMode, the class met twice a week, on Tuesdays and Thursdays. During the first two hours of each session, from 9:00 to 11:00 a.m., the class occupied a standard classroom. Activities consisted of a mixture of group work, pair work, class discussion, and short lecture. Small groups, typically ranging from three to four students, were assembled based on cards which were randomly distributed during each class session. Students were grouped according to card color, card number, or card letter. Thus, not only were students grouped differently each class session, but groups were rearranged within class sessions as well. The instructor used a white board as well an LCD. The class typically took a break from 11:00-11:30 a.m.

During the second half of class activities resumed in a computer lab directly across the hall from the classroom. This portion of class lasted until 1:00 p.m. The computer lab contained more than enough computers so that each student could use one. The room arrangement included moveable chairs and large flat screens on pivots. There was also an LCD which the instructor was able to use to make any individual student's work station visible to the entire class.

The researcher observed two partial class sessions and one full class day, totaling roughly seven and a half hours of class time. The first classroom observation occurred Thursday, November 18, 2010, from 9:00 to 10:55 a.m. The second observation occurred Tuesday, November 23, 2010, from 9:00 to 10:55 a.m. The third observation occurred Thursday December 2, 2010. On this day, both morning (8:55 to 10:50 a.m.) and afternoon sessions (11:30 a.m. to 1:00 p.m.) were observed. The computer lab portion of class began at 11:30 a.m.; for clarity, this second half of class is referred to as the fourth observation. The first classroom observation is presented in full to illustrate the pacing of the class sessions.

First Classroom Observation

The November 18 class began promptly at 9:00 a.m. The instructional focus was correlation. Classroom activities centered on an instructor-developed worksheet entitled "Introduction to the Correlation Coefficient and Its Properties," followed by another instructor-developed worksheet entitled "Introduction to the Correlation Formula."

The first worksheet began with a four paragraphs of review to remind students of their previous exposure to scatterplots, including observing positive and negative relationships using a line and observing differences in the amount of "scatter" around one line versus another. The text focused the students' attention as follows: "In this lesson we will describe the strength and direction of relationships that look linear using a statistic called the correlation coefficient. The correlation coefficient is denoted r." The introduction concluded by indicating that the formula for r would come "in the next lesson." "Our goal in this lesson is to determine the properties of the statistic r."

The worksheet contained two tasks. The first was "Task 1: Investigating the properties of r." (The second task was identified as "Task 2: Linear correlation with non-linear scatterplots.") In the first question within task 1, students were asked to identify the type of association represented in nine scatterplots (positive, negative, no association). In the second question, students were asked to look at the r value and determine how the r value relates to the patterns. The third question consisted of three bulleted sub-questions, including: what do you think r measures, is there a largest possible value for r, and is there a smallest possible value for r. Students were focused on these bullets during the first ten minutes of group work, as described next.

At 9:00 a.m. the instructor began to scan the room and noted out loud who was present while recording attendance. As she noted each student's presence, she acknowledged them. While taking roll, for example, the instructor greeted a late-comer, "Ok, come on in. You're late but glad you're here."

After taking roll, the instructor addressed the class as follows: "So today it looks like we're going to have a lot of stragglers, so we'll start in groups. Let's see what people have been able to do [with the homework.]" Students were asked to review the three bullets on page two of the first worksheet, "make sure you agree," then "write a takeaway." As students moved into groups, the instructor prompted, "Let's see what you can get done in ten minutes."

During this time, the instructor circulated, observed, and provided assistance, along with commenting on the completeness of the homework and the group's work. To one student, for example, she commented, "I see a lot of blank spaces – you're supposed to do this for homework." After several minutes when a group had fallen silent she asked, "Did you finish all the tasks?" The researcher also circulated, so observations pertain to different groups.

The first observed group consisted of three students: two Latino male (LM) and one Latino female (LF). Their discussion while observed primarily focused on the largest possible r-value and the smallest possible r-value. Students disagreed regarding the smallest possible r-value. The exchange that follows reflects part of their conversation. LM1, "I wrote it down, but I got it wrong." LM2, "Isn't it zero?" "LM1, "No, negative one. The highest is one and the lowest is negative one. I read it."

The second observed group also consisted of two LM and two LF students. One student summed up her experience for another student: "It was kind of hard at first, what's the r-value. But then we got it." Upon completion LM1 sat silent, LF1 was writing, and LF2 was reading. One of the female students turned to the fourth student (LM2), who had arrived late and recently joined the group. She asked, "You finished it?" He responded, "Yes."

The instructor then obtained the attention of the room and asked each group if they were able to complete all the questions. Three groups indicated they had finished and were ready to continue, but two groups were not yet ready. The instructor allotted another two minutes.

During the additional minutes, the researcher observed another group which was working on "takeaways." An African American female (AAF) and LM were discussing the statistics vocabulary. AAF, "What exactly does r mean?" LM, "Correlation coefficient." AAF, "Oh my God, that doesn't even have an 'r' in it! I feel sorry for people coming in [to statistics] from other classes; they won't have these [vocabulary]."

Shifting back to an earlier question, the AAF then clarified, “So this is a one, just a negative one?! I can do this!”

At 9:26 a.m., the instructor called the class back together to discuss the “big picture.” “Let’s come back and discuss the takeaways. Let’s take about 15 minutes to talk about what we think.” A Latino male was already responding with “…I can tell you...” before the instructor asked the first question. The first question was, “When I’m thinking about correlation, am I thinking of one variable? Two variables?” She repeated the question a few times until several students in the class waved two fingers in response. The instructor continued, “I’m trying to measure something about their relationship. Math people being math people probably have a sophisticated formula. We haven’t seen that yet but we will.” A Latino female called out, “r measures the strength and direction of a linear relationship.” The instructor wrote this student’s response on the board then asked, “Who can say this in a way that isn’t so mathy?” Another Latina female responded, “The distance of the dataset along the positive or negative line.” The instructor wrote this on the board, underlining “distance” and “positive or negative,” then asked, “Who understands the second definition better?” The instructor also addressed the student by name and said, “You probably did better than me [at explaining it].” The instructor then asked again, “Another way to explain it?” A third response was given by another LF and written on the board by the instructor: “Gives a numerical value in relation to a positive or negative line.”

At 9:30 a.m., while leaving these three descriptions of r on the board, the lesson shifted to scatterplots which provide graphic representations of the correlation. To begin the instructor asked, “Can someone volunteer to draw this for me? Pretend I’ve been absent and you’re explaining it to me.” The student who had provided the second definition for correlation volunteered, “I’m not sure, but can I try?” She drew three graphs on the board and explained, “If the association is not as strong, then r varies in value between one and negative one.” The instructor applauded her understanding, “I’m impressed, you’ve been out! Can you say that again?” She then positioned herself as the semi-passive facilitator: “I’m being the secretary. How many people agree?” A Latina female offered, “What our group decided….”

The class discussed each graph, with several students offering observations about the correlation represented by a particular scatterplot (strong, weak, positive, or negative). Students also sometimes called out agreement (e.g., “I agree with her”). The instructor reviewed the difference between 0.01 and 0.1. A student responded that at 0.01 “there would be no association” versus 0.1 indicating a “very weak” association. The instructor asked, “Do I have anything that looks like that?”

At 9:40 a.m., the instructor began to summarize the activity, “So what do we have so far? That r is strength and direction, it’s numerical, it can be shown as a line….” Then she asked, “Is there a largest possible value?” She verbalized the names of four students who responded by indicating the value “one” (“I’m hearing [students’ names] say one"). She then asked, "Can anyone help me think through that?" The discussion of the various graphs continued. One student kept her hand up for a long time and when called upon compared two graphs: "Both are negative one, but one [line] has a greater angle." The instructor replied, "Exceptional observation." Other students clapped. The discussion continued until approximately 9:45. "Good, those are all right ideas! I'm impressed. We could write these up in a blue box in a math book…. I'm feeling like we're done summarizing –anyone feel like we're not?" There was no audible response from the class, but most students appeared to be alert. However, four students had momentarily disconnected: two were talking about homework and two were talking about something personal.

At 9:45 a.m., the lesson shifted to some new scatterplots. The instructor asked, "Can anybody get us started? We're looking at these three scatterplots and we're told that two of these have an r-value close to zero." Students readily responded. Latino male: "One looks like a rainbow." Another Latino male noted an "X"-shaped pattern in a second scatterplot. The instructor paraphrased a student's response, "I understood her to say 'Not linear.' She's using some good algebra vocabulary: 'upside down parabola.'" A Latino female noted her confusion, "But I still don't understand why it's zero." The instructor referenced a previous class where non-linear data had been presented.

The instructor then proceeded to prompt a conversation about a takeaway addressing linearity: “What in the world is the takeaway? Why did I have you do these?” One of the students who had been talking to a friend (as noted two paragraphs ago) rejoined the classroom conversation. The instructor paraphrased the student’s response, “If r is close to zero, I would add one thing to what she is saying: there is no *linear* relationship between the two variables.” The instructor ended the lesson by noting the importance of using a scatterplot when interpreting an r-value since it is possible for a non-linear relationship to be revealed via the scatterplot. To emphasize this, she told the students “a story about a faculty inquiry project” during which a faculty member was looking at “different quantitative variables and trying to see if they predicted grades in a course.” The instructor sought to further substantiate the story by incorporating the researcher in this conversation: “Does this sounds familiar?” While the story was about a real-world application, it did not appear to be of particular interest to the students: some appeared to drift off and no one asked any questions.

By this time, one hour of class time had elapsed. A student (LF) asked, “How did you get the r?” The instructor responded, “Using something like [computer graphing software] and let the PC do it. Are you at a point where you’re ready to see the formula? I’m going to put the formula up in ten minutes.” After this announcement, several students in the class groaned with anticipation: “Aw!” The instructor was visibly pleased at their interest but continued with her initial plan, “I’m going to put everyone in groups to make sure [you’re ready]… come on, get up and move around! … If you get stuck, ask me or go on. I think [this task] is review. We'll see if you agree."

This group work session was similar to the earlier session, although students were in new groups. The focus was on the second handout, "Introduction to the Correlation Formula." There were seven groups in total, with roughly four students per group. Overall, students seemed alert and active.

In the first observed group, a Latino female read the introductory paragraph aloud, "This is a version of a famous drawing of the Vitruvian Man by Leonardo da Vinci in 1487." A student (LF2) turned to the researcher to make sure the researcher had a handout to follow along, "Do you have one?" As LF1 kept reading, she commented, "That's interesting," and she spread her arms out as in the da Vinci drawing. "I don't think that's true," she commented regarding the assertion that "a man's arm span is equal to his height." She noted, "I think we're on the right track – oh look, it varies!" As LF1 spoke, other students were writing on their sheets. A LM noted, "This was a long time ago when artists were also scientists. When you go to a physical trainer now, they just measure your femur."

In another observed group, there was more back-and-forth conversation between students. Students expressed uncertainty ("I don't know if that's right.") and excitement ("I can't believe I'm actually getting this.") They also asked each other questions such as, "How'd you come up with those dots?" They encouraged each other

(“You already said it!”) They also corrected each other, as in this exchange between an African American female and two Latino students. AAF, “Do you cancel these? I’ve never seen anything like this before.” LF and LM both responded, “I think we’ve seen in before.” The students’ conversations sometimes veered from the task at hand, as in this example: “What are you majoring in?” Peer’s response: “Journalism. I’m just doing this for the [degree].”

After roughly 15 minutes at 10:17 a.m., the instructor announced, “I’m going to talk for about ten minutes.” She asked students to turn to the next page of the handout which showed the correlation formula. She began by referencing a previous comment by an AAF, “I’m going back to something [student’s name] said, ‘r is a numerical value.’” The instructor continued, “So, first question… any time you see a formula first don’t freak out, then ask… does anything look familiar?” A Latino male noted the X minus X-bar portion of the equation. “How many people think that looks familiar?” Many students raised their hands. A student (LF) called out, “I see where this is going! Do you want me to draw a visual?” The students in her group encouraged her, “Go girl.” The student drew a visual at the board. The instructor conferred with the class, “Are you getting this? I’m seeing some nods.” Then she turned to the student at the board, “Can you explain again more slowly?” She thanked the student by saying, “Fabulous.”

As the instructor continued to work with the students on distance from the mean, she reminded them of prior work done in the class ("When did we do that?"). She was receptive to a humorous observation made by a LM. As she laughed, most of the students laughed, too. She continued to stay on task, however. "What can you tell me about the data point?" A LF responded, "It's below average on both x and y." The instructor praised the student as well as the class, "Notice how mathy we're being!" Then she asked, "I'd like someone to draw a data point where x is larger than average but y is smaller." A LM student drew a point on the board matching the instructor's specifications, then drew a second point also matching the specifications at the direction of a classmate. The instructor then circled back, referencing the student who had exclaimed, "I see where this is going!" She asked the class, "What in the world do you think she saw?"

As the discussion shifted back to the formula, the instructor reviewed the order of operations necessary to properly calculate the formula. Regarding order of operations she noted, "We haven't talked about that yet." She wrote each step under the header "Steps" on the board while a student (AAF) coached her through the order. AAF, "First you have to find the mean." Again the instructor asked, "Have we seen [X minus X-bar] before?" This time approximately 80% of the class responded with agreement. "What does 'average distance from the mean' mean?" As the instructor drew a graph which represented various data points and their distance from the mean, she encouraged, "You know this. Talk to me about it." A student (LF) described the formula for average distance from the mean while the instructor wrote the formula on the board. The instructor asked the class, “Where do you see average in the formula?” When a student (LM) gave a response which harkened back to an earlier lesson, the instructor acknowledged, “I remember that [student’s name] because you always thought very visually.”

The instructor talked through the meaning of each symbol in the formula by posing questions to which students readily responded. She asked, for example, “What does n represent? What does X represent? What does X-bar mean?” She amplified a student’s observations about X by stating, “These [observations] would be the same for Y… good!” At 10:35 a.m., the instructor announced “One last point to make, then I’m going to get you working with this formula.” As the instructor shifted the students back into group work, an AAF student called her over, “Sylvia, I just have to tell you something.” The student noted how talking through the formula helped her. The student observed, “If you can just add and subtract…” the rest of the formula is “like English.”

By 10:36 a.m., the students were working in groups again. “I’m going to give you about 15 minutes then we’ll take our break. Start working on task three.” Task three was titled, “Digging into the correlation formula.” After this “lecture/group discussion” portion of class, students seemed to focus more slowly than they had earlier. The instructor prompted once again, “Turn to task three.”

In task three, the first question guided students through observing whether a given man's height and arm span were above average, below average, or average. Students located the man in a table as well as in three separate graphs. The first graph plotted data points for both height and arm span, and two subsequent graphs each represented just one of these variables. Students were asked to determine the distance from the mean for both height and arm span. Finally students were asked to calculate the z-scores, although the "z-score" term was not introduced until later in the worksheet. Sample means and standard deviations for both height and arm span were provided in a table on the worksheet. Students "plugged" these values for the particular case into the provided formula for z-score, then completed the calculation by hand or using a standard calculator.

In the next set of questions, students were asked to locate various men within the sample who met certain specifications. Students were asked to observe whether z-scores would be positive, negative, or zero. The prompt, worded as follows, encouraged students to determine their response through reasoning before performing the calculation: "Determine this without making any calculations if you can." After this, students were prompted to perform the calculations. Finally, students were asked to match words with various parts of the formula, calculate the correlation, and then "[d]ouble check that your answer matches your estimate in Task 1."

As just noted, students initially appeared to be sluggish during this portion of class. In the first observed group, a LF student noted that her "brain was tired after an hour." Students were discussing the following semester, noting that it would be good to continue with the same instructor since they now "knew her style."

In the second observed group, students were somewhat more on task. Three Latino students were talking out loud but not necessarily to each other as they busily wrote on their worksheets. The AAF in the group was also talking out loud, "I wonder… I'm going to ask her [referring to the instructor]. I have to refer to my notes." A LM remarked, "These guys are just short," then he made an unusual noise. The AAF turned to him, "You know what, you're a weirdo… and I am, too." The AAF student then turned the group more collectively to the task, "What did you use? This is where I'm saying, why can't we round up? Sylvia help us… she's going to ignore me." The last statement was said somewhat jokingly. As an aside the AAF commented, "If I walked in to this class and saw that formula, I would walk out." After talking with the AAF, the instructor interrupted the group work. "There's a question that keeps coming up and I want to see if it's [the same question posed by the AAF and another student]." Three students (two LM and one LF) provide their respective answers: 1.10, 1.20, and 1.10. Instructor: "Okay, listen up here. This depends on rounding. The answer is in this range. You'd have to do this 11 times." There was an emphasis on the word "range." AAF, "Oh, I get it now."

The group work resumed within two minutes. The instructor chuckled with appreciation while observing one of the groups, “You guys are so compulsive, you figured it out by hand?!” By this time, all the students appeared to be alert again and engaged in different group discussions. The AAF commented to the LM, “I’m frustrated. I was getting it.” She continued discussing the problem with a LF from the group as the break began. As the researcher rose to leave, the AAF turned to the researcher and asked, “Is it really possible to do statistics without going through algebra? Is it the class or the instructor? Is that your research question?” The researcher responded, “The instructor is one variable.”

Analysis and summary of first classroom observation.

Among the strongest overarching impressions from the first classroom observation was the near constant activity; there was virtually no instructor-led lecture that did not involve student interaction. There were times when the entire class was silent, and the question posed by the instructor “hung in the air.” More frequently, however, students volunteered responses without being called upon. Some students disengaged periodically, but no student disengaged for the entire class session.

Also among the strongest impressions from the first classroom observation was the degree of familiarity and personalized interactions between the instructor and the students, and among students. The instructor consciously interacted with individual students, almost always using students’ names and often referencing something specific to that student, as in the example where the instructor reminded the student of how he "always thought very visually" about averages. Personal conversations with the instructor revealed considerable familiarity with each student, including, for example, awareness of their comfort level with risk-taking and social standing amongst peers.

Students also initiated interaction. Overall, students seemed to feel comfortable requesting the instructor's attention, asking questions, and making comments. The researcher also witnessed several instances where students coached and prompted each other in ways which appeared to have been modeled by the instructor. For example, during whole class discussions, students clapped and called out encouraging remarks. This student-student interactivity crossed group boundaries. Puente and non-Puente students, for example, appeared to work comfortably together and supported each other.

During group work, students appeared to seek understanding rather than merely identifying correct answers. Students discussed their work rather than simply copying from one another, occasionally prompting peers who were quiet or distracted. In addition, students showed concern for peers who needed to "catch up." In fact, this ethos of everyone within the classroom being involved and cared for was so ingrained that students sought to incorporate the researcher, ensuring the researcher had a handout and was able to follow along during a small group breakouts.

Students' thoughts and experiences were central to the class. In order to reinforce this and encourage participation, the instructor frequently sought to shift the power balance in the classroom. The instructor informed the researcher that this was something she consciously sought to do. This classroom observation showed many instances of power-shifting. For example, the instructor made comments to students such as “You probably did better than me…” and “I’m being the secretary. How many people agree?” She asked students for their ideas, opinions, and thought-processes, e.g., “Pretend I’ve been absent and you’re explaining it to me,” “We’ll see if you agree,” and “Can anyone help me think through that?” On other occasions, the instructor situated herself as a fellow learner with the students, e.g., “Let’s… talk about what we think.”

Student learning determined the pace of the class session. While the instructor verbalized the length of time which would be spent on an activity, and remained aware of the time allotted, these blocks were flexible and frequently adjusted. The instructor conferred with each group rather than relying on a sense of the room or the time allocated. Timeframes were often presented as a challenge, e.g., “Let’s see what you can get done in ten minutes.”

The lesson’s focus on correlation substantiates students’ assertions that they were “already learning statistics.” The statistics material was made more approachable in several ways. The instructor privileged both “plain English” descriptions and “textbook” descriptions, typically soliciting multiple responses to the same question. Students were asked to describe their understanding in “less mathy” ways, but also affirmed for being “mathy.” Information was provided verbally and visually. As noted in the worksheet, students had already been prepared to learn correlation through prior exposure to scatterplots. Also as noted in the worksheet, the formula for r would not be introduced until the next lesson; the instructor first focused students on its properties. In other words mathematics was subordinated to statistics and introduced only within the context of statistics. In fact, the mathematics was so subordinated that the students *asked for it*. One of the most revealing moments of this class session was when a student asked to see the formula for r and the majority of the class groaned with anticipation when the instructor said she would not be posting the formula until ten minutes later.

Several aspects of the class session illuminated the emphasis on thorough explanations and deeper understanding. During group work, students were provided with step-by-step instructions to perform a task and then asked to reason and to test their understanding. Students discussed their responses, disagreed with each other, and resolved differences in understanding. Within both small groups and larger class discussions, students were willing to reveal confusion and to “try” in front of each other, evidencing some degree of risk-taking. Note, students tested not only their individual thoughts but those of their groups, e.g., “What our group decided....” This may have provided a safer avenue for more risk-averse students.

The instructor kept conceptual understanding at the forefront. She spoke about and drew students’ attention to the “big picture.” Students wrote “takeaways” to encapsulate their understanding. In addition, there was room for range and variability, both in descriptions and answers, e.g., “Good, those are all right ideas…” and “This depends on rounding. The answer is in this range.”

Explicit and implicit references were made to effort, reflecting the growth mindset theme presented in Chapter Five. The instructor, for example, noted students who left blank spaces on their worksheets, or students who were catching up on understanding despite a recent absence. She also praised students efforts in a way that was teasingly affectionate, e.g., “You guys are so compulsive, you figured it out by hand?!” Students’ externalized comments also pointed toward growth mindset. A student remarked about how something was difficult at first but became easier. After a small breakthrough another student exclaimed, “I can do this!” Another student asked, “I’m not sure, but can I try?”

In terms of the statistics subject matter, three moments were especially suggestive. At one point the instructor told a story about a faculty inquiry project. She was relating the use of correlation and scatterplots to a real-life project of one of her peers which investigated the ability to predict student grades. However, students appeared to be less interested in this story than they were in a subsequent activity utilizing a famous da Vinci drawing. While students had no detectable reactions to the faculty inquiry story, students immediately began to ponder and relate to the questions posed in the da Vinci problem. In fact, at least one student related the question to her own physical proportions. The third revealing moment regarding the content’s applicability was when one student confessed to another, “I’m just doing this for the degree.”

Second Classroom Observation

The structure of the second class session, observed on Tuesday, November 23, was similar to the first observed session the prior Thursday. The focus on correlation continued. Thus, what follows is a shortened observation highlighting key moments within the two hour session. These key moments pertain to personalized interactions, engaging all students, power-shifting, pacing, and the twin emphases on effort and understanding. In addition, there are some clear moments where the instructor genuinely encourages students to pose questions.

As during the previous class, the instructor took roll while acknowledging students by name, frequently including personalized remarks such as, “You’re always one of the first ones here!” and “I am so glad to see you!” and “Good to see you.” The instructor put students into groups based on card color. She prompted students to focus on task four, which was on the last page of the worksheet titled “Check your understanding [of correlation]).” Her instructions were as follows, “Go through the work like we frequently do and put a smiley face next to what you are confident about. Put a check mark or question mark next to things you want to make sure we discuss.” She provided a time limit: “Let’s try ten minutes on this activity and see where we are.” As the groups began their work, the instructor wrote the correlation formula on the white board and listed the following prompts: "(1) r measures, (2) use r when, (3) r reminds me of, (4) important things to know about r."

As the instructor circulated among the groups she noted, "As I'm glancing around I do see blank spaces. As you know by now, they don't indicate questions. They indicate lack of effort. Grrr. You can always try." After approximately ten minutes had elapsed, the instructor asked one of the groups, "So how does task four look?" A LM student said, "I wasn't here." She asked, "So does catching up mean you're just copying, or are you talking?" The LM responded, "They're explaining the formula…." He then stated the explanation of the formula as the instructor listened without interrupting. He described the mean and distinguished it from actual measurements. He noted the division by the standard deviation. After he completed his explanation, the instructor simply prompted, "So are you discussing the graphs yet? Because I'd like to get to that." After the instructor circulated to another group, the LM asked the two female students about multiplying negatives.

Turning to yet another group, the instructor noted a response on the page, "This [number] looks too large relative to the others." The instructor took a moment to recognize a particular student in the group, "So I'm really impressed that you missed [the last] class but printed the worksheet." Members of the group posed a question to the instructor. She offered an idea in response, including some suggestions for checking their work. LF: "That's what they were saying." Instructor to LF: "So now that you've figured that out, do you want to bring closure to the group by explaining it?"

Moving on to another group that was talking about colleges, the instructor asked, "Are you guys done? I'm going to give you another task." LM: "So we don't get rewarded?" Instructor: "You get my admiration." To one particular student, after viewing the student's worksheet, the instructor exclaimed, "Good!" and patted the student on the back.

After 45 minutes of group work elapsed, the instructor said, "I want to stop for a moment and see where we are. We have two choices: talk as a class or continue to work in group." Students responded with a show of hands. The instructor asked, "No opinion from the group in the back?" The consensus was to continue to work in groups. The instructor clarified, "Do you need more than five minutes?" Students indicated that five minutes was sufficient. After approximately six minutes, one group asked for two more minutes. The instructor said to the class, "I think this group is ahead – that's why they're asking for extra time!" The instructor told students:

> We're going to come back together now…. Because we were all working at different paces, I have some groups that now know something. I want them to help us, including particularly [names a particular LM student]. I'm going to remind us of our goals. We'll talk in broad terms about the questions on the board and calculate by hand, although usually we'll use technology, but we calculate some by hand so we understand.

By this time roughly one hour of class time had elapsed.

Next the instructor posed many questions, to which multiple students responded, or sometimes individual students responded. Instructor: “What would r look like? What seems reasonable?” Perhaps five students responded with figures ranging from -0.9 to -1.0. “Is correlation the same as slope?” Many students responded, “Yes.” The instructor said, “I’m curious what you think [about slope] because we haven’t talked about that yet. We’ll keep that idea for next time.”

The question and answer session continued for roughly forty minutes. The back-and-forth between instructor and students was broken up on several occasions by students coming up to the board to draw a response. For example, a LF drew a scatterplot. The instructor asked, “How many agree with [names particular student]?” “How do you know this point is negative?” A white male (WM) student responded, “Because it’s less than the mean.” The instructor asked for further clarification, “What is ‘less than the mean’?”

During this portion of class, the instructor repeated questions students had asked earlier in the morning. For example, “[student’s name] asked a great question about positive or negative standard deviation.” She also interjected, “Because you’re being so lovely and asking me hard questions….” At one point the instructor interjected, “I so appreciate folks who were absent last class [but who are catching up] and the groups that helped.” After this aside, she turned back to the task at hand, “Do we agree with that [answer], or do we not care, or what?”

Within one particular ten minute timeframe during the question and answer session, at least ten individual students tested their knowledge in front of the class. During one exchange the instructor encouraged, "What [student's name] is saying is close…." The student ruefully but good-naturedly added, "…but no cigar." Some students volunteered, others were called upon. The instructor pointed out those who were ready to respond by saying the students' names and informing the class, "[Students' names] can answer." She sometimes used this to encourage students who had not yet spoken, "[Student's name] can find the data point, but she's already helped us. [Student's name]?" As the student (LM) began to respond, "Wouldn't it be like…" other classmates joined in to help.

Transitioning to the next question, the instructor said, "Alright, are we good? I don't know why math teachers always do stuff that no one can figure out." This made some students laugh. As the next student was called to the board, students cheered him on by clapping and calling out "woo-hoo." A second student came up and added to the graph. The two students (both LM) questioned each other. One noted and explained some imprecision in the graph, "That's because it's a sketching of a graph."

> Instructor: [Student's name] is saying the graph is an estimate.
>
> AAF: But I want an answer!
>
> [The instructor provided some explanation.]
>
> AAF: You guys know I'm slow. Got it. Thank you.
>
> Instructor: This is the big point, the big 'so what'... if most points are negative, then the line is negative.

The instructor then asked another student (LM) to come show a graph on the LCD. He groaned. The instructor asked, “Do you not want to?” He moved toward the front of the class, indicating agreement. The instructor said, “Good.” (The instructor later explained to the researcher that she had selected this student in advance and asked him to prepare some examples because he was struggling in the class, had expressed lack of motivation, and had not been engaging sufficiently with the material.)

As the LM student showed some scatterplots via the LCD, the instructor walked to the back of the class, leaving him alone at the front. She prompted, “So show how you got the formula. Talk about the reference lines.” Another student asked him, “You figured this out on your own?” He responded, “No… if only!” After he had provided some explanation, the instructor provided some clarification and asked the class, “Now does this sound a little familiar?”

As the class proceeded into the next activity, a WM student asked, “Will we have to make a graph on the quiz?” The instructor responded, “[Student’s name], you’re not looking very engaged – what’s up?” Then she asked the class, “Who is ready to put some more values up? I got these from [names two students].” She prodded again, “Does someone have more values?” Students in one group conferred, “Does someone want to put these up?” Several students came to the board. As the last student at the board completed his work, others in the class shouted out “Good job, [student’s name]!” and clapped. An AAF student proclaimed, “Guess what, I can do this! I’m moving and grooving!” The instructor acknowledged her, “Excellent, [student's name]."

The instructor then turned to a LM student as if to confirm, "[Student's name], is this working out?" He nodded. The instructor clarified, "You may have some variation resulting from truncation versus rounding. We're just trying to get the basic idea. This is [Student's name]'s work. Does anyone have a question for him?" The instructor then asked him to incorporate his work on the board into the graph on the LCD. The LM student said to the instructor, "That will be 25 dollars." A LF humorously challenged his behavior: "Why are you being such a gold-digger?!"

The LM spent several minutes in front of the class and the instructor worked with him to lead the class through the last parts of the formula: "We have to add up *all* the products." [LM provided some explanation.] The instructor prompted, "Connect it to the formula." [He provided further explanation.] The instructor concluded, "Right now I feel like I am *done* with correlation. Over the break I'm not going to give a lot of homework but I want you to answer these four questions," referring to the questions posted on the board since the start of class. She ended class by stating, "If you haven't done a practice quiz, you might want to."

Analysis and summary of second classroom observation.

As with the first observation, the second observed class session seemed to be in constant motion. There was a high degree of interpersonal interactivity initiated not only by the instructor but also by students. Puente and non-Puente students appeared to work comfortably together and vocally supported each other. Some students disengaged periodically, but no student disengaged for the entire class session.

Student understanding was the focal point of the class session. Students checked their understanding and that of their peers through individual reflection, group work, and larger class discussions. Individual students often came to the front of the class to draw or write out steps; even when providing correct responses, these students were typically asked to further clarify and explain. The other students who were momentarily more “passive” during that time were asked to engage by determining whether they agreed with particular statements or descriptions. In one instance, a struggling student had been preselected to walk through some examples while the instructor coached him from the back of the room.

To foster understanding, the pacing and structure of the session was periodically adjusted, sometimes in consultation with the students (e.g., “We have two choices…”). The instructor also conferred with students periodically, e.g., “Is this working out?” “Now does this sound a little familiar?” During these instances, the instructor’s questions appeared to be sincere, and students generally appeared to feel comfortable responding honestly.

Students were asked to review the material in “broad terms” to get the “basic idea” of correlation, ultimately linking their growing conceptual understanding to mathematics formulas. Clarifications about mathematics operations were made when necessary, such as when one student who conferred with peers regarding multiplying negatives. At several moments the instructor emphasized estimation or allowance for variation in responses. However at times, precision was noted to be important.

Effort was certainly encouraged but not unduly rewarded for its own sake. This was exemplified by the instructor's exchange with a student who had been out: "So does catching up mean you're just copying, or are you talking?" It meant the latter (i.e. talking it through), and he substantiated that for her by disclosing his understanding to date. Although the instructor encouraged "catching up" at several points during the class session, she did not praise, correct, or admonish this particular student. She simply listened respectively, and then she firmly pointed him toward the next task to keep him moving. In another instance, a student's efforts were "rewarded" by the instructor asking her to "bring closure to the group by explaining it." A student who asked about the next quiz was implicitly and gently admonished for his seeming lack of effort: "[Y]ou're not looking very engaged – what's up?"

During this class session, the researcher noted the emphasis the instructor placed on students' questions. Questions were described as "great" and students were described as "lovely" for posing them. Also, frequently, the instructor responded to students' questions by providing suggestions and prompts rather than full responses. Often she would circle back to the questions later in the session after either providing students with time to work further (if in groups) or soliciting multiple ideas from the room (if in large group discussion).

Third Classroom Observation

As with the second classroom observation, what follows is a shortened observation highlighting key moments within the two hour session. These key moments pertain to personalized interactions, engaging all students, power-shifting, pacing, and the twin emphases on effort and understanding. This session also included some fairly explicit references to growth mindset, as well as some content which might be applied to addressing social justice issues. This session shows that while students were consulted regarding the structure and pacing of class, they did not always "get their way." Moreover, at the conclusion of class, several comments by an AAF student reflected the occasional frustration of the older students who sometimes expressed a desire for a more traditional instructional approach. In addition to reflecting a desire for traditional instruction, however, these comments also revealed an interest in learning and understanding mathematics formulas by a particular student who during the student interviews was one of the most math-phobic.

Class began just one or two minutes after 9:00 a.m. The initial focus was a worksheet titled "Cause and Effect." Two main questions, listed at the top of the first page, pertained to when sufficient evidence exists to establish a cause and effect relationship and whether a strong correlation provides such evidence. The instructor directed students to "use the usual marking of smiley face or question mark." She then announced, “Before we get into groups, let’s discuss the homework. How did you feel with one equal to ‘I tried but didn’t know what to do,’ and five equal to ‘Sylvia, I’m fine.’” At first students provided muted responses, but after more prompting from the instructor, they responded with a show of hands. She assessed, “Okay, we’re all over the place today,” then added with a grin and chuckle, “A lot of variability.” Several students chuckled as well. The class then proceeded into group work. Instructor: “I’m going to put us in groups to discuss what we’re unsure about for a few minutes. Let’s take ten minutes to talk through what we’re unsure about so we can focus on what we all need to hear.”

The group work began at 9:10. The first observed group consisted of three LF students and one LM student. Students conferred about the homework. Part of question one prompted students to select accurate headlines. The LM student said, “I put the fourth one.” LF1, “I did, too.” LF2, “I did in wrong then. I just thought…[described thought process].”

LM: “What did you get for question two?” LF2: “I didn’t put anything.” LM: “So why did you put a happy face?” LF3 explained her approach to the question. LM: “I tried to think about it like that but….” LF2: “What about … confounding variables? Sylvia!” The instructor responded to their request for help by posing a series of questions: “So we would be thinking…?” “Do you think that…?” “So how would it be associated?” “What would a positive association mean?” “Does that mean higher income equals naturally smarter?" The LM student pondered out loud, "What about teachers at the schools?" Instructor: "Yeah, that's what I was thinking. Teachers at higher income schools may be more highly trained, for example. That would be confounding." Students wrote on their worksheets and continued to confer with each other.

At 9:25, the instructor interrupted the group work with this directive, "At this point I'd like your group to agree on one thing. You might have several. Just pick one. Then we'll talk as a group until quarter 'til. Take two minutes."

After two minutes had elapsed, the instructor said, "Let's see if we can get this done in 15 minutes." Turning to LF3 in the observed group, the instructor asked, "[Student's name] what did you decide?" The instructor pulled various students into the discussion by amplifying their responses, for example "[Student's name], I like how you're phrasing that," and "So what I just heard [student's name] say is that she sees a connection between these questions."

After approximately ten minutes, the instructor said "So let's start with pages four through seven [i.e. question three] in broad strokes. Then you tell me if it's not broad enough." After a quick summary review of question two, which emphasized that correlation alone does not provide sufficient evidence of causality, the instructor proceeded to question three which focused on statistics related to smoking and the consensus regarding causality. She teased, "Back in the 70s before you were born…

that still trips me out!" She described how people were allowed to smoke in movie theaters and asked the class if they thought it had been also permissible to smoke in classrooms. She made a personal comment, "It makes me deeply angry." She noted the "pretty sophisticated" data collection methodology which correlated cigarette consumption with cancer rates by allowing a 30 year offset.

After a minute or two of describing these social norms and the evolving research at that time regarding smoking, students began to ask questions. A LF asked, "When you say per person, did they take an average for each person?" As the instructor further explained the presumed methodology which included men, women, and children, a LM student expressed shock that children were smoking and thus included in the study, "Whoa, children?!" At this point the instructor assessed the room, "How am I doing?" Students provided her with confirmation.

The instructor continued, "So… smoking causes cancer. Do you see the tension I am setting up here?" A LF hedged, "So even though the other examples are observational…?" The instructor noted that "statistics books would say if you don't have a comparative random sample you cannot prove causality and you would leave thinking [smoking may not cause cancer]… but this should cause dissonance, skepticism." This led into a discussion of three guidelines provided on the worksheet, attributed to Utts who asserted that together these three criteria, when dealing with observational studies, provide evidence of a causal connection: (1) "There is a reasonable explanation of cause and effect," (2) "The connection between the two variables happens under varying conditions," (3) "Potential confounding variables are ruled out."

The instructor then led a classroom conversation about confounding variables. The rapid pace of the conversation made precise notes difficult, but the following snippets capture the essence of the exchanges by showing the instructor's comments and responses:

> "Yes, yes, I love what you're doing because you're being very precise."
>
> "I'm hearing Doctors – Vets – U.S."
>
> "How am I doing here? Who asked about this one – have I answered your question?"
>
> "Yeah, I think I understood what you said there."
>
> "Yeah, I think I did, too."
>
> "So did I do enough here?"
>
> "[Student's name], that was a very succinct summary!"

By this time, it was 9:50 a.m., and 50 minutes of class time had elapsed. "I want you to leave class with the understanding that we draw causal conclusions all the time without comparative studies." "The cancer institute uses the word 'cause'; and they're scientists."

One of the students (AAF), circled back to the scatterplot on page four which showed cigarette consumption and cancer rates and asked, "Shouldn't it be a stronger association?" The instructor clarified that a correlation of 0.8 is high. She provided the example of George Burns who smoked until he died at age 100. "As long as we're talking about human beings, there is always variability." The student attempted to clarify, "As long as there is a confounding variable [the correlation] will be less than 1.0?" The instructor encouraged the student prior to correcting her, "What I respect about [student's name] is she missed and told me she was going to miss, but now she's catching up. I'm going to state this again…." Several students joined in to say, "We discussed this last class." Another AAF student clarified, "Well she wasn't here." The instructor joked, "I may make some quiz questions about this. True or false questions. You have a fifty-fifty chance!" The instructor concluded the discussion with "I'm leaving the cause and effect worksheet. Is everyone ready?" Hearing no response, she supplied potential answers in a humorous tone: "No I'm not ready! Let's quit!"

She asked a student to distribute the next worksheet and introduced the material by stating, "I'm going to start some new ideas." She encouraged students to think about the reason for the next lesson: "If I were in your shoes I'd be asking, 'Why do we need r if we can't show cause and effect?'" She amended this by imaging what a student might say to her: "'Okay, Sylvia, what in the world does that mean? Sounds pretty abstract!'" She then reassured students by saying, "We'll start with the big idea then play with it for two days."

At 10:00 a.m., the students began to look at the next worksheet titled, "Using Scatterplots and Statistics to Investigate a Mystery." The first mystery was the disappearance of Amelia Earhart, and the instructor began by asking students what they already knew about her. Students responded with several thoughts involving the Burmuda Triangle and various oceans. The instructor then played two short video clips (perhaps five minutes each) of an interview with Earhart. “I’m impressed you’re listening, that’s good,” she remarked. One student needled another, “She’s saying she thought you weren’t listening.”

Students began speculating humorously about what might have happened to Earhart; their speculations involved references to health care and cigarettes from the previous lesson. Their speculations where quieted by other students, “Shhh.” Instructor, “This was a really interesting incident. If you look at the handout, it will tell you just a little. You can read more if you’re interested.” She then referenced the use of forensics, the potential, anticipated major of several students in the class. A LM student texted for approximately 30 seconds. The instructor pulled him back into the class activities by asking, “We always put the explanatory variable on the x axis, right [student’s name]?”

The instructor transitioned by saying, “I’m going to have you get up and change groups just to have us move around and wake ourselves up a bit.” Students groaned. Instructor: “Let’s see if we can get through in 15 minutes.” Some students told this instructor that they wanted to pair up rather than group into four-somes. Despite this initial reluctance, within a few seconds all students were in groups of four, with one group of five. Instructor: “I’m glad you’re being so resourceful.” Upon getting into groups, each student in the class appeared to be focused on the worksheet and the group work.

The first observed group consisted of three LM and two LF students. A LF (LF1) tacitly took charge of the group and asked the others, “Do you get it?” Three responded “yes” and one responded “no.” To the student (LM1) who responded no she said, “But you’re brilliant, you should know!” LF2 admonished her, “You’re praising him instead of making him work.”

After a few minutes of group work, LF1 remarked, “Now we’re working ahead.” The group was working to predict the height of a female skeleton based on forearm size. LF2: “Well, 164 or 165, it’s pretty close.” LF1: “How do you know that’s the mean?” LF2: “I’m assuming.” LF1 glanced around the group for confirmation and asked, “Are you still with us [LM2 student’s name]?” The instructor observed briefly then encouraged, “The project is to make predictions.” While the instructor was present, LM2 described his understanding of the prediction. The instructor replied, “Yes! Make sure your group understands what you just said.”

After the instructor moved to observe a different group, both LM2 and LF1 talked through their individual understandings, effectively talking over each other. After a minute or two, they jointly came to the same number. Then they conferred about their understandings. LF1: “Cool, that makes sense, but I’m still wondering….” LM2: “Would that be …?” LF1: “That’s my question, too.” When the instructor came back, the two students asked their question. Instructor: "I'm going to explain that later. You can go on to this next section which was going to be homework while I check on other groups."

During this entire time, two of the LM students were mostly quiet but appeared to follow along. Occasionally they voiced questions or others in the group "checked in" with them, as in this query, "You good, [student's name]? Because we're done, so we can go back."

A second observed group consisted of one AAF and three LF students. As the researcher joined the group, the AAF student was asking her classmates, "Do you think it's important?" The instructor clarified, "There's no right or wrong," and prompted to students to transcribe their responses from their scratch paper onto the worksheet. The AAF student then asked her classmates, "So if we had to do this all over, could we?" LF1: "I think I understand it better now." AAF: "Would you have guessed r equals 0.85 without the line? I need to know the line. I wish she wouldn't teach backwards!"

At roughly 10:45 a.m., the instructor interrupted with this announcement, "Three groups [out of five] have actually finished quite a bit, including some of [tonight's] homework, so this is what we're going to do…." She noted a LM student, "[Student's name] wants to know how to calculate the line of best fit and that's what we'll do next [class session]." AAF: "That was my question! I wish she'd lecture first. I'm going to look it up." The instructor concluded the morning session by stating, "I'm going to be next door [in the computer lab] at 11:15 if you want to get started."

Analysis and summary of third classroom observation.

The third classroom observation continues to substantiate the preponderance of personalized interactions, engagement of all students, power-shifting, pacing, and twin emphases on effort and understanding. This session included probably the most explicit reference to growth mindset concepts, as one LF admonished another: "You're praising him instead of making him work."

Some of the topics discussed might be applied to addressing social justice issues, including socioeconomics related to educational equity and protecting children's health. In fact, the instructor at one point noted, "It makes me deeply angry." While these social justice-related topics were of interest to students, at least insofar as was indicated by high levels of student engagement, these topics appeared to be of no greater interest than the Amelia Earhart topic or the da Vinci topic from the prior class.

As in the prior class sessions, the instructor situated students in the center of the classroom and sought to shift the power-balance between instructor and students. For example, she amplified students' comments ("I like how you're phrasing that.") and asked for critical feedback ("How am I doing here? Have I answered your question?"). However, this classroom observation also showed that while students were consulted regarding the structure and pacing of class, they did not always "get their way," as in the activity where some students requested dyads over four-person groups.

At the conclusion of class, several comments by an AAF student reflected the occasional frustration of the older students who sometimes expressed a desire for a more traditional instructional approach. However, these comments also revealed an interest in learning and understanding mathematics formulas by a particular student who during the interviews was identified as one of the most math-phobic in the class. Her interest was so keen that she declared, “I’m going to look it up.”

Fourth Classroom Observation

The final classroom observation focused on a different portion of the day. The description of this session will be brief since more of the activity was solitary or in dyads. However, this observation does capture an important “hands-on” component of StatMode not fully reflected in the prior three observations.

The afternoon session began in the lab at approximately 11:30 a.m. The instructor provided the following introduction, “We’re going to spend our time analyzing the data. Now, [student’s name] already mentioned this is not an easy assignment due to the number of variables.” The instructor allotted roughly 30 minutes to the task: “We’ll spend until 12:00 unless I feel like [people are] ‘goofing off.’ Until noon, work individually. I’m going to float around. [Researcher’s name] is going to float around, too. So by noon you should have something.”

Roughly half the students worked individually. Others worked quietly in pairs or triads. All but one student appeared to be “on task”; one student was working in [computer graphing software] while also briefly viewing a YouTube video. The instructor prodded different individuals or groups with questions such as, "That's a great question, what are you noticing?" "So this group is really chatting, is it about backpacks [i.e. graphing backpack weight]?"

By 11:54 each student had created one or more graphs. Each graph was unique. Students were beginning to explain their graphs to each other. LM: "Does this make sense to you?" After he briefly explained his graph, LF laughed and clapped, "That's a good one actually." LF1: "This says that girls have heavier backpacks because they're smarter." LF2: "I believe it. Do you have pain and grade [in your graph]? The first graders have back pain, can you believe it?!"

Many students had hands up, asking for the instructor's assistance. While she circulated to individuals or small groups, many continued to work with their hands still raised. Several seemed to resolve their questions by talking to other students.

At approximately 12:02 the instructor asked, "Are we ready to do our speed date? No? Okay, I'm going to give you six minutes. If you're like [student's name] and have 15 [graphs], then pick one." The researcher observed two particular students conferring and discussing their graphs. LF: "Do you have any [graphs] that make sense? Because I have three [graphs]…." LM: "No." LF: "The only thing that makes sense to me is pain and backpack weight." She began writing an explanation then asked, "Are you confused? I get confused when I start writing."

At 12:10 the instructor said, “Since I have several people with questions, I think I have six hands, we’re going to look at each question. [Student’s name], you had your hand up.” The instructor made the LM’s computer screen visible to the entire class. “This looks confusing, is that your question?” The instructor made a small adjustment to his graph and said, “Try that… Was that your whole issue? Now this looks like something.” The instructor posed a question about the meaning of the graph: “Does [the r-value] mean they are or are not related?” LM: “Are.” A classmate (LF) sought clarification by asking, “Which variables?” The LM student explained the variables used in the graph, after which the instructor commented, “That’s a powerful graph and good observations.” Five students total asked questions or made comments regarding to this particular graph. One student made a particular comment which the instructor amplified, “I don’t know if you heard that but [student’s name] had excellent advice. Are you willing to say it one more time, louder?” After she repeated it, another student asked her to repeat it a third time.

At 12:17 the instructor asked, “Anyone else with a question?” LF: “I have a question.” The instructor made the LF’s computer screen visible to the entire class and exclaimed, “Oh my gosh, this is really interesting.” Then she clarified for the class, “This is joint work.” The instructor proceeded to lead a discussion based on the LF’s graph: “So [student’s name], I’m going to ask some questions of the class to make sure they’re understanding [your graph].”

After a few minutes, the instructor shifted back to the dyad / speed-dating activity by saying, “Okay, I want us now to get something on your screen, maybe two things. Now remember the idea is to get us talking, practicing what to say. Even if you don’t like what you have, we’re just at the beginning.” She prompted further, “Are we getting in a line? Are we speed dating? In the middle please.” Students paired up twice for approximately ten minutes each time to discuss the meanings of their graphs.

The instructor suggested students take the last few minutes of the class session to crystallize their insights: “I’d like you when you’re finished to go back to your computers and update your work. What did you realize? What do you want to change? What do you want to write? Do you feel more confident?” Before dismissing the class, the instructor suggested they begin the homework, “Okay I want you to take a look at the homework assignment. Use a flash drive or copy to Word and start some writing.” She noted, “You’ll notice that A-level work incorporates outside sources.” Then she dismissed them, “Okay, we’ll see you Tuesday. The more you do on your paper now, the less there is to do later.” Several students stayed and continued to work. One student pulled the instructor aside, “Thank you for helping me.” Instructor, “Yeah, you did some great work today.”

Analysis and summary of fourth classroom observation.

This fourth and final observation revealed many of the same qualities of interactivity and high student engagement. Perhaps even more than in the prior sessions, student work and student understanding was central. Students were asked to create original graphs then describe the graphs verbally and in writing. The activity was prefaced as "challenging" and the instructor expressed interest in the students' work, including recognizing graphs as variously "confusing," "powerful," and "really interesting." The instructor apparently sought to encourage students by sharing these examples but also by stating, "Even if you don't like what you have, we're just at the beginning."

Overall Summary

This chapter addressed students' motivations for continued engagement with challenging statistics material, as well as portrayed the structure and pacing of typical class sessions which supported students' engagement and learning. Regarding motivation, in general students were highly pragmatic about "getting through" mathematics. Students did not appear to be especially motivated by practical applications of statistics or culturally relevant topics. While the latter could not be fully investigated for reasons noted in Chapter Three, there was no evidence that students needed more culturally relevant material. Instead, students' descriptions implied that they were motivated by challenging course content (i.e. statistics even while still in the pre-statistics class). In addition, student interviewees emphasized how their critical thinking and reasoning skills were utilized within and enhanced by the course—something they valued and which made the course feel more approachable. Student interviewees highlighted the instructor's interest in, support for, and detailed responsiveness to their questions. In addition, some students were able to identify the variety of activities and cycling back to previous topics as two other mechanisms through which the instructor sought to deepen their conceptual understanding of the material.

The four classroom observations evidenced the preponderance of personalized interactions whereby the instructor recognized and engaged individual students. In addition to the instructor's concern for each student, the students themselves cared about and supported each other's learning. The variety of activities also ensured that all students were engaged during each class; while distractions did occur, they generally appeared to be brief. Students' efforts were often recognized and discussed, but not unduly rewarded for their own sake.

The classroom observations showed that the instructor sought to make student learning and student agency central to the class. Activities and pacing were adjusted based upon frequent, informal assessment of students' learning. Students were often, but not always, consulted regarding pacing and the selection of activities. The instructor used a variety of approaches to shift power toward students, at times equalizing herself with or even subordinating herself to students. Students' questions were encouraged and highlighted.

The StatMode emphasis on conceptual understanding and exercising reasoning skills was broadly substantiated by the classroom observations. In addition, the focus on statistics material was evident, with mathematics procedures serving as the necessary means to calculating statistics but not the primary objective of the course. Students appeared to be ready for mathematics formulas when they were introduced; in fact, on more than one occasion students requested to see formulas. Some lessons highlighted the range of responses and estimations that are sometimes acceptable within the study of statistics. According to students' apparent reactions to classroom projects, pronounced cultural relevance and direct applicability did not necessarily appear to motivate students.

Per the classroom observations, there did not appear to be any bifurcation between Puente students and other students in the class. Rarely but occasionally, differences in age were apparent. Taken overall, the classroom observation data does suggest that female students may tend to take leadership roles during group work; however, the composition of the class makes this difficult to analyze in a firmer way due to the larger representation of women in the class.

Chapter Seven: Discussion and Recommendations

Low completion rates for developmental mathematics sequences and in gateway mathematics courses prevent a majority of community college students from achieving their educational goal of transfer. No other discipline directly impacts community college student outcomes as strongly as mathematics. African American and Latino students experience even less success than their white and Asian peers in lower-division mathematics. As a result, lengthy developmental mathematics sequences have a disproportionately negative impact on underprepared students of color.

In national debates regarding how to improve success rates for transfer-level mathematics, two frequently proposed modifications include shortened, accelerated sequences and contextualization. As yet, no peer-reviewed studies have examined mathematics sequences that combine these approaches. An aim of this study was to fill this gap in the literature.

StatMode was selected as the subject of this study for the following reasons: (a) as an open-entry, two-course mathematics sequence, it included a sizable proportion of students (34%) placing at the arithmetic and pre algebra levels; (b) the accelerated sequence contextualized mathematics using statistics, even in the pre-statistics course; and (c) a large majority of enrollees (97%) were underrepresented students of color. The cohort was primarily comprised of younger Latina/o students and a few older African American students. A majority of StatMode students (59%) were simultaneously enrolled in Puente. All Puente students were under 20 years old.

A mixed methods approach was used to determine whether the accelerated program resulted in proportional transfer-level mathematics completions (i.e. sequence completions) for this group of underrepresented students. Quantitative data for all 29 students in the cohort were collected through normal course-related activities. The study also sought to explain from the students' perspectives which aspects of the program seemed most important to their learning. Qualitative data were collected through 11 student interviews, four classroom observations, and regular discussions with the instructor. The corroboration of findings using multiple data sources is presented next.

Triangulation of Findings

Student Findings by Demographics

Overall, 86% of the StatMode cohort successfully completed the two-course sequence, earning a C or higher in transfer-level statistics. This sequence completion rate for the StatMode cohort far exceeds the national rate which shows that approximately 33% of community college students with developmental mathematics needs advance far enough to be eligible to *attempt* college-level mathematics. Due to the composition of the StatMode cohort, nearly all the successful students were Latina/o and African American. Gender, age group, and incoming mathematics eligibility level were not significantly related to the course and sequence outcome variables. When students who were simultaneously enrolled in Puente were compared to Non-Puente students, three outcome variables showed statistically significant differences or differences which approached statistical significance. The three statistically significant outcome variables were first semester grades, overall sequence completion, and combined GPA. Additional statistical analysis related to these variables suggested that Puente status may be associated with overall retention rather than increased performance.

In addition to successfully completing transfer-level statistics, StatMode students performed comparably to or out-performed a better-prepared group of primarily white college students from four-year institutions on questions from a nationally-normed post-test, the Comprehensive Assessment of Outcomes for a first course in Statistics (CAOS). Questions were selected for higher discrimination (i.e. greater than .35) and categorized into two domains. For the data exploration and descriptive statistics domain, StatMode students averaged 61% of questions answered correctly compared to 53% for students from the national sample. For the second domain of probability and inference, StatMode students had a mean performance of 50%, compared to the national mean of 49%. Puente students did not score significantly differently on the CAOS questions.

While Puente status was statistically significant for some of the quantitative analysis, it appeared to have limited effect per the qualitative analysis. In fact, based on the 11 students interviews and four classroom observations, student demographics appeared to be largely irrelevant. For example, growth mindset appeared to be salient for all student subgroups, with few exceptions. Growth mindset seemed less salient for two students who expressed the strongest math aversion and who could not cite any prior positive mathematics experiences. Another subgroup difference was that the perceived value of group work appeared to be mediated by age and possibly ethnicity, with younger, Latina/o students more enthusiastic about group work and less enthusiastic about traditional instructional approaches. Another age difference was that older students seemed more comfortable directly challenging the practical relevance of mathematics.

Prior Fixed Mindset and Current Growth Mindset

Three key themes arose from the student interviews. The first theme relates to prior mathematics experiences. Overall, students described limited effective encouragement from instructors and other adults regarding their mathematics abilities. They also described approaching mathematics in particular with a fixed mindset, i.e. they believed themselves to be largely incapable of coping with challenging mathematics material. Student interviewees sharply contrasted their current StatMode experiences with prior mathematics classes.

The second theme from the student interviews relates to growth mindset. This theme, which emerged early in the data collection, encompasses four subthemes. These subthemes include the need to approach the mathematics material confidently (i.e. with a growth mindset), the importance of emphasizing learning over performance, acknowledging all students' abilities to learn through effort (implying a negation of stereotype threat), and valuing errors and risk-taking as avenues for learning. A great majority of student interviewees believed growth mindset was critically important. Clearly the instructor also believed growth mindset to be an important concept for students: she deliberately shared a growth mindset article with students early in the first semester. In addition, her syllabus enjoined students in large, bolded, capital letters: "WORK HARD, BE BRAVE, AND HAVE A GREAT SEMESTER!" She continued throughout the StatMode sequence to consciously reinforce the conceptual underpinnings of growth mindset. While not always referred to as "growth mindset," this theme and related subthemes were evident within the classroom observations.

Unlike several students who identified growth mindset as the most important aspect of StatMode, the instructor was not of the opinion that growth mindset represented the *most* critical difference between StatMode and other mathematics. She was aware of several additional influences which affected her pedagogical approach. Still, she acknowledged growth mindset to be something which she could readily reflect on and adjust for while the class was in motion. She stated that she tried to reinforce growth mindset through references which explicitly linked specific efforts with related learning. In other words, she was not interested in "A for effort." In fact, she described “praising” effort alone as “insulting to students.” Rather, as an example, she would publically acknowledge a student who had missed class but was catching up and showing evidence of comprehending the missed material.

All growth mindset subthemes were apparent within the classroom observations, although some appeared with particular prominence. The instructor spoke with the researcher and shared how she willfully “suspended judgment” about how individual students might likely perform in the class. Student interviewees confirmed this by describing how the instructor cared for each student’s learning and saw each student as capable. The degree of encouragement provided and engagement fostered during the classroom observations also demonstrated the instructor’s commitment to including all students in the learning process. In addition, the classroom observations suggested that the instructor modeled this behavior for students who then frequently mirrored the behavior with each other during group work as well as during larger class discussions.

Student interviewees consistently described StatMode as learning-focused, and nearly every exchange within the classroom observations corroborated this. A prevalent example of the focus on learning, noted in the interviews and seen throughout the classroom observations, was the way homework problems were discussed in class. Homework was “checked.” However, the instructor did not simply assess which questions students answered correctly or incorrectly; students’ understanding was also checked. One way students were encouraged to focus on understanding was by going through their own homework and assessing their levels of knowledge in each area. This was also a conscious attempt by the instructor to foster students' metacognition.

Another prevalent example of the focus on learning and deeper understanding was the use of group work as noted in the interviews, seen throughout the classroom observations, and discussed with the instructor. During group work, students were encouraged to clarify with each other what they understood well and what remained confusing. Students did not simply exchange answers or procedural means to attaining answers. Instead they tested and exchanged their current understandings and collectively worked to build better-rounded, deeper understandings. As students mentioned, well-intentioned group work often does not fit this description. Some student interviewees and the instructor noted ways that group work was adjusted to facilitate its effectiveness. The instructor also utilized group work, along with other mechanisms, to continually assess and inform herself about students' understanding.

Student interviewees especially noted the instructor's patience and helpfulness in fostering students' learning. Classroom observations substantiated this by showing how the instructor adjusted the pacing of the course to meet students' needs. In addition, the classroom observations showed how the instructor sought to reduce power imbalances between her and the students, or as she put it, "Wean them of authority." Discussions with the instructor further corroborated that she also sought to reduce power imbalances between students by attending to student's relative social capital. For example, she might seek to amplify an insight from a student who appeared to be somewhat marginalized by peers. These shifts most likely made the group work more productive, although students were perhaps not conscious of it. Both the pacing and power shifts allowed students a greater sense of ownership over their learning. As Guss put it, "She's like, we're going to analyze this data and what do you guys think, what do you guys see? It's like, she actually gave us the control to go this direction."

Students appeared to have considerable rapport with the instructor. During the interviews and classroom observations, students comfortably called the instructor by her first name. While neither the students nor the instructor mentioned it, humor and good-natured teasing were evident throughout the classroom observations. The instructor was candid and reflective about how this rapport was sometimes difficult to develop. She described several situations where she emailed, called, or otherwise conferred with students who appeared to be struggling—with varying degrees of success. In addition to reaching out and opening lines of communication, it was evident that she endeavored to understand from each students' perspective what kind of encouragement they needed from her in order to engage with the course material. A clear example pertained to a student she described as in danger of failing and for whom she designed special projects which might be more engaging for him given his particular interests. One such project was witnessed and included toward the end of the second classroom observation. The student somewhat reluctantly completed the project. Ultimately, the student stayed in the sequence and completed both courses successfully.

Students were not evaluated via a quantitative instrument specific to growth mindset since the theme was unanticipated. However, conceptually there is considerable overlap between the agency and pathways components of Adult Dispositional Hope Scale (ADHS) and growth mindset. Toward the end of the pre-statistics course, each student interviewee indicated relatively high hope on both the agency and pathways portions of the ADHS. Students described this sense of capacity during the interviewees, and also, on occasion, students proclaimed a sense of capacity during the classroom observations, e.g., "I can do this!"

Student Motivation to Learn Statistics

The third theme from the student interviews relates to motivation. As later confirmed by the instructor, student interviewees revealed overriding pragmatic motivations centered on the need to complete mathematics requirements. Students showed limited interest in statistics applicability and did not indicate an interest in more culturally relevant projects. While the latter could not be overtly explored during the interviews for reasons noted in Chapter Three, classroom observations suggest that projects with pronounced cultural relevance or explicit social justice references were not necessary to entice the students in this study to engage with statistics problems. Instead, students' descriptions implied that they were motivated by the challenging course material.

Students described the pre-statistics course as essentially “already statistics” and something they felt proud to study. Classroom observations corroborated the emphasis on statistics concepts, with mathematical procedures and formulas broached only when relevant to the statistics material. Moreover, mathematical formulas were only presented after students’ conceptual understanding of the “big ideas” and the “so what” were firmly in place. Procedural clarifications (e.g., multiplying negatives) appeared to occur on an as-needed basis, either within small groups between individual students or as a pointed tangent during a class discussion.

The instructional emphasis on statistics was intentional, and from the instructor’s vantage point this may have represented the most important aspect of StatMode. The instructor was deeply aware of students’ pragmatism and acknowledged that real-world applicability provided weak motivation for students, as evidenced both in the interviews and classroom observations. She herself seemed unconvinced that contextualization was particularly important to students’ learning. However, the instructor believed conceptual emphasis was important and statistics provided a context for that. While some of her lessons had practical implications, she seemed to excite motivation more through mental curiosity and conceptual focus than through an emphasis on application. Students seemed as engaged with the backpack lesson as with the lesson seeking to better understand the disappearance of Amelia Earhart. When students were able to use the material outside of class, the instructor was as enthusiastic as the students; however, like the students she seemed to view it as somewhat unexpected and exceptional.

Limitations of the Study

StatMode was selected for this case study because it is atypical. While providing potential insights, this approach limits the generalizability of the findings. Student self-selection also compromises generalizability. Even with the same instructor, it cannot be assumed that all future implementations of the course would generate equally positive quantitative outcomes.

In addition, the small size of the study population did not allow for extensive quantitative analysis. For example, demographic variables could only be examined individually so findings like those associated with Puente could not be run with statistical controls. This is potentially problematic due to the fact that Puente students represented the majority of younger students in the class, as well as first generation college (FGC) students. Effects presumed to be attributed to Puente status might be partially attributable to age or FGC status.

Due to the researcher's ethnicity and the condensed timeframe of the study which limited the researcher's ability to deepen rapport with student interviewees, there was minimal direct investigation of students' perspectives with regard to cultural relevance and equity issues. Another fact regarding ethnicity seems worthy of particular note: there were only two white people associated with the class—the instructor and one male student. This lack of ethnic heterogeneity may have reduced stereotype threat. In addition, the instructor indicated through various means her strong belief that each student could succeed, and students felt that encouragement. Within a context of greater ethnic heterogeneity, stereotype threat could potentially be more evident and perhaps more difficult to overcome.

Another limitation of the study relates to timeframe which restricted qualitative data collection to the fall semester only. The high overall sequence success rate suggests that students continued to cope effectively with the statistics material through to the end of the spring semester. However, it's possible that students related to the material differently as it became more challenging in the spring semester.

Two more limitations relate to students' consciousness. While a primary goal of this study was to understand the students' perspectives better, students only have a partial view of the instructional process. Growth mindset, for example, clearly resonated with students; however, it was also something that was relatively easy for students to articulate since they had read an article about it.

The second limitation with regard to students' consciousness pertains to the fact that students were keenly aware that StatMode was a pilot being studied as well as evaluated. This may have discouraged students from sharing negative perceptions. While this limitation was anticipated and investigated via particular questions in the qualitative interview protocol, quantitative controls were not possible. A Hawthorne

Effect may have contributed to students' desire to succeed in order to "prove" the value of the sequence, and this heightened desire may have led to improved success.

Despite these limitations, the study has clear implications for educational equity and mathematics pedagogy.

Implications for Educational Equity and Pedagogy

Two primary concepts undergird StatMode: sequence acceleration and mathematics contextualization through statistics. This study has clear implications for educational equity insofar as the findings showed that it is *possible* for mathematics to be taught successfully to underprepared, underrepresented students through an accelerated, contextualized approach. While the extent of generalizability is unknown, presumably most community colleges enroll sizeable numbers of students who are not oriented toward calculus and who could benefit from a sequence similar to StatMode.

The statistics subject matter appeared to sufficiently engage these particular underrepresented students even without an emphasis on direct utility, predominance of explicit social justice themes, or projects with pronounced cultural relevance. Students related to a range of projects, including those which on their face might appear to be less relevant (e.g., Amelia Earhart). Students found the statistics subject matter to be approachable. Students appeared to be motivated by challenging material which fostered a conception of themselves as intellectually capable. Moreover, the pedagogical approach sought to provide students with some degree of control over their learning and power within the classroom. These study findings suggest that effective and empowering intellectual engagement may be more important than relevance.

Affective components of the pedagogy employed by StatMode were palpable and important to students. The caring and helpful approach of the instructor, and the notion that not only they but all their peers were capable, seemed especially important. Concrete use of the growth mindset concept appeared to effectively suggest to students that their mathematics abilities were previously underestimated. However, mindset is malleable and must be reinforced. Growth mindset was reinforced in StatMode through verbalizations by the instructor and between peers. In addition, the pedagogical structure reinforced growth mindset. While not possible to assert based on this study alone, it is conceivable that an attentive instructor who fosters growth mindset (or perhaps similar conceptions of hope) is more important for students who have been marginalized by prior mathematics experiences.

Study findings suggest that students with no prior positive mathematics experiences may be less receptive to growth mindset concepts. Such students may continue to struggle with mathematics material. While the two students in this study who met this description were ultimately successful, their relatively entrenched math aversion continued to influence their performance in the sequence.

In terms of particular demographic differences, Puente-related findings suggest that some students, perhaps specifically FGC students or younger students, may benefit from additional mechanisms to promote retention.

Issues of tracking remain concerning since this accelerated approach does not prepare students sufficiently for STEM fields should they decide to change majors. This conundrum regarding whether StatMode represents tracking (away from STEM majors) or detracking (toward transfer) is heightened for those students who have been most marginalized. These students have had the least preparation for STEM *and* the least preparation for transfer. Overall these adult students viewed StatMode as a realizable pathway rather than a foreclosure of opportunity. This does not negate the need to provide adequate opportunities for underrepresented students who wish to pursue STEM-related degrees. However, the provision of one pathway does not preclude the provision of another.

Recommendations for Action

This study has implications for mathematics instruction at community colleges. Mathematics has been identified as a critical gate-keeper for community college students seeking to transfer. Structural changes may be necessary to substantially improve the number of students, particularly underprepared students, who complete the mathematics required to be transfer-eligible. Other instructional interventions appear to only marginally improve mathematics success and completion rates.

Any community college could elect to create an accelerated statistics sequence and identify faculty to teach it, as long as the transfer-level course is acknowledged as sufficiently rigorous. The proportion of students electing to enroll in statistics to complete their transfer requirements has been increasing. Student interest in shortened statistics sequences is likely to be high, making such a sequence viable institutionally.

The concept of growth mindset appeared to be particularly salient in reference to mathematics. The statistics material may have allowed students to more readily adopt a growth mindset; since it was a new challenge, it could be viewed as a “fresh start.” However, introducing students to the concept of growth mindset is simple, cost-free, and not time-consuming. Reinforcing growth mindset is, arguably, a relatively easy pedagogical change to make and to scale up.

Given the fact that students did not appear to be motivated by the statistics content per se, alternate forms of mathematics contextualization could be investigated for potential effectiveness. The subject chosen for contextualization should be viewed as legitimate and challenging. Also, students should be afforded with opportunities to take risks and make mistakes, which is not always permissible in mathematics-based subjects. Finally, the institution would have to determine the student demand for the subject chosen. Statistics has had built-in demand because it fulfills major requirements as well as transfer requirements.

Study findings suggest that affective components of the statistics classroom may be more important than culturally relevant subject matter. These affective components may be particularly important to students who doubt their abilities to succeed in a mathematics-based subject area. Mathematics instructors should be attentive to creating a productive and inviting classroom environment.

The StatMode instructor has been described as highly invested. While this has implications for generalizability, it also has implications for the field. Arguably all instructors *should* be highly invested in their students' success. StatMode students perceived the instructor's interest in their learning as genuine, and this mattered deeply to them. While students learned the statistics material, the instructor learned about the students and their learning. Instructors should consider actively cultivating their own learning in parallel with their students.

A final recommendation for action is to inform students about pedagogical approaches being used in the classroom. This study benefited from students' ability to name and articulate growth mindset. As self-aware adult learners, students could likely provide, from their vantage point, insights into the relative effectiveness of other pedagogical approaches if they were sufficiently cognizant of them.

Recommendations for Further Study

While the small size of the cohort, student self-selection, and single instructor limit the generalizability of this study's findings, the potential for transferability and scaling up is substantial. A larger study of a new accelerated statistics sequence is already underway. This study includes multiple instructors at several community colleges. The range of instructors will help to show the range of outcomes which might be expected from early adopters. While student self-selection will still be a limitation, and this particular sequence is limited to students at or above elementary algebra, the larger number of participants will allow for more complex quantitative analyses. To the extent that these new sequences cooperate with programs such as Puente, this study's findings with regard to Puente could be replicated, refuted, or otherwise amended based on further analysis. Also, effects of the classroom composition with regard to ethnicity (i.e. degree of ethnic heterogeneity) could be investigated in a comparative way.

Instructor- and sequence-related variables warrant further scrutiny as the number and variety of accelerated statistics sequences expands. In terms of scalability, one question is whether part time instructors are as effective, especially given limited access to professional development and limited interaction with students outside the classroom. In terms of effective student preparation, performance in the culminating statistics course could be compared to the performance of students who enroll in statistics after completing the traditional algebra sequence—controlling for instructor when possible.

Several recommendations for further research pertain to mindset. It would be useful to determine and quantify students' mindsets at the beginning and end of each course in a two-course accelerated statistics sequence. This information could be incorporated into quantitative analyses to assess whether mindset is significantly related to student learning as measured by course success, sequence success, and content-based exams such as CAOS.

Mindsets can be context-dependent, so it could meaningful to assess mindset with regard to mathematics in particular. However, it is recommended that both mathematics mindset and general mindset be assessed. The subordination of mathematics to statistics even in the pre-statistics class of a sequence such as StatMode means that some students may naturally approach the material with a non-mathematics or modified mathematics mindset. Also, due to findings from other studies which suggest that growth mindset may be less effective when challenges are exceptionally difficult, it would be useful to gauge students' opinion of subject matter difficulty during the same data collection points. Measures of hope could also be incorporated into the analyses. These additional data points would allow investigation of whether there is any interaction between mindset, hope, subject topic (mathematics versus statistics), perceived subject matter difficulty, and student performance at several key points in an accelerated statistics sequence.

A deeper investigation into the interrelationship between math anxiety or math aversion and relative changes to mindset is also warranted to further test this study's suggestion that students with deep-seated math aversion and no prior positive experiences may be less open to altering their mindset.

Contextualization and relevance also warrant further examination. This study's findings suggest that statistics contextualization in the pre-statistics course was meaningful primarily due to students' perceptions of the material as legitimately challenging, not due to perceptions of practical applicability or relevance of the material itself. There are three proposed avenues for investigating this further: (a) determine whether students' sense of the importance and applicability of statistics changes between the beginning, middle, and end of the sequence; (b) pilot and assess other forms of contextualization beyond statistics to determine viability; and (c) solicit deeper, more nuanced information about what motivates students to work on and intellectually engage with particular mathematics or statistics problems.

Conclusion

The need to redress low community college mathematics sequence completion rates and thereby improve transfer rates has become an imperative. Even during the timeframe of this study, the pressure on community colleges continues to rise with regard to this critical gatekeeper discipline. Many policy-makers have vocally suggested that alternative approaches such as sequence acceleration and contextualization warrant consideration.

This study's findings suggest that a two-course accelerated statistics sequence can be effective for some students, including underprepared students who place low in mathematics. This research is particularly promising with regard to educational equity and mathematics. Additional research is needed to determine more precisely which aspects of StatMode were most effective and under what conditions the sequence can be replicated successfully.

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APPENDIX A: Literature for Developmental Mathematics Sequences (Page 1)

Date and Author	**Location, Year, Sample Description and Size**	**Treatment of Demographic Variables**	**Most Advanced Analysis**	**Findings**
(2010) Crisp & Nora	National Beginning Postsecondary Students (BPS:04/06) dataset; Latino students with transfer plans, first time in community college in 2003-04; Followed students through 2006; *n* = 570	Focused on Latino students; Included many variables such as parental citizenship and high school math which were assessed for significance	Logistic regression	For Latino students, remediation was associated with near-term persistence and a significant association was found between high school math level and success in years two and three
(2009) Roksa, Jenkins, Jaggars, Zeidenberg, & Cho	Virginia system; First time students in summer or fall 2004; Followed through summer 2008; *n* = 24,140	Controlled ethnicity, age, and other demographic variables	Logistic regression	One-third of students who enter community colleges with developmental math needs advanced to college-level math; Students who completed developmental math sequences subsequently completed college-level math coursework at rates similar to peers placed directly into college-level math
(2009) Bettinger & Long	Ohio system; Full-time, traditional-aged students (18-20) who entered public colleges in fall 1998; Followed students for 6 years; *n* = 28,376	Controlled ethnicity and other demographic variables; Selected for traditionally-aged students	Regression dis-continuity	Students who took remedial courses achieved better retention and degree completion rates; Students placed into developmental math were 15% more likely to transfer

APPENDIX A: Literature for Developmental Mathematics Sequences (Page 2)

Date and Author	**Location, Year, Sample Description and Size**	**Treatment of Demographic Variables**	**Most Advanced Analysis**	**Findings**
(2009) Bailey, Jeong, & Cho	57 colleges nationally; First time, degree-seeking students in fall 2003 to fall 2004; Followed for 3 academic years; *n* = 256,672	Ethnicity, gender, age, full-time status, vocational major, and developmental referral included in regression	Ordered logit regression	33% of students who enter community colleges with developmental math needs advanced to college-level math; 27% of students never enrolled in developmental math after having been referred and 11% never failed a math course yet did not complete the sequence
(2008) Calcagno & Long	Florida system; First time students from fall 1997 through fall 2000; Followed students for 6 years; *n* = 98,146	Controlled ethnicity, age, and other demographic variables	Regression discontinuity	Remediation promoted early persistence, but only slightly; Remediation was not associated with improved degree completion rates or improved transfer rates
(2008) Bahr	California system; First time students in fall 2005 who enrolled in at least one nonvocational math course; Followed through spring 2003; *n* = 87,613	Controlled ethnicity, age, and other demographic variables	Regression, Predicted probabilities	Students who completed developmental math sequences subsequently completed college-level math coursework at rates similar to peers placed directly into college-level math

APPENDIX A: Literature for Developmental Mathematics Sequences (Page 3)

Date and Author	**Location, Year, Sample Description and Size**	**Treatment of Demographic Variables**	**Most Advanced Analysis**	**Findings**
(2007) Parmer & Cutler	Single college in Ohio; Elementary Algebra students; One instructional quarter; Sample sizes ranged from $n = 641$ to $n = 1,028$	None	Chi-square analyses	Students who completed elementary algebra scored less than one-half point lower on the assessment test than students placing directly into intermediate algebra
(2007) Fike & Fike	Single college in Texas; Intermediate Algebra students; $n = 1,318$	Investigated ethnicity and gender	Logistic regression	White students had higher ending grades ($M = 2.20$, $SD = 1.423$) than Latino students ($M = 1.90$, $SD = 1.504$)
(2007) Calcagno, Crosta, Bailey, & Jenkins	Florida system; First time, degree-seeking students in 1998-99; Followed through spring 2004; $n = 35,073$	Investigated age	Single risk discrete-time hazard model	Older students were shown to be more likely to complete a degree (1.24 times as likely) after controlling for math placement
(2001) Dozier	Single college in New York; Developmental Math students; Spring 1999; $n = 540$	Investigated documented and undocumented international students	Descriptive	More undocumented students required developmental math (64%), compared to documented students (39%)

APPENDIX B: Interview Protocol Including Hope Scale (Page 1)

Questions @ Math Background

For the first few questions, I'd like you to think back to some of your earlier experiences in math. This could have been in elementary school, high school, or other community college courses.

1. If you had to pick just one word to describe how you used to feel about math, what would it be?

2. Thinking back, please describe your best math experience.

[Probes: What made it a good experience? What grade were you in?]

3. Please describe your worst math experience.

[Probes: What made it a bad experience? What grade were you in?]

4. Have you ever questioned your ability to be good at math?

[Probe: What or who made you question your ability? How did it make you question your ability?]

5. Did a peer, parent, or past teacher ever make you feel more confident about doing math?

[Probe: What did they do that made you feel more confident? Who was it?]

6. What was the last math class you took before this one?

[Probes: What was your last math class like for you? What grade were you in? What year was it?]

Questions @ StatMode Experiences

Thanks. Now that I know a little more about your math background, I'd like to ask you about StatMode.

7. How did you find out about StatMode? What made you decide to enroll?

8. Is this course what you expected? How so?

APPENDIX B: Interview Protocol Including Hope Scale (Page 2)

9. Is StatMode like other math classes you have taken? How would you describe your prior math classes? How would you describe StatMode?

10. What happens on a typical day in class? What kinds of things does the instructor do? What do the students do? What do you do?

11. Some people have come to observe StatMode this semester. How do you feel when people come to sit in on the class?

12. What kinds of things are you learning in StatMode?

13. What importance do you place on learning mathematics? How much math do you think you'll need for your future job or career?

14. Can you use what you're learning in StatMode in your everyday life? Does that matter to you?

15. If you had to pick one thing, what is the most important aspect of StatMode?

16. What would you change about StatMode?

17. What would you tell another student about StatMode?

Before we end the interview, please respond to a short survey about your background.

APPENDIX B: Interview Protocol Including Hope Scale (Page 3)

Demographic Questions

1. Please write your Student ID: ________________________
2. Please pick a Pseudonym / Alias: _______________________
3. How many semesters have you been enrolled at MCC? (*check one*)
   ___ This is my **first** semester at MCC
   ___ This is my **second** semester
   ___ This is my **third** semester
   ___ This is my **fourth** semester
   ___ I have been enrolled **five** semesters or more
4. Have you enrolled at any other colleges in the past? (*check all that apply*)
   ___ No, MCC is the only community college I have attended
   ___ Yes, I have attended another community college
   ___ Yes, I have attended a four-year college
5. What is your age? *Please write in:* ___________
6. What is your ethnic identity / ethnicity? *Please write in:* _______________
7. What is the highest level of education your parents have completed?

Mother's Education	**Father's Education**
a. ____ Less than elementary	a. ____ Less than elementary
b. ____ Elementary or equivalent	b. ____ Elementary or equivalent
c. ____ Middle school or equivalent	c. ____ Middle school or equivalent
d. ____ High school or equivalent	d. ____ High school or equivalent
e. ____ Some College	e. ____ Some College
f. ____ Community College degree	f. ____ Community College degree
g. ____ 4-year college degree or higher	g. ____ 4-year college degree or higher
h. ____ Unknown	h. ____ Unknown
i. Other _________________	i. Other _________________
Please write the country in which your Mother's education was completed _________________	Please write the country in which your Father's education was completed _________________

APPENDIX B: Interview Protocol Including Hope Scale (Page 4)

Outlook Questions

Read each item carefully. Using the scale shown below, please select the number that best describes YOU and put that number in the blank provided in the column on the right.

1 = Definitely False 2 = Mostly False 3 = Mostly True 4 = Definitely True

ITEM	RATING
[A] I can think of many ways to get out of a jam.	
[B] I energetically pursue my goals.	
[C] I feel tired most of the time.	
[D] There are lots of ways around any problem.	
[E] I am easily defeated in an argument.	
[F] I can think of many ways to get the things in life that are most important to me.	
[G] I worry about my health.	
[H] Even when others get discouraged, I know I can find a way to solve the problem.	
[I] My past experiences have prepared me well for my future.	
[J] I’ve been pretty successful in life.	
[K] I usually find myself worrying about something.	
[L] I meet the goals that I set for myself.	

APPENDIX C: Interview Consent Form (Page 1)

San Francisco State University
Informed Consent to Participate in a Research Study
Statistics Pathways for Developmental Mathematics at Community Colleges

A. PURPOSE AND BACKGROUND

You are being asked to participate in this study because you are enrolled in the StatMode mathematics sequence at XXXXXXXXX College. The purpose of this research study is to learn about student experiences in StatMode and related completion rates.

The researcher, Pamela Mery, is a graduate student at San Francisco State University conducting research for a doctoral dissertation.

B. PROCEDURES

If you agree to participate in this research study, the following will occur:

- You will be interviewed for approximately one hour about your experiences in StatMode. The interview will include questions such as "Is StatMode like other math classes you have taken?" and "What happens on a typical day in class?"
- The interview will be audiotaped to ensure accuracy in reporting your statements.
- The interview will take place at a time and location convenient to you.
- The researcher may contact you later to clarify your interview answers.
- Your total time commitment will be no more than 90 minutes.
- In addition to providing consent for the interview, your signature on this form allows the researcher to use data related to your academic performance in StatMode in order to better understand and analyze your interview responses. This data will include midterm grades, final grades, and scores on examinations given in the course. During the research analysis process, your midterm grades, final grades, and exam scores will be linked to your interview responses.

C. RISKS

There is a risk of loss of privacy. However, no names or identities will be used in any published reports of the research. Only the researcher will have access to the research data. Students' names will be replaced with pseudonyms in both the interview transcripts and academic records. To further safeguard privacy, the name XXXXXXXXX College will not appear in published reports. There is a risk of discomfort due to the nature of the questions asked; however, the participant can answer only those questions he/she chooses to answer, and can stop participation in the research at any time. Your participation or non-participation in this study will have no affect on your standing in StatMode.

D. CONFIDENTIALITY

The research data will be kept in a secure, password-protected location and only the researcher will have access to the data. Each participant will be assigned a pseudonym known only to the researcher. Academic records including midterm grades, final grades, and scores on examinations will be associated with this pseudonym and stripped of any personally

APPENDIX C: Interview Consent Form (Page 2)

identifiable information. Audio recordings of interviews will be transcribed, then immediately destroyed. Personally identifiable information within the transcripts will be replaced with pseudonyms. All non-electronic documentation containing personally identifiable information will be kept in a locked drawer, inside a locked office at City College of San Francisco. At the conclusion of the study, all identifying information will be removed and the data will be kept in the same secure location. Data will be reported in aggregated form or with an associated pseudonym which protects the individual's identity.

E. DIRECT BENEFITS

There will be no direct benefits to the participant.

F. COSTS

There will be no cost to you for participating in this research.

G. COMPENSATION

There will be no compensation for participating in this research.

H. ALTERNATIVES

The alternative is not to participate in the research. All StatMode students will complete the regular course requirements, but only those who participate in the study will have their data shared with the researcher.

I. QUESTIONS

You have spoken with Pamela Mery about this study and have had your questions answered. If you have any further questions about the study, you may contact the researcher by email at pmery@sfsu.edu or you may contact the researcher's advisor, Professor Helen Hyun at hhh@sfsu.edu. Questions about your rights as a study participant, or comments or complaints about the study, may also be addressed to the Office for the Protection of Human Subjects at 415: 338-1093 or protocol@sfsu.edu.

J. CONSENT

You have been given a copy of this consent form to keep.

PARTICIPATION IN THIS RESEARCH IS VOLUNTARY. You are free to decline to participate in this research study, or to withdraw your participation at any point, without penalty. Your decision whether or not to participate in this research study will have no influence on your present or future status at San Francisco State University or XXXXXXXXX College.

Signature ______________________________ Date: _________

Research Participant

Signature ______________________________ Date: _________

Researcher