HIGH SCHOOL COURSE COMPLETION AND MATHEMATICS
REMEDICATION AT THE CALIFORNIA STATE UNIVERSITY

A Thesis
Presented
To the Faculty of
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in
Mathematics Education

by
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HIGH SCHOOL COURSE COMPLETION AND MATHEMATICS REMEDIATION AT THE CALIFORNIA STATE UNIVERSITY

A Thesis

by

Mark A. Wilpolt

Spring 2013

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TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Publication Rights</th>
<th>iii</th>
</tr>
</thead>
<tbody>
<tr>
<td>List of Tables</td>
<td>vi</td>
</tr>
<tr>
<td>List of Figures</td>
<td>vii</td>
</tr>
<tr>
<td>Abstract</td>
<td>viii</td>
</tr>
</tbody>
</table>

CHAPTER

I. Introduction ........................................................................ 1
   Problem Statement .......................................................... 1
   The Research Question ..................................................... 3
   Theoretical Perspectives .................................................. 5
   Purpose and Significance of the Study ............................... 7

II Review of Prior Research .................................................. 9
   Course Sequence After Algebra 2 ....................................... 9
   Course Sequence and College Remediation ............................ 10
   The Senior Year ............................................................. 13
   What Students Are Taking ................................................. 14

III Methodology ........................................................................ 16
   Data Collection and Classification .................................... 16
   Data Analysis ..................................................................... 20
   Limitations of Study ....................................................... 21

IV Results ................................................................................. 22
   Main Hypothesis ............................................................. 26
   Is Statistics as Good as Advanced Math? ............................. 27
   A Look at Senior-Year Math ............................................... 28
   “A” Students in Algebra 2 .................................................. 29
<table>
<thead>
<tr>
<th>CHAPTER</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repeating Algebra 2</td>
<td>30</td>
</tr>
<tr>
<td>Male versus Female</td>
<td>30</td>
</tr>
<tr>
<td>Ethnicity</td>
<td>32</td>
</tr>
<tr>
<td>Differences in Performance Service Area and Outside</td>
<td>34</td>
</tr>
<tr>
<td>Service Area</td>
<td></td>
</tr>
<tr>
<td>Out-of-State Students</td>
<td>38</td>
</tr>
<tr>
<td>Out-of-Country Students</td>
<td>39</td>
</tr>
<tr>
<td>Secondary Questions</td>
<td>39</td>
</tr>
<tr>
<td>Other Variables</td>
<td>40</td>
</tr>
<tr>
<td>Taking Math After Algebra 2</td>
<td>41</td>
</tr>
<tr>
<td>Results Summary</td>
<td>43</td>
</tr>
<tr>
<td>V Conclusions, Discussion, and Recommendations</td>
<td>45</td>
</tr>
<tr>
<td>Conclusions</td>
<td>45</td>
</tr>
<tr>
<td>Closing Remarks—The Good News</td>
<td>61</td>
</tr>
<tr>
<td>References</td>
<td>63</td>
</tr>
<tr>
<td>Appendices</td>
<td></td>
</tr>
<tr>
<td>A. Descriptive Statistics from Prior Research</td>
<td>72</td>
</tr>
<tr>
<td>B. Classification of High School Math Courses</td>
<td>75</td>
</tr>
<tr>
<td>C. Hmong Family and Clan Surnames</td>
<td>81</td>
</tr>
<tr>
<td>D. Remedial Levels by Ethnicity and Gender, Systemwide and CSU, Chico, for First-time Freshmen Fall 2010</td>
<td>83</td>
</tr>
<tr>
<td>E. Required Courses for 2008 Math Graduation Credits</td>
<td>85</td>
</tr>
<tr>
<td>F. Detailed Results of Data Collected from Fall 2010 CSU, Chico</td>
<td>88</td>
</tr>
<tr>
<td>G. Comparing Chico Service Area to Rest of State for Fall 2010</td>
<td>94</td>
</tr>
<tr>
<td>H. Course Sequence and Remediation for California Regions</td>
<td>97</td>
</tr>
<tr>
<td>I. Fall 2010 Remediation Rates for CSU, Chico International Students</td>
<td>100</td>
</tr>
</tbody>
</table>
# LIST OF TABLES

<table>
<thead>
<tr>
<th>TABLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Remediation Rates for Progressive Course Sequences for Fall 2010 CSU, Chico</td>
<td>24</td>
</tr>
<tr>
<td>2. Remediation Rates for Progressive Course Sequences for Fall 2010 CSU, Chico Freshmen</td>
<td>25</td>
</tr>
<tr>
<td>3. Algebra 2 Cutoff With and Without Senior Year Mathematics</td>
<td>28</td>
</tr>
<tr>
<td>4. Fall 2010 Freshmen Algebra 2 Grades and No More Math</td>
<td>29</td>
</tr>
<tr>
<td>5. Algebra 2 Cutoff Data by Gender for Fall 2010</td>
<td>31</td>
</tr>
<tr>
<td>6. Algebra 2 Cutoff Data by Ethnicity for Fall 2010 Freshmen</td>
<td>33</td>
</tr>
<tr>
<td>7. Comparing Remedial Rates Inside and Outside Chico Service Area</td>
<td>35</td>
</tr>
<tr>
<td>8. Comparisons Between Algebra 2 performance and Next Class</td>
<td>42</td>
</tr>
</tbody>
</table>
LIST OF FIGURES

<table>
<thead>
<tr>
<th>FIGURE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Highest high school math course completed for fall 2010 CSU, Chico freshmen</td>
</tr>
<tr>
<td>2.</td>
<td>Course taking sequences for fall 2010 CSU Chico first-time freshmen</td>
</tr>
<tr>
<td>3.</td>
<td>Course sequence and math readiness for fall 2010 CSU, Chico freshmen</td>
</tr>
<tr>
<td>4.</td>
<td>Fall 2010 CSU, Chico freshmen remediation rates by course sequence for Chico service area</td>
</tr>
<tr>
<td>5.</td>
<td>Remediation rates, by course sequence for Fall 2010 CSU, Chico freshmen from outside the Chico service area</td>
</tr>
</tbody>
</table>
ABSTRACT

HIGH SCHOOL COURSE COMPLETION AND MATHEMATICS REMEDIATION AT THE CALIFORNIA STATE UNIVERSITY

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Master of Science in Mathematics Education

California State University, Chico

Spring 2013

The California State University (CSU) measures freshman preparedness for college level math (math) with the Entry Level Math (ELM) requirement. Students unable to meet this benchmark are required to complete from one to two semesters of remedial math during their freshman year before they are eligible to enroll in a math course that counts toward their degree.

CSU freshmen come mostly from California high schools, but these students have completed different levels of high school math. The purpose of this study is to see what is happening regarding CSU incoming freshmen’s highest level math class taken, and their need for remediation. Specifically, with regard to satisfying the CSU Entry Level Math requirement, is there a significant difference between students that stopped at Algebra 2 and students that took the math class that follows Algebra 2? In this study, I called that class Advanced Math. I examined the high school transcripts of 1,755 first-
time freshmen for fall 2010 at CSU, Chico. I compared these students’ highest math course taken and which years they were taken to their “ELM Status”: whether they satisfied the Entry Level Math requirement. Other variables such as gender, ethnicity, GPA, and SAT scores were also examined.

I concluded that for students that do not progress beyond algebra 2, remediation is almost twice as likely as it is for students that took Advanced Math, regardless of whether or not these classes were taken in the senior year. Females and Hmong (Asian) are placed remedial at a greater rate than whites, males and non-Hmong Asians, but the huge decrease in remedial placement for post-Algebra 2 students happens for almost all subgroups. A math class in the senior year is associated with a 12.5% decrease in the need for remediation; but that is not as powerful an indicator as going beyond algebra 2. Out of 1,755 students, 58% of those that stopped at Algebra 2 could not fulfill the ELM requirement; however, of those that took the next class, Advanced Math, only 27% required remediation. Taking more classes beyond that lessens the likelihood of remediation yet further.
CHAPTER I

INTRODUCTION

Problem Statement

From 70 to 75% of students who graduate from high school go on to some form of postsecondary education within two years of their high school graduation (Haycock, Barth, Mitchell, & Wilkins, 1999). Ideally, these students should come prepared to begin the first math class required for their major. However, millions of freshmen entering postsecondary institutions in the U.S. enroll in one or more remedial courses in reading, writing, or math each year. Estimates range from 33 to 50% of all freshmen (Boser & Burd, 2009; Haycock et al., 1999). Last year, 25,000 California State University (CSU) freshmen found themselves in a remedial math course.

The CSU measures freshman preparedness for college level math in the following ways: a score of 550 or higher on the math portion of the SAT, 23 or above on the ACT, 3 or higher on the advanced placement (AP) exam, or a designation of “Ready for College” on the 11th grade California Standards Test (CST). A student earning a “Ready for College-Conditional” designation on the 11th grade CST can take a senior year math class and the requirement is fulfilled. Any of these accomplishments will exempt the student from the Entry Level Math (ELM) test administered by the university; otherwise, the incoming freshman must take that placement test. If a student cannot meet any of the aforementioned benchmarks or pass the ELM, he or she is required to complete remedial
math classes in the first year at college. At the CSU, the number of freshmen that are placed into a required remedial math class has been around 37% for each of the last six years (CSU 2012). According to the entrance requirements for the CSU, these are students from the top third of their graduating class, maintaining at least a B average, and completing a supposedly rigorous outline of college preparatory courses. Although they have met the college entrance requirements, more than a third of incoming freshmen are not prepared in math.

The problem is not new. In 1972, 59% of incoming CSU freshmen were labeled as proficient in math and not requiring remediation, compared to 64% in 2006 (CSU Public Affairs, 2006). In 2003, CSU Chancellor Charles Reed set a priority to reduce the need for remediation to 10% by the year 2007. But as it has remained at roughly 37% since 2005, that goal has clearly not been met. The problem in California seems to be mirroring a national problem. The national average for remedial math in college is close to the CSU average: about a third nationally (Long, Iatarola, & Conger, 2009).

Beginning one’s college career in a remedial math or English class is demoralizing and costs money for both the student and the budget-strained colleges. Students who begin college in remedial classes are less likely to complete a four-year degree (Adelman, 1999). One study found that 63% of those who require one or two remedial math courses fail to earn degrees (National Center for Education Statistics, 2004).

The remedial student or the parent will be paying for extra tuition, time, and classes that do not count toward earned degree units. Community colleges provide the
greatest share of remedial education, and “because state and local governments provide subsidies to many community colleges on top of the tax monies already allocated to their high schools, the taxpayers are actually paying twice for these students’ education” (Alliance for Excellent Education, 2006, p. 4). Nationwide, the cost of remediation ranged from 2.31 to 2.89 billion dollars in public post-secondary institutions during the 2004-2005 academic years (Strong American Schools, 2008). There are remedial programs in more than 75% of public four-year institutions (Boser & Burd, 2009), including all of the 23 campuses of the CSU system, which requires CSU to allocate facilities, staff, and time to these students.

If most high school students are going to college, preparedness for college should be an institutionalized part of their high school’s curriculum or graduation requirements. So why are so many coming to college unprepared in math? This question is too big to answer. But in my work here at CSU, Chico with the Early Assessment Program (EAP), an outreach program whose mission is to improve college preparedness in our local area, I have been exposed to research that might point to some specific clues. There might be a relationship between college preparedness and the number and nature of one’s high school math classes. And that relationship seems to pivot around Algebra 2.

The Research Question

The main objective of this study was to answer the question: Is there a significant difference between CSU, Chico freshmen that stopped at Algebra 2 in high school
and those that took up to Advanced Math, with regard to satisfying the CSU Entry Level Math requirement?

The literature so far suggests that there is a difference, and this is the main message that I hope to make more public, in the hope that it might impact remediation in the CSU system. However, with the same data, other secondary questions can be answered.

1. Does math readiness or remediation depend on course sequence in general? If so, what course sequence is the best for college preparation in math?

2. Are other variables like gender, ethnicity, GPA, factors in college readiness?

3. What percentage of our applicants takes a senior year math class, and does it make a difference in preparation?

4. What other classes besides trigonometry or pre-calculus are chosen by the student who has completed Algebra 2?

5. Are students that are moving onward from Algebra 2 the higher performing students, that is, students that received higher grades in that class?

   In this study, I also investigate whether a high school statistics course is deserving of that Advanced Math designation. That is, I investigate those students that took statistics as their only post-Algebra 2 course to see if they met the college readiness benchmark, as well as those that took trigonometry or analysis/pre-calculus as their post-Algebra 2 course. To my knowledge, there is no research yet on this.
Theoretical Perspectives

Why are so many coming to college unprepared in math? Many researchers and education advocates are pointing to an expectations gap between what high school courses teach and what colleges expect from their students (Cohen, 2008; Kirst & Venezia, 2006). The high school requirements are implemented by school, district, and state mandates, and measured by a variety of high school assessments that often are not aligned with college expectations. Organizations like the Center for Education Policy Research, American College Testing Inc. (ACT), American Diploma Project (ADP), the Stanford Bridge Project, Educational Policy Improvement Center, EdSource, the Education Trust, and the West Regional Educational Laboratory (WestEd) are pointing out these gaps and offering recommendations on what to do about them. There is a difference, they are finding, between being “college eligible” (meeting the minimum entrance requirements of the college) and being “college ready” (ready to successfully handle the rigors of college courses). The perspective of these organizations set the tone for my research.

In a survey conducted by ACT, 79% of secondary math teachers answered “well” or “very well” to the question “How well do your state standards prepare your students for college level work?” but only 42% of college instructors thought so. The Stanford Bridge Project is “the intellectual leader in the kindergarten-through-college (K-16) movement” (Schoenfeld, 2005, p. 1). Project director Michael Kirst is one of many that lament the disconnect or distance between educators and policymakers in the K-12 community and the postsecondary institutions. Kirst and Venezia (2006) say high
schools and colleges need to create integration between their systems, and “align their courses and assessments to improve college readiness” (p. 3). The details of a math curriculum are one part of this alignment. In fact, Kirst and Venezia suggest, States should be able to use their data systems to answer questions like: Considering those students who require remediation in college, what percentage took a college-preparatory curriculum in high school? (p. 4)

This particular question, as well as previous research conducted by Richard Ford at CSU, Chico, was the inspiration for my study.

The Education Trust has advocated for change “in both higher education and K-12—in our standards, assessments and our graduation requirements—to turn this pattern around” (Haycock et al., 1999).

The ADP is conducted by Achieve (2011), an independent, non-profit education reform organization whose mission is “to help states raise academic standards, improve assessments and to prioritize college and career readiness” (p. 2) Achieve’s (2004) report found that all students, whether they are heading to college or embarking on a meaningful career, need the same level of knowledge in the foundational subjects of English and math. The ADP has so far joined 35 states together (The ADP Network) to “agree to align high school standards, assessments, curricula, and graduation requirements with what employers and colleges expect of students” (Tonn, 2006, p. 1). Achieve (2009b) argues that for high school graduates to be prepared for success in college and careers, they need to complete “a challenging course of study in math that includes the content typically taught through [at least] an Algebra 2 course (or its equivalent)” (p. 14).
The Algebra 2 course, Achieve (2009b) says, needs to be effective. The states in the ADP Assessment Consortium are reassessing the rigor and efficacy of their Algebra 2 programs, as measured by a common “End of Course Algebra 2 Exam.” Their research provided a significant stepping-off point for my study.

Thanks in part to these organizations, there is a new spirit of math reform spreading across the nation. Forty-four states have adopted the Common Core State Standards (CCSS): “A clear and focused progression of learning from kindergarten to high school graduation,” designed to do “what it takes for high school graduates to be ready for college and careers and build on the finest state and international standards” (Achieve, 2011, p. 10).

These advocates and researchers are looking at many facets of college preparation: good teaching, good schools, vigorous standards, student and parent awareness, high school counseling, student support services, and more. Curriculum is what I am looking at here—and most of these organizations are advocating for a three to four year plan of rigorous college preparatory math. While some say “college preparatory” means courses up to at least Algebra 2, others argue that students need to go beyond algebra 2 in order to successfully qualify as “college ready.” This is the focus of my study.

Purpose and Significance of the Study

This study can add to the conversation about a disconnect between high school requirements and college expectations by showing how the college preparatory Algebra 2 class might not be enough. The study will help inform the decisions that need to be made by students, their parents, counselors, teachers, and administrators. There has
been some research on course selection and college preparation, but none (that I can ascertain) regarding only the CSU’s 23 campuses, which form the largest university system in the United States. This work can benefit the mission and budget of the CSU if more high school students become aware that their course sequence is important and, hopefully, bring down the number that require remedial classes. The students and parents can benefit, saving time and money toward graduation. Teachers at the high school level will know that their students are better prepared for a college career. Teachers at the CSU can enjoy a student that has come into their classroom with better preparation. Parents, students, and educators can better understand the likelihood that students taking particular high school math classes will need math remediation before continuing in college. This study will only address the CSU campus in Chico; but its findings can be used to inform, stimulate, and provide a framework for future research systemwide.

More specifically, this research can benefit the EAP and our other outreach organizations at CSU, Chico in their missions to inform our local college-bound students on what college preparation means. We can look at remediation rates and course sequences at the individual school level, identifying feeder schools that might merit special attention or intervention.
CHAPTER II

REVIEW OF PRIOR RESEARCH

Though causality has not been entirely established, several studies suggest that taking more credits in math and more advanced math courses at the high-school level increases

1. Proficiency on high school standardized math exams (Berkner & Chavez, 1997; Bryk, Lee, & Smith, 1990; Cool & Keith, 1991; Gamoran, 1987; Rock & Pollack, 1995; Schneider, 2003; Shettle et al., 2007).

2. The likelihood of high school graduation (Schneider, Swanson, & Riegle-Crumb, 1998; Adelman, 1999).

3. Entry into and performance while in college (Adelman, 1999; Schneider et al., 1998).

4. Affects choice of college major (Federman, 2007).

Course Sequence After Algebra 2

Research so far is giving clues that courses taken in high school have a great impact on college success and on the need for remediation. In 2000, a groundbreaking U.S. Department of Education study concluded that the most significant predictor of college completion is not SAT scores, or socioeconomic status, but the level of advanced math the student completes (Adelman, 1999). Six years later, Adelman (2005) provided
an update: “The highest level of math in high school is the strongest predictor of BA attainment, regardless of race, family income or background” (p. 33). Of those students whose highest high school math completed was Algebra 2, only 39% ended up obtaining a B.A., but the attainment number jumped up to 60% for those who took trigonometry and 71% for pre-calculus. “[T]he tipping point of momentum toward a bachelor’s degree,” Adelman says, is “firmly above Algebra 2” (p. 34). Here we have our first hint that Algebra 2 might not be enough to really prepare for college.

Course Sequence and College Remediation

In a study of 623 students at North Arkansas College, Berry (2003) found that of the students who completed a course higher than Algebra 2, 73% placed into college-level math, and did not require remediation; in contrast, 28% of those whose highest course was Algebra II placed into college level math. That is, 72% required remediation. Hoyt and Sorensen (2001), in a study of 414 students bound for Utah Valley State College, found that of students whose highest level math class was Algebra 2, 56.7% were placed into remedial math. Of students that progressed to the next class after Algebra 2 (trigonometry), 42.9% were placed into remedial math.

In the research that inspired my study, Ford (2007) looked at 1,395 incoming freshmen from the local service area (the North valley) from 2004 to 2006. Of students that did not go beyond Algebra 2 in high school, 60% required remediation. But of students that completed at least one class beyond Algebra 2, only 18% required remediation (Appendix A). Students that stopped at Algebra 2, but earned a B+ or higher in that class, had a lower remedial rate than the other Algebra 2 students. Students taking math in their
senior year had a slightly lower overall remedial rate than those taking no senior year math. The biggest drop in remediation rates happened for students that went beyond Algebra 2, whether or not it happened in the senior year (Ford, 2007).

A similar study by Fong (2008) of 4,753 freshmen in Nevada found similar results: 64% of Algebra 2 graduates ended up in remedial math, but only 32% of trigonometry graduates, and only 15% of pre-calculus graduates needed remediation (Appendix A).

In Florida, where (much like California and Nevada) more than a third of college students require remedial math, Long et al. (2009) found that even after controlling for students’ academic achievement before high school and other characteristics, the highest math class taken in high school was “a strong, positive predictor of readiness.” They found a 14.2% increase in readiness when students went beyond Algebra 2 to a more advanced math course. They investigated the contribution of the highest math course taken in high school to racial, socioeconomic, and gender gaps in readiness for college level math and found that between 28 and 35% of black-white, Hispanic-white, and poverty gaps can be explained by differences in the math courses students taken in high school while differences in students’ educational needs, eighth-grade math scores, and eighth-grade campuses explain much of the rest. (p. 3)

Long et al. imply, then, that ensuring that black, Hispanic, and poor students take the same math courses as white and non-poor students could greatly increase their college readiness, and by taking more advanced courses, white students could nearly reach Asian students’ readiness rates. Whether or not the student takes those advanced courses, the authors say, may be influenced by those other factors – mostly 8th grade math scores.
Different socioeconomic groups and ethnic groups may gain in varying degree by taking advanced courses, but they all gain. Taking a more advanced math class benefits all demographic subgroups across the board.

American College Testing Inc. (ACT) (2005) has collected data on college readiness for decades. Their benchmark for “college readiness” is a score of 22 or better on the ACT test available to 11th and 12th graders. Historically, nationwide about 43% of students reach that score of 22. A study of 403,000 students in 2003 found that students only taking up to Algebra 2 had a 22% chance of meeting the benchmark, but students taking trigonometry (after Algebra 2) had a 37% chance. Taking yet another “Advanced Math” class increased the probability to 45% (ACT, 2005).

In another study of 81,574 high school students from 1993 to 2004 in three states, ACT (2007) found only 16% of students taking three years of math met the readiness benchmark, and 35% for 3.5 years of math. “It is not until students take one full year of additional math courses beyond the [three-year recommended] core that we see more than half (62%) of ACT-tested students ready for college-level work in math” (p. 9). It goes up to 75% for students with 4.5 years of college prep math (students that have begun their “college prep math” by taking Algebra I in 8th grade).

In the same study, ACT (2007) found that of students who said they were taking three years of math in high school (up to and including Algebra 2), 26% ended up requiring remediation upon entering college. Those taking a fourth year of advanced math reduced the remediation rate to 17%, and 6% for those taking two advanced math classes after Algebra 2.
Though each of these studies uses a different benchmark to measure college readiness, they each show a marked increase in students meeting a benchmark when students are taking an advanced math course after Algebra 2.

In summary, Algebra 2 is widely seen as a “gatekeeper,” a class essential for students bound for a four-year university (EdSource, 2007). The literature consistently shows that whether we are talking about students in Nevada, nationwide, or students headed for CSU universities, merely completing Algebra 2 is no guarantee of achieving college readiness. Stopping one’s high school math coursetaking at Algebra 2 is highly associated with failing to meet the readiness requirement.

The Senior Year

Research is suggesting that the senior year in high school is important for strengthening college readiness in math, though not as influential as the highest math class completed. Both the CSU, Chico pilot study and the Nevada study found that a math class in the senior year is associated with a 7% to 9% decrease in the need for remediation (Fong, 2008; Ford, 2007). In California, students are less likely to take math each year they progress through high school. While almost all 8th graders in 2006 were in a math class, by 11th grade the number has gone down to 77% (EdSource, 2007). At the time of this writing, the percentage of California seniors in a math class still needs to be determined. My study should provide a good estimate of that percentage.

The research so far favors a senior year in high school spent doing math, and even more importantly, taking math courses after Algebra 2. This could provide a powerful recipe for success in college, starting with avoiding the need for remediation.
However, do our students, their parents and their counselors know about this? And could administrators or policymakers implement reforms based on these results?

**What Students Are Taking**

State policymakers are increasingly realizing the importance of taking as much high school math as possible. In March 2011, Massachusetts joined the ranks of only ten other states that are now mandating four years of math, *up to at least the Algebra 2 level*, for high school graduation (see Appendix E for a list of state requirements).

But neither Algebra 2 nor senior year math are required by the California Department of Education (CDE). California only requires that students take “at least two courses of math,” one of which “must meet or exceed the rigor of the content standards for Algebra I” (CDE, 2010, p. 1). School districts, however, can implement their own policies and recommendations. The requirement for students applying to a CSU university is “at least three years of math, including Algebra 1, Geometry and Algebra 2,” and it is the job of the high school counselors to notify their college-bound students of this requirement.

However in a recent study, less than half of 9th graders had discussed college requirements with a counselor. The number increased to 77% by 11th grade, but, by that time, some students have already made their course choices (Conley, 2005). The research is not specific as to whether students are aware of a real need for advanced math beyond Algebra 2. The course planning worksheet distributed to 9th graders and their parents by one major local feeder school for CSU, Chico states “CSU/UC’s recommend additional years of math, science and foreign language,” but this is a small footnote that provides no more specific information (Chico High School, 2010, p. 1). Greene and Forster (2003) found
that only 32% of U.S. graduates have completed a college preparation program of four years of English, three years of math, two years each of natural science, social science and foreign language, and an achievement level of “basic” on the National Assessment of Educational Progress (NAEP).

Unfortunately, many students are not choosing to take classes beyond Algebra 2. Nationwide, in 2004, 33% of high school students (an increase from 10.7% in 1982) took pre-calculus or calculus (Planty, 2007). Sometimes the class after Algebra 2 is not even available. Latino students nationwide, for example, are far less likely to attend high schools offering trigonometry (let alone calculus) than white or Asian students. Students from the lowest one-fifth of socioeconomic status attend high schools that are much less likely to offer any math higher than Algebra 2 than schools serving students in the upper quintiles (Adelman, 2005). This raises serious questions in a state that is concerned with an “equity gap” in education. Fewer than half of African American, Latino, and Native American graduates take math beyond Algebra 2, but 69% of Asian and 54% of white graduates did (Planty, 2007). Thirty-three percent of students from disadvantaged families take math beyond Algebra 2, compared with 72% of affluent students (Dalton, 2007).
CHAPTER III

METHODOLOGY

Data Collection and Classification

Data collection was performed in the Office of the Registrar at CSU, Chico using their ImageNow system to view the high school transcripts of the 1,853 first-time freshmen for fall 2010. I had access to transcripts of 409 freshmen from the local service area from fall 2009, and 437 local service area freshmen from fall 2008. Permission to use this material was granted by the Registrar at CSU, Chico which reserves all rights in the material. Foreign students and out-of-state students were excluded from this study— their high school transcripts did not provide detailed information of the levels of math taken. Also excluded were students that fulfilled the ELM requirement by taking a general education transferable math class from a community college before coming to CSU, Chico. The Office of Admissions provided an Excel spreadsheet file containing relevant information for each student, including ELM status, ELM score (if taken), ethnicity, GPA, high school name, SAT score. Additionally, I recorded the level of math class taken and the grade received for each semester of math in 10th, 11th, and 12th grades. I categorized all students by whether they passed the ELM requirement and which one of nine different math course sequences they took.

Grades were numerated using the generally accepted grading scale of A=4.0, A+=3.7, B+=3.3, B=3.0, B-=2.7, C+=2.3, C=2.0, C-=1.7, D+=1.3, D=1.0, D-=0.7, F=0. If
a student was on a quarter system instead of a semester, the quarter grades were will be averaged to yield a semester grade.

To designate the level of math taken, I followed criteria developed by Burkam and Lee (2003), Long et al. (2009), and Plany (2007) (Appendix B). Burkam and Lee used an eight-level index, and Fong (2007) also used these criteria. But my study did not need all of these levels, mainly focusing on what was happening between their levels 5: Middle 2, 6: Advanced I, and higher. I preserved the division between these two levels, naming them levels 3 and 4 in my criteria. I designated an introductory algebra class (whether or not it is a two-year sequence) as 1 and the geometry class that, in California, usually follows algebra as a 2. However, Burkam and Lee place statistics in the same category (Advanced I) as trigonometry, analytic geometry, and third-year algebra. Long et al. (2009) place probability and statistics in their level 3, the same level as Algebra 2, calling it “Another level 3 course,” implying a lower level than Burkam and Lee. In my experience teaching high school math, a statistics course does not use and reinforce algebraic and geometric concepts. Though 20% of the ELM contains questions on probability and statistics, a statistics class may, in fact, represent a year’s vacation from the concepts that make up 80% of the CSU ELM placement test. One of the purposes in this study was to see if there is a difference in math readiness between students who spend their senior year taking a statistics course compared to students taking some other, more rigorous advanced math class. So, in this study, I did not treat probability/statistics and other statistics classes as a level 3 (like Long et al.), nor as advanced math (such as Burkam & Lee), but in a category by itself. I designated them as S (statistics or probability/
statistics), APS (advanced placement statistics that follows Algebra 2), and 4.5 (AP
statistics course taken by a student that had already completed a class in my category 4.

Also, Burkam and Lee have two categories (Advanced I and Advanced II) between
the levels of Algebra 2 and calculus. But in many transcripts, students take pre-calculus
(B/L level Advanced II) after Algebra 2, and then take calculus, while many others take
Trig/Analytical Geometry (B/L level Advanced I) after Algebra 2 and then followed that
with calculus. In other words, students in this study are using classes in either of those
Burkam and Lee levels as post-Algebra 2 bridges to calculus. Since this study is interested
mainly in the question “Does going beyond Algebra 2 make a difference for our students?,”
I combined Burkam and Lee’s levels 6 (Advanced I) and 7 (Advanced II) into one post-
Algebra 2 level, named 4 in my datasets. Long and Iatarola (2009) did something like this,
using a 4 for any post-Algebra 2 course that came before calculus, naming it Advanced
Algebra/Trigonometry/other level 3 course. In this study any course that has Algebra 2 as a
prerequisite at that school, and that is continuing to use or reinforce algebraic and/or geo-
metric concepts was considered a 4. The vast majority of these courses were called Trigo-
nometry, Analysis, Algebra 3, Analytic Geometry, and Pre-calculus. In this study, I refer to
this category as Advanced Math.

Planty (2007) designates the classes Algebra I/Geometry, and Algebra II as
the broad category middle academic, and the courses Trigonometry/Algebra 3, pre-
calculus, and calculus under the broad category Advanced Academic. My classification
scheme generally focuses on the differences between these two broader categories.
There are other courses in the California transcript data not shown in Burkam and Lee (2003) that, in my opinion, met those criteria, including Advanced Topics, Finite Math, Math Studies SL, IBmath3, and SMAC Math. For each of these, I researched their course descriptions and syllabi or contacted the teachers to determine if it met the criteria for a 4 (Advanced Math). The highest level in the Burkam and Lee criteria is Advanced III/Calculus, and that is also the highest level (5) in my list. Out of almost 1,800 transcripts, only 25 (1.4%) had math classes that did not fall into any of these categories, such as Business Math, Discrete Math, Modern Math, and Math Ideas. I did not have enough information about them to call them an Advanced Math class, so gave them a designation of Other.

In the data file provided to me by the Office of Admissions, there were eight ethnic groups: Asian, American Indian/Alaska Native, Black/African American, Decline to State, Native Hawaiian/Pacific Islander, Hispanic/Latino, Two or more Races/Ethnicities, and White. I feel that it would benefit my colleagues in future research to disaggregate members of the Hmong community. The Hmong are a distinct ethnic group in California with their own immigration history since the late 1970s and are identifiable by surnames of the 21 clans in this community (Appendix C). I separated these students and designated them with the ethnicity Hmong. Remedial rates, information on courses taken, and other details from this large subset of Californians may be useful to future researchers.

Students can be exempted from the ELM (thereby demonstrating college readiness in math) via benchmark scores in the ACT, SAT I, SAT II, AP Exam, or CST test
with EAP. Sometimes the type of exemption was helpful in explaining differences in preparedness associated with different high school courses.

Data Analysis

I tested the null hypothesis “With regard to fulfilling the ELM requirement, stopping at Algebra 2 is not any different than stopping at Advanced Math for students attending CSU, Chico.” The population was all CSU, Chico students, and my sample was all fall 2010 freshmen. Though this was is not a random sample (see Limitations of Study below), it can be argued that this year’s cohort is representative of all domestic students that have come to CSU, Chico as first-time freshmen in the last few years. I used confidence intervals to compare the probability of remediation for Algebra 2 students to that for Advanced Math students, and confidence intervals for any difference in success rate between the Algebra 2 students and students completing other course sequences. To investigate a secondary question, whether Math readiness is dependent on course sequence, a chi-square test for independence was performed. To investigate whether math readiness might be influenced by other variables like ethnicity, gender, or GPA, multiple logistic regression was performed using the online version of StatCrunch statistical software.

Descriptive statistics, like the figures below, reveal other important information: which other classes were taken, what proportion of students are taking four years of math, what proportion are taking classes after Algebra 2, placement success of different grades, and other issues.
Limitations of Study

If there is a relationship between course selection and math readiness, I can’t say that this is a causal relationship. There are, perhaps, many other factors (lurking variables) that have not been examined, such as socioeconomic status, educational needs, prior academic achievement, and quality of the middle school attended. But prior academic achievement could be partially reflected or built in to the variable course sequence—that is, a student that has reached pre-calculus by 11th grade was showing that they had good academic achievement prior to that.

There is the possibility of self-selection: students that are already performing at a low level in math may be self-selecting by choosing to not move on to advanced math in high school.

There could potentially have been problems with analyzing transcripts: the course classification schema used is reasonably rigorous, but what is in a course title as listed on a transcript might not be the same as what is actually taught. That is, a trigonometry course at one school may not be as rigorous as the similarly named course at another school.

Lastly, students in this study were not selected at random. Any inference about all CSU, Chico freshmen would be based on a sample of all 1,755 freshmen from California in the fall of 2010.
CHAPTER IV

RESULTS

Twenty-three percent of students stopped at Algebra 2 in high school (Figure 1). Nine percent took a statistics class after Algebra 2, but the majority of students (68%) moved on to at least one Advanced Math class.

Forty-one percent stopped at Advanced Math, 10% followed that with a statistics class, and 16% took calculus in high school. Seventy-four percent of students took a math class in their senior year.

Figure 1. Highest high school math course completed for fall 2010 CSU, Chico freshmen.
Of students that took no math past Algebra 2, more than half (58.8%) were unable to fulfill the ELM requirement and were placed into remediation at CSU, Chico (Figure 2 and Table 1). Students taking Algebra 2 in their senior year were in the most danger of requiring remediation (66.3%). Of students that completed Algebra 2 and then took no 12th grade math, 53.0% required remediation.

There is a large difference between students who did not progress beyond Algebra 2 and students who progressed to Advanced Math or beyond (that is, students whose highest math course was advanced, statistics after advanced, or calculus). Of those
Table 1

Remediation Rates for Progressive Course Sequences For Fall 2010 CSU, Chico

*Freshmen*

<table>
<thead>
<tr>
<th>Course sequence</th>
<th>Total</th>
<th>Remedial</th>
<th>% Remedial</th>
<th>95% CI for difference from highest math = Algebra 2 (p&lt;0.0001)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highest math = Algebra 2</td>
<td>413</td>
<td>243</td>
<td>58.8</td>
<td></td>
</tr>
<tr>
<td>Algebra 2 → Statistics or Other</td>
<td>145</td>
<td>52</td>
<td>35.9</td>
<td>0.1360, 0.3187</td>
</tr>
<tr>
<td>Highest math = Advanced Math</td>
<td>727</td>
<td>194</td>
<td>26.7</td>
<td>0.2631, 0.3778</td>
</tr>
<tr>
<td>Advanced Math → Statistics or Other</td>
<td>193</td>
<td>22</td>
<td>11.4</td>
<td>0.4066, 0.5373</td>
</tr>
<tr>
<td>Calculus</td>
<td>277</td>
<td>16</td>
<td>5.8</td>
<td>0.4733, 0.5831</td>
</tr>
<tr>
<td>Total</td>
<td>1,755</td>
<td>527</td>
<td>30.0</td>
<td></td>
</tr>
</tbody>
</table>

whose highest class was Algebra 2, 243 out of 413 (58.8%) placed remedial. Of those who progressed to Advanced Math or beyond, 231 out of 1197 (19.3%) placed remedial. (95% confidence interval for this difference is 33.93 to 44.39%, p<0.0001).

For course sequences after Algebra 2, a statistics course or some other course is was associated with a lower chance of remedial placement; however, but the big decrease in remedial probability happened after taking a course that could be called Advanced Math (Table 1). Only 26.7% of students taking Advanced Math as their highest math class required remediation, less than half the rate of those that only took Algebra 2.
Table 2 and Figure 3 also show that taking successively more math classes corresponds with successively lower remediation rates. A class like statistics after Algebra 2 is good, but Advanced Math is better, an advanced class followed by a non-calculus class is even better, and students taking calculus place remedial only 5.8% of the time.

Table 2

**Remedial Rates for Progressive Course Sequences for Fall 2010 CSU, Chico Freshmen**

<table>
<thead>
<tr>
<th>Course sequence</th>
<th>Total</th>
<th>Count (% Remedial)</th>
<th>95% CI for difference from highest math= Algebra 2</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highest class = Algebra 2</td>
<td>413</td>
<td>243(58.8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Algebra 2 → AP Statistics</td>
<td>44</td>
<td>16(36.4)</td>
<td>7.24 - 37.24</td>
<td>0.0047</td>
</tr>
<tr>
<td>Algebra 2 → Statistics</td>
<td>84</td>
<td>30(35.7)</td>
<td>12.01 - 34.57</td>
<td>0.0001</td>
</tr>
<tr>
<td>Advanced Math, senior year</td>
<td>493</td>
<td>134(27.2)</td>
<td>25.26 - 37.58</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Advanced Math, no grade 12 math</td>
<td>234</td>
<td>60(25.6)</td>
<td>25.7 - 40.3</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Advanced → Statistics</td>
<td>43</td>
<td>9(20.9)</td>
<td>23.11 - 50.19</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Advanced → AP Statistics</td>
<td>143</td>
<td>13(9.8)</td>
<td>43.77 - 56.77</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Calculus</td>
<td>277</td>
<td>16(5.8)</td>
<td>47.31 - 58.33</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>
Main Hypothesis

To make inferences about a larger student population than just fall 2010 freshmen at CSU, Chico, for instance all CSU, Chico freshmen, we would have to assume that the 2010 freshmen are a representative sample of all incoming freshmen at CSU, Chico. The following analyses are intended only after we make that assumption. The 95% confidence interval for the difference in math preparation success between CSU, Chico freshmen who have taken math only up to Algebra 2 and those who have
taken math only up to Advanced Math is from 26.3% to 37.8%. Taking just one class beyond Algebra 2 is associated with a large and statistically significant difference in math preparation for CSU, Chico students. Taking more classes beyond Advanced Math is associated with even larger differences (Figure 3). Table 2 shows that a student taking Advanced Math in his or her senior year has from a 25.26% to a 37.58% better chance of fulfilling the CSU ELM requirement than the student that stopped at Algebra 2. A student taking AP statistics after Advanced Math has from a 43.77% to 56.77% greater chance of fulfilling the ELM requirement than someone taking only up to Algebra 2.

Is Statistics as Good as Advanced Math?

A Statistics class seems to help those who have another year of high school to complete after Algebra 2 (Table 3), though not as much as Advanced Math. Remedial rates go from 51.5% to 36.4% for AP statistics and 35.4% for statistics. For students who took Algebra 2, the different classes statistics and AP statistics are associated with about the same change in measurements of college preparation.

The students taking regular statistics after Advanced Math had a 21% remediation rate, a slight improvement from those that didn’t take another class (25% remedial). But the best improvement came from the category Advanced Math + AP Statistics which provided the lowest remediation rate of all except calculus. This is probably due to the AP test, one of the exemptions allowed by the CSU. Twenty-one of the 143 students in this category took and passed this test (Appendix F). If it were not for the opportunity provided by that exemption, the remedial rate in this category would be more comparable to the Advanced + Regular Statistics category. The students in Algebra 2 then AP
Table 3

*Algebra 2 Cutoff With and Without Senior Year Mathematics*

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th># Remedial</th>
<th>% Remedial</th>
<th>95% CI for difference (p&lt;0.0001)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Took any math in senior year</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Highest class not beyond Algebra 2</td>
<td>181</td>
<td>120</td>
<td>66.3</td>
<td></td>
</tr>
<tr>
<td>Completed class beyond Algebra 2</td>
<td>1,108</td>
<td>226</td>
<td>20.4</td>
<td>0.3862, 0.5318</td>
</tr>
<tr>
<td></td>
<td>1,289</td>
<td>346</td>
<td>26.8</td>
<td></td>
</tr>
<tr>
<td><strong>No senior year mathematics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Highest class not beyond Algebra 2</td>
<td>232</td>
<td>123</td>
<td>53.0</td>
<td></td>
</tr>
<tr>
<td>Completed Advanced Math</td>
<td>234</td>
<td>60</td>
<td>25.6</td>
<td>0.1886, 0.3589</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.0738, 0.1749</td>
</tr>
<tr>
<td>Total</td>
<td>466</td>
<td>183</td>
<td>39.3</td>
<td></td>
</tr>
</tbody>
</table>

Statistics category did not benefit as well from this exemption. Only 3 of those 45 students passed that test.

A Look at Senior-Year Math

Table 3 illustrates the difference between taking a math class in the senior year and taking no math in the senior year. Overall, 39.3% of those taking no math in their senior year were placed in remedial math. Of those taking a math class in their senior year, 26.8% were placed remedial, a significant difference (p<0.0001). However, this difference of 12.5% is not as great as the differences seen within each of the categories between “Completed a class beyond Algebra 2” and “Highest class not beyond
Algebra 2.” Those differences are 45.9% for students taking senior-year math and 27.4% for those taking no senior-year math.

“A” Students in Algebra 2

For students that stopped at Algebra 2, Table 4 summarizes the data according to grades received in Algebra 2 and whether they took that class in their senior year (SY) or before (NSY).

Table 4

*Fall 2010 Freshmen Algebra 2 Grades and No More Math*

<table>
<thead>
<tr>
<th>Summary</th>
<th>Total</th>
<th># Remedial</th>
<th>% Remedial</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highest math = Algebra 2</td>
<td>413</td>
<td>243</td>
<td>58.8</td>
<td></td>
</tr>
<tr>
<td>“B” average or better in Algebra 2</td>
<td>61</td>
<td>31</td>
<td>50.1</td>
<td>0.6887</td>
</tr>
<tr>
<td>- NSY</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>“B” average or better in Algebra 2</td>
<td>42</td>
<td>26</td>
<td>61.9</td>
<td>0.4918</td>
</tr>
<tr>
<td>- SY</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>“A” in at least 1 semester in Algebra 2</td>
<td>21</td>
<td>10</td>
<td>47.6</td>
<td>0.6326</td>
</tr>
<tr>
<td>- NSY</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>“A” in at least 1 semester in Algebra 2</td>
<td>14</td>
<td>6</td>
<td>42.9</td>
<td>0.0534</td>
</tr>
<tr>
<td>- SY</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A higher grade in Algebra 2 class was of some benefit to students who did not progress beyond algebra 2, but with these small sample sizes the results were not statistically significant. The p values listed are from a z test of the difference between each remedial proportion and the remedial proportion of the rest of students in that category (SY or NSY) from Table 4. For those stopping at Algebra 2, with no math in their senior
year, the overall remedial average is 53.0%. The remedial average is 50.1% for students that got a B or better grade average in Algebra 2 ($p=0.6886$), and 47.6% for those who earned an A in at least one of the semesters taking Algebra 2 ($p=0.6326$). For those taking Algebra 2 in their senior year, the overall remedial average is 66.3%. The remedial average is 61.9% for students that got a B or better in Algebra 2 ($p=0.4918$), and 42.9% for those who earned an A in at least one of the semesters taking Algebra 2 ($p=0.0534$). This last category is the only one that showed a significant improvement, but the sample size of 14 prevents making a generalization beyond these students.

Repeating Algebra 2

Of 30 students that repeated Algebra 2 in 11th grade (even though they took no math in 12th grade), 22 were able to earn an exemption or pass the ELM. Only eight (26.67%) needed remediation. This is a significant difference ($p=0.0039$) from classmates that took Algebra 2 once in 11th grade and took no 12th grade math (55.41% remedial). In fact, these 30 repeaters ended up almost as math ready as those that took Advanced Math in 11th grade then no 12th grade math (25.2% remedial, Table 4). Out of the 78 students repeating Algebra 2 in their senior year, 49 (62.8%) did not succeed in avoiding remediation. This is not significantly different ($p=0.389$) than their classmates taking Algebra 2 for the first-time in 12th grade (71 out of 103 or 69.6% remedial).

Male versus Female

More women (56.5% of freshmen) than men came to CSU, Chico in fall 2010. Statewide, the CSU freshmen enrollment for fall 2010 was 57.3% female (CSU, 2011). This reflects the nationwide 2010 college enrollment figure of 57.1% female and 42.9%
male (NCES, 2011). The 32.5% remediation rate for CSU, Chico women was significantly higher ($p=0.01$) than 26.8% for men. For the whole CSU system statewide in fall 2010, there was an even wider gender gap in remediation: 42.7% for women and 25.4% for men (Appendix D, Table 5).

Table 5

*Algebra 2 Cutoff Data by Gender for Fall 2010*

<table>
<thead>
<tr>
<th></th>
<th>Male count(percent)</th>
<th>Female count(percent)</th>
<th>Male % remedial</th>
<th>Female % remedial</th>
<th>$p$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highest math = Algebra 2</td>
<td>158(20.8)</td>
<td>255(25.7)</td>
<td>58.2</td>
<td>60.0</td>
<td>0.7216</td>
</tr>
<tr>
<td>Algebra 2 $\rightarrow$ Statistics or Other</td>
<td>56(7.4)</td>
<td>89(9.0)</td>
<td>40.4</td>
<td>32.6</td>
<td>0.3391</td>
</tr>
<tr>
<td>Highest math = Advanced Math</td>
<td>330(43.4)</td>
<td>397</td>
<td>23.0</td>
<td>29.7</td>
<td>0.0422</td>
</tr>
<tr>
<td>Advanced $\rightarrow$ Statistics or Other</td>
<td>95(12.5)</td>
<td>98(10.6)</td>
<td>9.2</td>
<td>14.3</td>
<td>0.2671</td>
</tr>
<tr>
<td>Calculus</td>
<td>122(16.0)</td>
<td>155(15.6)</td>
<td>3.3</td>
<td>9.0</td>
<td>0.0538</td>
</tr>
<tr>
<td>Total</td>
<td>761</td>
<td>994</td>
<td>26.8</td>
<td>32.5</td>
<td>0.01</td>
</tr>
</tbody>
</table>

In fall 2010, the totals of freshman women outnumber the men in almost every category (Table 6). A detailed course sequence comparison is found in Appendix F. In five out of six of the most populous categories, however, a higher percentage of women end remedial. Also of interest is the result that proportionally more young women than men are stopping at Algebra 2, and proportionally less women than men advance to the
pre-calculus level or beyond. Here, 255 females (25.7%) did not go beyond Algebra 2 in high school, compared to 20.8% for males. And while 65.4% of females continued on to Advanced Math, for the males it was 71.9% (a significant difference of $p=0.0038$). More males are moving on to Advanced Math, and less males are remedial.

Of the 158 males that stopped at Algebra 2, 58.2 failed to meet the CSU ELM requirement; of the 255 females that stopped at Algebra 2, 60.0 are remedial. The statistically insignificant difference ($p=0.7216$) makes this a more “equal opportunity” condition, that is, stopping at Algebra 2 seems to affect males just as badly as it does females. However, of students that took Advanced Math or above, 22% of females were remedial compared to only 16.3% of males, a significant difference ($p=0.0125$).

**Ethnicity**

Table 6 shows fall 2010 freshmen broken down the by ethnicity. The majority of freshmen students coming to CSU, Chico are white (56% of freshmen) and Hispanic (23%). There were only 31 African American (1.7%), 8 American Indian (0.5%), and one Native Hawaiian. Compared to the rest of the state, this campus is disproportionately white: in fall 2010, the statewide Hispanic enrollment was 37.4%, with 29.5% white (Appendix D). Detailed remedial data are in Appendix F.

Hispanics are going to at least the Advanced Math level at a slightly below average rate, but the difference is not significant ($p=0.3428$). The Advanced Math overall average for this freshman class is 67.9%, while the Hispanic average is 65.3%. While Hispanics are remedial in slightly greater proportion than the overall class (overall
Table 6

*Algebra 2 Cutoff Data by Ethnicity for Fall 2010 Freshmen*

<table>
<thead>
<tr>
<th></th>
<th>White</th>
<th>Hispanic</th>
<th>Decline To state</th>
<th>Two or more ethnicities</th>
<th>Asian</th>
<th>Hmong</th>
<th>Black</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>984</td>
<td>412</td>
<td>93</td>
<td>91</td>
<td>68</td>
<td>63</td>
<td>31</td>
</tr>
<tr>
<td>Remedial</td>
<td>269</td>
<td>129</td>
<td>30</td>
<td>24</td>
<td>19</td>
<td>35</td>
<td>10</td>
</tr>
<tr>
<td>% Remedial (average = 30.0%)</td>
<td>27.3</td>
<td>31.3</td>
<td>32.2</td>
<td>26.4</td>
<td>27.9</td>
<td>55.6</td>
<td>32.3</td>
</tr>
<tr>
<td>% Taking Advanced Math (average = 67.9%)</td>
<td>67.8</td>
<td>65.3</td>
<td>66.7</td>
<td>76.9</td>
<td>80.9</td>
<td>73.0</td>
<td>74.2</td>
</tr>
<tr>
<td>% Highest course = Algebra 2</td>
<td>23.2</td>
<td>26.7</td>
<td>25.8</td>
<td>17.6</td>
<td>13.2</td>
<td>27.0</td>
<td>19.4</td>
</tr>
<tr>
<td>Of those, % remedial</td>
<td>57.9</td>
<td>55.5</td>
<td>62.5</td>
<td>68.8</td>
<td>66.7</td>
<td>70.6</td>
<td>50</td>
</tr>
</tbody>
</table>

30.0%, Hispanic 31.3%), this is not statistically significant ($p=0.6346$). Comparing the Hispanics in this class to whites (27.3% remedial) still does not produce a significant difference ($p= 0.1337$). In fact, for Hispanics, remedial rates are below the overall average in four out of the nine major course sequence categories, including the largest category (Advanced Math in 12th grade), although none is statistically significant. The 40.0% remedial Hispanics in the “Algebra 2 but no 12th grade math” category show the biggest difference ($p=0.1188$) below the overall average of 51.5%. In the categories where Hispanics are more remedial than the overall average, none is statistically significant. In short, Hispanic freshmen are doing about as well as the overall group.

The situation is not the same for the rest of the state, however. The statewide remedial rate for Hispanics in fall 2010 was 49.4%, compared to an overall statewide
remedial rate of 35.3% (Appendix D). The Hispanic students coming to Chico State in fall 2010 were much more prepared, at 31.3% remedial.

Hmong students, however, while taking Advanced Math in slightly higher proportion than the overall average, are scoring remedial significantly more than the overall (55.6% of Hmong remedial compared to 30.0% overall rate, \( p<0.0001 \)). Advanced Math courses, it seems, are not benefitting this group as well as whites. While the white students are progressing to Advanced Math at a slightly worse than average rate, their remedial rates (27.4%, \( p=0.1708 \)) are lower than the overall average.

Regardless of ethnicity, of students that did not progress past Algebra 2, most fail to fulfill the CSU ELM requirement. For the major ethnic groups in this cohort, 57.9% are white and 55.5% are Hispanic. Comparing whites to Hispanics, stopping at Algebra 2 is an equal-opportunity condition for placing them in a remedial math class. For Hmong it is 70.6% and 68.8% for “Two or more.”. For blacks it is 0% and 66.7% for Asians, but these were obtained from only six black and nine Asian students, so it is inappropriate to make generalizations from these low numbers.

Differences in Performance Service Area and Outside Service Area

There is a marked difference between the measured performance of freshmen coming from the Chico Service Area and those from the rest of the state. The Chico service area consists of Butte, Tehama, Lassen, Modoc, Siskiyou, Sutter, and Yuba counties—the north state, stretching from Yuba City to the Oregon border, but not including the North coast. Overall, in fall 2010, 38.3% of students from the Chico service area were placed in remedial math, but only 28% from the rest of the state. The Chico service area
students also had a lower average ELM score than the non-service area students, and the “Rest of state” outperformed the “Service Area” averages in most categories (Table 7). This is probably because the admissions requirements for local students are set lower by Admissions and Records (Chapter 4): the university is admitting lower performing students from the local service area.

Table 7

Comparing Remedial Rates Inside and Outside Chico Service Area

<table>
<thead>
<tr>
<th>Course</th>
<th>Remedial in service area</th>
<th>% Remedial</th>
<th>Remedial in rest of state</th>
<th>% Remedial</th>
<th>p value for difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algebra 2, senior year</td>
<td>34 (out of 43)</td>
<td>79.1</td>
<td>86 (out of 138)</td>
<td>62.3</td>
<td>0.0425*</td>
</tr>
<tr>
<td>Algebra 2 → no senior math</td>
<td>40 (out of 64)</td>
<td>62.5</td>
<td>83 (out of 168)</td>
<td>49.4</td>
<td>0.0741</td>
</tr>
<tr>
<td>Algebra 2 → Statistics</td>
<td>6 (out of 12)</td>
<td>50.0</td>
<td>40 (out of 116)</td>
<td>34.5</td>
<td>0.2862</td>
</tr>
<tr>
<td>Advanced math, senior year</td>
<td>35 (out of 93)</td>
<td>37.6</td>
<td>99 (out of 400)</td>
<td>24.9</td>
<td>0.0119*</td>
</tr>
<tr>
<td>Advanced → no senior math</td>
<td>12 (out of 56)</td>
<td>21.4</td>
<td>48 (out of 178)</td>
<td>26.6</td>
<td>0.4078</td>
</tr>
<tr>
<td>Advanced → Statistics</td>
<td>2 (out of 16)</td>
<td>12.5</td>
<td>20 (out of 170)</td>
<td>11.8</td>
<td>0.9306</td>
</tr>
<tr>
<td>Calculus</td>
<td>9 (out of 76)</td>
<td>11.8</td>
<td>7 (out of 201)</td>
<td>3.6</td>
<td>0.0078*</td>
</tr>
<tr>
<td>Totals</td>
<td>138 (out of 360)</td>
<td>38.3</td>
<td>383 (out of 1,371)</td>
<td>28.0</td>
<td>0.0001*</td>
</tr>
<tr>
<td>Avg. GPA</td>
<td></td>
<td>3.36</td>
<td></td>
<td>3.26</td>
<td></td>
</tr>
<tr>
<td>Avg. SAT math score</td>
<td></td>
<td>508</td>
<td></td>
<td>529</td>
<td></td>
</tr>
</tbody>
</table>

*significant at alpha = .05
This also corresponds with a marked difference in the proportions of students progressing beyond algebra 2 (Figures 4 and 5; see Appendix G for more detail). Of the

fall 2010 freshmen from the local service area, 66.9% have taken Advanced Math or above, but from the nonlocal population, 68.5% of students have taken Advanced Math or above \((p=0.4072)\). This is not a statistically significant difference; however, 29.7% of students from the local service area have not progressed beyond Algebra 2, compared to 22.3% from the rest of the state \((p=.0034)\). Of those 107 local area students, 74 (69.2%) were placed in remedial math.

*Figure 4.* Fall 2010 CSU, Chico freshmen remediation rates by course sequence for Chico service area \((n=360, 38.3\% \text{ remedial})\).
There are relatively more seniors taking math in the nonlocal population:

76.4% of students from the rest of California were in a math class their senior year, while only 66.9% of service area students were in math during 12th grade.

The females from our local area are faring much worse also, especially those that stop at Algebra 2. Our service area female freshmen were 49.8% remedial and males were 27.4% remedial, compared to the overall fall 2010 CSU, Chico female and male rates of 32.5% and 26.8%, respectively. And recall that of all CSU, Chico freshmen, 59.3% of females stopping at Algebra 2 were remedial compared to and 56.4% of males. But somehow, from our area, 83.3% of Algebra 2 females were remedial and only 47.16% of males.

*Figure 5.* Remediation rates, by course sequence for Fall 2010 CSU, Chico freshmen from outside the Chico service area (n=1,371, 28.0% remedial).
Even more area-specific comparisons can be made between the Los Angeles, San Francisco Bay, Chico service areas and the “Rest of state” (Appendix H). The San Francisco Bay area is sending students with the lowest remediation rate, 21.8%. The Los Angeles area has more students progressing to at least Advanced Math (72%), but their remediation rate (32.3%) is a full 10 percentage points below that of the SF Bay area. The SF Bay area, Chico area, and “Rest of state” have similar percentages of students progressing to at least Advanced Math: 68%, 65% and 67%, respectively. But their remediation rates are more widely varying: 21.8%, 39.3% and 26.3%, respectively.

The Chico area has the highest percentage (29.7%) of students that do not progress past the Algebra 2 level. And students in that category are performing below other sub-regions: 69.2% of the Chico area Algebra 2 students were placed into remediation, compared to 61% for the Los Angeles area, 38.9% for the San Francisco Bay area, and 51.4% for “Rest of state.”

Out-of-State Students

In fall 2010, CSU, Chico admitted 44 freshmen from 19 other states and Puerto Rico; most came from Washington, Oregon, Utah, Nevada, and Colorado. They are not included in this study, but their math placement does merit mentioning. Only 4 of these 44 students were deemed remedial. Excluding general education (GE) math exemptions and students without detailed transcripts, I still counted 4 out of 36 remedials from out of state (11.1%), significantly below the overall California percentage of 29.9% ($p<0.0001$). Interestingly, 29 of these 36 students progressed to at least Advanced Math. Only 3 of the 36 (8.3%) did not progress beyond Algebra 2, significantly below the over-
all 2010 (in-state) percentage of 23.6% progressing beyond past Algebra 2 ($p<0.0001$). That is, our out-of-state students have taken more college preparatory math than our in-state students. This could be explained by the higher admissions requirements for out-of-state students set by Admissions and Records (see Chapter 5). The university is admitting higher performing students, as measured by a combination of GPA and SAT scores, from outside the state.

Out-of-Country Students

International students were also excluded from this study, but their math placement merits mentioning. Of the 58 freshmen coming from other countries in 2010, 33 (56.9%) were placed in remedial math, considerably higher than the overall California 2010 average of 29.9%. From two countries, the remedial rate was 100%. Transcripts from these students did not adequately describe the math courses taken, but the descriptive results are interesting (Appendix I).

Secondary Questions

To test the conjecture “Does math readiness depend on course sequence?” a chi-square test of independence was performed. I tested for the null hypothesis: “Course sequence is independent of Math readiness” for nine course sequences, which can be seen in Appendix F. It was rejected ($\alpha=0.01$, chi-square 86.12, $p<0.0001$).

I concluded that there is strong evidence supporting the assumption that remediation depends on course sequence. This extremely low $p$ value is driven by the large residuals: the differences between the Observed Ready levels in each category and what would be the Math Ready levels in each category if those students placed at the 70.1%
average CSU, Chico readiness rate. The biggest differences are in the categories “Algebra 2 in senior year” (the observed is far less than expected), “Algebra 2 then no senior math” (again, far less), and Calculus (the observed is far more than the expected).

Other Variables

To address the question “Are other factors statistically significant with regard to remediation?” a multiple logistic regression was performed with independent variables gender, high school GPA, SAT math score, SAT English score, and course sequence. Course sequence was a quantitative variable the different course options on an interval scale from 1 to 9 (Appendix F).

The statistically significant variables are course sequence ($p<0.0001$), SAT Math score ($p=0.011$), and High School GPA ($p=0.057$).

Interestingly, regarding all fall 2010 incoming freshmen, gender is not a statistically significant variable ($p=0.7644$). However, a logistic regression on just the data from the Chico service area, resulted in gender as a significant variable ($p<0.001$) (Appendix F). Recall that females from the Chico service area placed remedial at a much higher rate than males from the Chico service area.

The odds ratio of SAT Math is 1.004043, which implies that for every point increase in a student’s SAT math score, the odds (not probability) of fulfilling the CSU ELM requirement would improve by a factor of from 1.000927 to 1.007169. For the variable high school GPA, the result is surprising: a higher GPA is associated with decreased odds of passing the ELM requirement. Indeed, the average GPA of the “ELM Pass=1”
students is 3.2816, but the average GPA for the “ELM not passed” students is higher at 3.2820.

The odds ratio for course sequence is the most telling. An odds ratio of around 1.29 means for each step up the course sequence “ladder” (from 1 to 9), the odds of passing the ELM requirement change by a factor of 1.23 to 1.35, that is, the odds improve by 23% to 35%.

Taking Math After Algebra 2

To see if there is a relationship between math performance and the courses that a student might choose, I looked at the grades that students received in Algebra 2 when they took that class, which, for the vast majority of the cohort, was in either 10th or 11th grade. For a student that has passed Algebra 2 as a sophomore, there are four scenarios in which a student will move forward in the next two years. For a student who has passed Algebra 2 as a junior, there are two scenarios for moving forward. For each of these six scenarios, I performed a t test to test the null hypothesis “There is no difference in the average grades between these students and their classmates that did not move beyond Algebra 2.”

For sophomores passing Algebra 2, only students advancing to a calculus class showed a grade average that was significantly different than students that took no more math after Algebra 2 (Table 8). This is an indication that higher performing students will eventually take calculus. Students that moved on to Advanced Math, or Advanced Math then some other class (usually a statistics class), had a higher average grade, but one that was not significantly higher. Students that took just a statistics class
Table 8

Comparisons Between Algebra 2 Performance and Next Class

<table>
<thead>
<tr>
<th>Next class</th>
<th>Algebra 2 GPA</th>
<th>SD</th>
<th>Total</th>
<th>Remedial</th>
<th>% Remedial</th>
<th>t test for difference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Algebra 2 sophomores</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No more math after Algebra 2</td>
<td>2.558</td>
<td>0.63273</td>
<td>26</td>
<td>16</td>
<td>61.50</td>
<td></td>
</tr>
<tr>
<td>Only Advanced Math in grade 11 or 12</td>
<td>2.746</td>
<td>0.67601</td>
<td>216</td>
<td>61</td>
<td>28.20</td>
<td>(p=0.1788)</td>
</tr>
<tr>
<td>Advanced + more</td>
<td>2.780</td>
<td>0.71386</td>
<td>226</td>
<td>17</td>
<td>7.50</td>
<td>(p=0.1303)</td>
</tr>
<tr>
<td>Advanced + Calculus</td>
<td>2.983</td>
<td>0.72252</td>
<td>153</td>
<td>6</td>
<td>3.90</td>
<td>(p=0.0054^*)</td>
</tr>
<tr>
<td>Only Statistics</td>
<td>2.477</td>
<td>0.61024</td>
<td>24</td>
<td>8</td>
<td>33.30</td>
<td>(p=0.6476)</td>
</tr>
<tr>
<td>Algebra 2 (\rightarrow) Advanced Math</td>
<td>1.599</td>
<td>0.93721</td>
<td>28</td>
<td>9</td>
<td>32.10</td>
<td></td>
</tr>
<tr>
<td>Repeat Algebra 2 (\rightarrow) Statistics</td>
<td>1.731</td>
<td>0.76762</td>
<td>8</td>
<td>4</td>
<td>50.00</td>
<td></td>
</tr>
<tr>
<td>Repeat Algebra 2 (\rightarrow) no math</td>
<td>1.664</td>
<td>0.71594</td>
<td>28</td>
<td>7</td>
<td>25.00</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>702</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Algebra 2 juniors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No more math after Algebra 2</td>
<td>2.512</td>
<td>0.44531</td>
<td>159</td>
<td>88</td>
<td>55.35</td>
<td></td>
</tr>
<tr>
<td>Advanced Math, in grade 12</td>
<td>2.865</td>
<td>0.49077</td>
<td>343</td>
<td>98</td>
<td>28.57</td>
<td>(p &lt; 0.0001^*)</td>
</tr>
<tr>
<td>Statistics, grade 12</td>
<td>2.672</td>
<td>0.39837</td>
<td>102</td>
<td>38</td>
<td>37.25</td>
<td>(p=0.0035^*)</td>
</tr>
<tr>
<td>Repeat Algebra 2, grade 12</td>
<td>1.546</td>
<td>0.73272</td>
<td>65</td>
<td>41</td>
<td>63.08</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td>669</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Significant at alpha = 0.05

after Algebra 2 were actually lower performing on average; yet these three scenarios resulted in a decreased remedial rate. Students that needed (or chose) to repeat Algebra 2
had an understandably lower grade average and most did not pass the class. However, the three scenarios under “Will repeat Algebra 2” all had lower remedial rates in the end. Interestingly, here are 64 students who are considerably lower performing than their classmates at the sophomore level, yet only 20 (31.25%) were remedial, half the rate of those that passed Algebra 2 but did not move on. Repeating Algebra 2 in 12th grade did not benefit that group, however.

It would have been better if the sample of “Will take no more math after Algebra 2” was a bigger sample size than 26. However, for sophomores, so far, it is not necessarily the smarter kids that achieve lower remedial levels.

For juniors passing Algebra 2, however, those advancing to Advanced Math in 12th grade were significantly higher performing ($p<0.0001$) than their classmates that did not move on, and those moving on to a statistics class were also significantly higher performing ($p=0.0035$). This gives partial support to the notion that students that are advancing to Advanced Math or statistics, who are also students that mostly pass the ELM requirement, were already higher performing students in the 11th grade, before they took a post-Algebra 2 class.

Results Summary

Of the first-time freshmen in fall 2010 at CSU, Chico 23% did not progress beyond algebra 2 in high school, and the majority of these students required remediation. Taking courses after Algebra 2 is associated with a much higher probability of meeting the CSU ELM requirement. A high school math experience can generally be categorized into nine course sequences, and each of these can be associated with correspondingly
higher chances of meeting the ELM math requirement. Compared to those who stop at Algebra 2, students who then take statistics or AP statistics do better, students who take Advanced Math do even better, students who take Advanced Math then statistics do even better, and students taking calculus do best. Females do not do as well as males, there are small differences in performance in different ethnicities (except with Hmong, where there is a large difference), and freshmen from the local area do not do as well as the rest of the state. Students that take post-Algebra 2 classes show better math preparedness as measured by the ELM requirement, regardless of gender, ethnicity, and geographic origin.

There is some evidence that 11th students moving beyond Algebra 2 are already higher performing math students; but at the 10th grade level, the evidence is not as strong. On the contrary, there are plenty of scenarios in which a low performing sophomore has a better chance of fulfilling the ELM requirement than that of the average sophomore who stopped at Algebra 2.
CHAPTER V

CONCLUSIONS, DISCUSSION, AND RECOMMENDATIONS

Conclusions

Consistent with previous research, this data shows that taking a math class past the level of Algebra 2, especially at the Advanced Math level, is associated with a greatly improved chance of fulfilling the entrance requirements for college level math, in this case, at CSU, Chico.

1. For students that do not progress past Algebra 2, remediation is almost twice as likely as it is for students that take Advanced Math. This happens regardless of area of student origin, gender, and for all ethnicities except Hmong (who already, at Algebra 2, have an exceedingly high remedial rate. See below). Even for the best freshmen, those from the SF Bay area, the 38% Algebra 2 remedial rate is double the rate for students from the same region that have gone on to Advanced Math. For those not going beyond Algebra 2, getting an A in Algebra 2 is associated with an appreciably lower incidence of remediation.

2. More of our local service area students are placed remedial than incoming freshmen from the rest of the state. Part of the reason for this is likely the higher admission standard applied to nonlocal freshman admissions. Each year, the Office of Admissions
sets a benchmark index for applicants to meet to receive admission priority. The fall 2010 formula for this index was

\[(\text{Your GPA} \times 800) + (\text{Your SAT Reasoning Test total}) = \text{Your Index}\]

For example, a 3.2 GPA and SAT scores of 550 in math reasoning and 560 in English reasoning would result in an index of \((3.2 \times 800) + (550+560)=3660\). While the local applicants to CSU, Chico in fall 2010 had to meet an index of 2900, the nonlocal applicants had to meet a combined score of 3450, which, the Director of Admissions says, was “the highest ever” for CSU, Chico. (Out-of-state applicants had to meet an even higher index of 3502.) And although their overall average GPA was lower than the local admissions (3.26 vs. 3.36), the nonlocal admissions made up for that difference by performing better on the SAT, with an average SAT math score 20 points higher than local students.

At the same time, the number of students that stop at Algebra 2 was much higher in the local area than the rest of the state (32.3% versus 19.5%). And less local students were taking Advanced Math (64.3% versus 68.8%), and less are in a senior year math class (66.9% versus 76.4%) than students from the rest of the state. But the differences between the SF Bay area (22% remedial overall, with 68% of students progressing to at least Advanced Math) and the Los Angeles area (32% remedial, with 72% progressing to at least Advanced Math) suggest that there is more at work than just course sequence.

Future research could look at, for example, the rigor of those schools, demographics, and proportion of qualified teachers.

I cannot conclude whether students outside the local region and outside the state were performing better because they were taking more Advanced Math courses, or
they are taking more Advanced Math courses because they perform better. However, I can say that regardless of geographic region, students that stop at Algebra 2 end up in remediation at least twice as much as those that progress to at least Advanced Math.

3. Females need remediation more than males, especially those from our area. Females were taking less Advanced Math classes, but also they were underperforming the males that were taking the same classes. In Florida, the Long study (Long, 2009) observed that even though about the same percentage of women were taking advanced courses as men, they score lower on the National Assessment of Educational Progress [NAEP]. Long says that one explanation for the gender gap in Florida may be self-selection: they observe that proportionally more women were going to college, and the males going to the colleges in that study have higher 8th grade math scores. They propose that those male high school graduates, then, were a more select group than the broad spectrum of women going to college. (The males with lower math achievement in 8th grade were taking themselves out of the college-bound sample.) I cannot say if that dynamic is at work here. A recent report by the National Center for Education Statistics (NCES) found that though females now take more challenging math and science courses and receive higher grades for those courses than males, males who take advanced math courses still score higher on the NAEP than females who take the same courses.” (Shettle, 2007) That is, females were not gaining as much from the advanced courses as males; and my study also confirms this.

4. Ethnicity seems to make a difference. Hispanics and Hmong were placed remedial at a greater rate than whites and non-Hmong Asians, the highest performing subgroup in
this study. The difference in Hispanics, though, is not significant in this Chico group, though it is significant at the statewide level. Whites and non-Hmong Asians seem to do better with the same course sequences than Hispanics and Hmong. Vang (2005) cites some of the reasons for low Hmong academic performance as English language deficiency (Hmong were the third largest LEP group in California public schools), low expectations from teachers, lack of access to necessary assistance at home and elsewhere, and a myriad of other problems that accompany extreme socioeconomic disadvantage. The small numbers of African American, Native American and “Two or more ethnicities” make it hard to conclude anything about the fall 2010 students in these groups. Regardless of gender or subgroup, however, there is a large difference in college readiness between students whose highest math class was Algebra 2, and students that take Advanced Math. As Long and Iatarola (2007) also observed, moving on to Advanced Math is associated with a reduced need for remediation for all groups.

5. Taking a math class in the senior year is associated with a 12.5% decrease in the need for remediation. But that is not as powerful an indicator as going beyond Algebra 2. Also, of those that decided to not take math in 12th grade, it is they who had stopped at Algebra 2 that were in the most danger—51.5% ended up remedial. Of the Advanced Math students who take the year off, only 25.4% do not fulfill the ELM requirement.

6. Statistics and AP statistics have about the same effect on students coming out of Algebra 2, improving their remediation rates and at about the same rate. AP statistics is a much better class for those coming out of Advanced Math—they were more successful partly because more were earning exemptions through the AP exam. Either way, taking
any statistics class is beneficial to CSU, Chico applicants; after all, portions of the CST, SAT, and ELM tests have problems that require some knowledge of statistics.

7. The students that move beyond Algebra 2 after 11th grade were already showing that they were performing better in math, on average, than their classmates that did not take post-Algebra 2 classes. So one could argue that it may not be the post-Algebra 2 class that is helping the student satisfy the ELM requirement. Rather, the post-Algebra 2 student is already better at math. At the 10th grade level, however, the grade received in Algebra 2 was not as predictive. The lower performing 10th grader still opportunities to improve her college preparedness.

The similarities of this study with the Nevada and Utah studies were interesting: the math remediation rate in Nevada was 37.6% statewide, and at the CSU it had been at 37% for the last 5 years. As in the Nevada study, the remediation rate dropped precipitously for students progressing past the Algebra 2 level to Advanced Math (58% to 26.9% in this study, 63.2% to 24.5% in Nevada). As in the Nevada study, we have 67% of 12th graders in a math class; I saw 74% in my study. Of students taking Algebra 2 or below in 12th grade, the Nevada study found 63.2% remedial; my data shows 66.3%. And very much like the Utah study, which found 56.7% of those stopping at Algebra 2 to be remedial, the fall 2010 CSU, Chico data shows 58.8%.

The biggest conclusion that can be drawn is that students that were on schedule with their college prep math classes (students that were taking Algebra 2 by their junior year) were not done preparing for college with the Algebra 2 class. They need to continue on in their senior year, as tortuous as it may seem to them. I cannot conclude
whether it is the class beyond Algebra 2 that is causing the decrease in remediation risk, or if it is the already higher-performing student that chooses to progress beyond Algebra 2. But if there was any self-selection bias in this study, I recommend that all future high school students self-select themselves into an Advanced Math class.

The senior year can make a huge difference, if a student has completed Algebra 2 in 11th grade: of those that took Algebra 2 and then took a math vacation in 12th grade, more than half (51.5%) ended up in remediation. But for those that used their senior year to take Advanced Math, that remediation rate drops to only 27.2%. There should be no question, then, on what a student should be doing when they get to 12th grade. Those who have just finished Algebra 2 should move on to some Advanced Math class. Those who have just finished an Advanced Math class, if they were thinking of a technical major in college, should go on to calculus. Otherwise, statistics is a good option.

What is happening during the senior year, besides more reinforcement of math concepts? It may be fresher in their memory when they take the ELM, which can be taken as early as the spring of the senior year if they were accepted for admission by the CSU. There were also more opportunities to get exemptions from the ELM.

The EAP exemption, implemented in 2004, is actually designed to encourage students to take math in their senior year. If a student scores high enough on the Algebra 2 or Summative CST test administered in 11th grade during April, the CSU awards them a “Conditionally ready” exemption which will exempt them from the ELM if they complete a math class (Algebra 2 or higher) in their senior year—with no further placement testing required. This exemption was only awarded to four out of 1,370 students.
that took Algebra 2 in 11th grade and took no math in 12th grade. But the EAP exemption was awarded to 42 students who took Algebra 2 in 11th grade followed by some other math class in 12th grade. The EAP gave them an opportunity to prove themselves math ready during their senior year.

With or without a conditionally ready exemption from the EAP, the senior year is the ultimate opportunity for our students, and it is overlooked by far too many. The 232 Algebra 2 students and the 234 Advanced Math students taking the senior year off (Figure 2, Chapter 4) were tied for second place behind calculus, in number of students in each category. But if we divided our categories into “What we were taking during the senior year,” these students would constitute the largest category: taking nothing. More than a quarter of our incoming freshmen (n=567) had a choice about their senior year, and they chose nothing. What if those students had met the challenge of a fourth year of math? My contention is that the numbers of those students needing remediation would decrease from 180 to perhaps 90.

An estimated 85% of current jobs and almost 90% of the fastest-growing and best-paying jobs now require some postsecondary education (US Department of Labor, 2006). So it’s good that 80% of high school students say they plan to go to some sort of postsecondary education (Ingels, Burns, Chen, Cataldi, & Charleston, 2005). But even if some students were not going to college, “employers and faculty agree that high school graduates need increasingly similar levels of rigor” (Achieve, 2008a, p. 1). Policymakers in states around the nation know that they need to make changes in order for these students to be better prepared for college or the workplace.
In 1983, the federal government (National Commission for Excellence, 1983) recommending a core curriculum including three years of education for graduation. Thirty years later, the nation still has not completed this recommended reform. But the good news is that in the last six to ten years there has been a sea change in the philosophy of standards, expectations, and requirements across the country, which is finally starting to align with what many math reformers have been recommending for three decades. Where a decade ago the commonly accepted standard that high school students must meet was Algebra I, now the general consensus is that it is Algebra 2 (Phillips & Wong, 2010). As of 2010, more than 40 states have adopted the Common Core Standards (CCSS), aligning English and math content standards “that would better prepare students for success in college, career, and the competitive global economy” (California Dept. of Education, 2010, p. 1). The CCSS recommended math curriculum of three years of math, in a number of possible pathways that take the student at least to the level of Algebra 2. Adopting standards may not guarantee implementation, and that is not the same as a graduation requirement. But this is good news.

And states are also improving their graduation requirements: Between 2000 and 2008, 37 states increased the number of math courses required for graduation (Stillman & Blank, 2009). Further, 20 states and the District of Columbia now require that all high school graduates complete math coursework at least through Algebra 2 or its equivalent, though this adoption seems to have stalled at 20 states, with requirements first applying to graduating classes in only eight states as of 2011 (Achieve, 2011).
In Oregon in 2005, only two years of math at any level were required. Starting with the class of 2014, students will be required to take three years of math “at or above the Algebra I level, including geometry” (Rafael & Ishimaru, 2012).

Arizona is changing the math requirements for their graduating class of 2013, from three years of math consisting of “Algebra I, Geometry and an additional course with significant math content as determined by district governing boards or charter schools,” to four years of math, consisting of “Algebra I, Geometry, Algebra 2 (or its equivalent) and an additional course with significant math content as determined by district governing boards or charter schools” (Arizona Dept. of Education, 2012, p. 1).

In this positive reform spirit, I can offer some recommendations, inspired by recommendations from the Stanford Bridge Project, the American Diploma Project, WestEd, and researchers Conley (2005) and Kirst and Venezia (2006).

1. Continue to work to align high school standards with the knowledge and skills required for success after high school. The CCSS is a way that states are moving toward this, and the CCSS claim to be “fewer, clearer and higher.” The communication among the systems of K-8, high schools, and colleges needs to continue to grow.

2. Require all California graduates to take four years of math in a curriculum aligned with state standards that prepare them for life after high school. I agree with the ADP’s call for “four years of math, including courses that cover the content typically found in Algebra I and II, geometry, data analysis and statistics” (Cohen, 2008, p. 1). If California adopts that graduation requirement, at least to Algebra 2, we’d be joining the ranks of 18 other states that were already there. Eight other states require at least three years of math,
with a course sequence specified as up to at least Algebra 2. Alabama has made it “at least one class beyond Algebra 2” (Achieve, 2008b, p. 2).

California is a member of the ADP network, is adopting the CCSS, and has state standards that say students are expected to take math up to Algebra 2. But standards are not the same as requirements. Only two years of math, up to Algebra I, were required to graduate in this state. And it does not appear that the state plans to change this requirement.

The CSU system is the largest public university system in the country, yet students in California’s high schools are held to one of the lowest standards in the country. California would do well to raise standards at least to the level of these other states.

Students’ performance will respond to raising standards. Through 1998-2000, California implemented new standards requiring Algebra I for graduation and pushing for beginning Algebra I in 8th grade. Since then, the percentage of 8th graders proficient in Algebra I went from 12% in 2003 to 19% in 2006. And more high school students have been enrolling in higher-level math courses: the percentage of high school students in an Algebra 2 or higher class went from 13% in 2003 to 16% in 2006, and the percentage in any math class increased from 80% to almost 90%. And though math enrollment still decreased from 8th grade to 11th grade, the pattern became less pronounced from 2003 to 2006: 77% of 11th graders were in a math class in 2006.

The threat of not receiving a high school diploma has meant a steady and substantial increase in the number of students taking Algebra I. This emphasis on Algebra I appears to be encouraging more students to also take higher-level math, though the numbers are increasing at a slower pace. (EdSource, 2007, p. 4)
Abraham and Creech (2002) found that states with performance standards for college admission have seen a long-term decline in the proportion of students who need remediation.

Six years after the San Jose Unified High School District mandated that all students complete three years of math up to Algebra 2 in 1998 (i.e., an A-G curriculum for all), the graduation rate was still holding steady at 90% (Maxwell, 2006). Here, higher standards did not lead to more dropouts but more achievement. SAT scores have risen, GPAs have risen, and the percentage of students completing a college-ready curriculum went to 65%, up from 37% in 2001, and compared to the state average of 33%. For Hispanics, this percentage went to 45%, while the state average was 21% (Murray, 2004).

Students want these more challenging courses. In one survey, 74% of recent high school graduates surveyed believe that requiring four years of math and science would have better prepared them for life after high school; and about 80% of graduates say they would have worked harder had their high schools demanded more (Hart, 2005).

Even if we did not mandate “up to Algebra 2,” requiring four years would also have the effect of producing more students taking higher level courses—and Algebra 2 and beyond are likely to be included in these courses, since most students are now taking Algebra 1 in 8th grade. Finklestein and Fong’s (2008) study found that by the end of 12th grade, only 52% of California high school students meet the three-year math requirement in the list of UC/CSU’s “A through G” college prep courses; mandating four years of math would improve this number.
The ACT (2007) fears that a core curriculum of three years of math up to Algebra 2 is still not enough. They know through their own research that only 16% of those taking just this three-year core are prepared:

Without improving the quality and content of the core, it appears that most students need to take additional higher-level courses to learn what they should have learned from a rigorous core curriculum, with no guarantee even then that they will be prepared for college-level work. (p. 10)

The results of my study agree with this. Improving course sequence may not close gender and ethnic performance gaps, but would be a step in the right direction for all students.

3. The curriculum needs to rigorous, It looks like many states, California included, are not going to require four years of math in the near future. In that case, the last quote implies that we need to improve the quality and content of the core curriculum. A study by ACT (2007) found that in schools that met their criteria as rigorous schools, students going no further than Algebra 2 had 50% readiness for college, compared to 26% from all ACT-tested schools. Students progressing to pre-calculus in a rigorous school were 84% college ready, compared to 56% otherwise. That is, Algebra 2, taught in a rigorous way, can result in nearly the same college preparedness as a non-rigorous pre-calculus curriculum (ACT). The course, as advertised in the school course offerings catalog, needs to match the course being taught. Some fear that an advanced course offered in some schools might not reflect the actual content and rigor of the curriculum, a problem referred to as “course credit inflation” (Dougherty, Mellor, & Jian, 2006).

Rigor can be verified with agreed upon end-of-course tests. In six states working with the Southern Regional Education Board (SERB), initial pass rates have steadily increased since initiating such an end-of-course test in Algebra I (Kaye, Lord, &
Bottoms, 2006). An Algebra 2 end-of-course test was recently developed by the ADP in concert with 14 states—The ADP Assessment Consortium. The test has common performance benchmarks designed to show “both evidence of content mastery and an indicator of readiness for a first-year credit-bearing college math course” (Achieve, 2009b, p. 8). This test was administered to about 103,000 students in 13 participating states in 2008; 14.3% scored at a level of prepared or well-prepared (Achieve, 2009a).

Though these initial scores are low, the hope is that schools will strive to reach for the new standard in a race-to-the-top attitude:

As curriculum and instruction are designed to meet the ADP exam standards and coursework is more closely aligned with those standards, it is also expected that performance will improve. Moreover, as teachers and students become more familiar with the exam standards and those standards become more embedded in curriculum and instruction, student motivation—and, therefore, performance itself—on the ADP Algebra exams should increase. (Achieve 2009a, p. 15)

4. Streamline the assessment system so that tests students take in high school can also serve as placement tests for college or diagnose their readiness for college. California already has one of these in the EAP. With questions augmented to the already established California Standards Test (CST) in 11th grade, the EAP gives the student an early assessment of how well prepared he is for college math so far. The highest scores indicate that the student is ready and he is exempted from placement testing if he chooses to attend a CSU university. Lower scores send a signal to the student that additional preparation is needed in his or her senior year. Exams like this in middle school and 9th grade could give us warning that a student might need extra help and/or services to move up to the next level.
5. Hold high schools accountable for graduating students who are ready for college and careers, and holding postsecondary institutions accountable for students’ success once enrolled. This means longitudinal data systems from K-16, tracking individuals’ progress toward college and career readiness, and schools sharing that data in their accountability reporting. Data can provide us lessons learned, what works, and early warnings. And data can help unify and integrate the too separate systems of elementary schools, high schools, and postsecondary schools (Cohen, 2008).

6. Powerful Teaching. In an Illinois study, students whose highest class was Algebra 2 ranged from 6% college ready to 21% college ready, depending on the Teacher Quality (TQ) index of the school. Students making it through Advanced Math ranged from 6% college ready (in the lowest TQ schools) to 58% college ready in the highest TQ schools (Peske & Haycock, 2006). We need well prepared, qualified math teachers in all schools, but teachers also need “the help of standards, assessments, curricula, pre-service preparation, and professional development aligned to college readiness if they are to succeed in the classroom” (Alliance for Excellence, 2007, p. 1).

7. Awareness, counseling and encouragement. We need to provide all students, parents, and educators with accurate information about the courses that are required for college and the access to those courses. We need them to have more knowledge of placement standards and create awareness that getting into college is not the same as preparing for college.

Many students and parents think that simply meeting the number of credits required for graduation will prepare them for college (Venezia & Kirst, 2003). A survey
of California students revealed that only 1% knew all of the course requirements for admission to postsecondary institutions, and students in accelerated curricular tracks were receiving more information (e.g., counseling, teachers) about college preparation than their peers in other tracks. They found students believing misconceptions like “easier classes in high school are better because of your GPA” and “I don’t need to start planning until sophomore year” (Venezia & Kirst). In one survey, only 40% of 11th graders knew that the CSU system has placement tests for English and math (Conley, 2005).

We need to encourage our students, especially the females (and especially our local females, who were 83.3% remedial when they stopped at Algebra 2), to move on to advanced math courses—not because it’s what the smart kids do, but because it helps them prepare for college. But students may be discouraged from taking the more challenging courses “as a result of low expectations by teachers” (Bamburg, 1994; Russell, 2008). Ali and Jenkins (2002) went so far as to state “the cycle of low achievement begins and ends with low expectations of our students” (p. 18). One-on-one counseling sessions have been shown to measurably prompt students to more carefully consider the courses they choose (Career Academy Support Network, 2007). And Masten’s (2002) study of the University of California’s ELC program saw students measurably changing their behavior in 12th grade when they got information from the university about their eligibility. Unfortunately, California is in last place (51st) in guidance counselors per student (Rosin & Wilson, 2008).

8. Early intervention is critical to keep students on-track. Of course, progressing beyond Algebra 2 by 12th grade is likely to be difficult for the student who is struggling
with Algebra 1 in 9th grade—a tough hurdle for many. In 2008, more than 200,000 students between grades 9 to 11 repeated the CST for Algebra I, implying that they are repeating the class. Of 9th graders who took the Algebra I CST, 38% had already taken it in a prior year, as had more than half of 10th and 11th graders who took the test.

Finklestein and Fong (2008) found that 42% of their California sample had not completed “two semesters of college preparatory math,” meaning a C or better in Algebra I or above. That means that if we are talking about following Algebra I with Geometry, Algebra 2, and one course beyond that, these students are already off track. They can still qualify for CSU and UC entrance requirements, but without summer school, at best they will be in my “Algebra 2 in senior year” category, 66.3% of whom needed remediation in 2010. And “students who fall off the college-preparatory track early in high school tend to move ever further from a complete college-preparatory program as they progress through high school” (Finklestein & Fong, 2008, p. 5). Eligibility for the CSU or UC, then, has a lot to do with what happens in 9th grade. I think that CSU college preparedness requires successful completion of Algebra I by 9th grade. We need to provide extra help in school and after school help and services for our struggling students to help them understand, not just pass, Algebra I by the end of 9th grade.

9. The CSU could amend entrance requirements. The CSU could, with the stroke of a pen, amend their entrance requirements to require that applicants complete four years of math in high school at least to the level of Algebra 2. They currently require three years of math, including Algebra 2, but this is a requirement that predates California’s 1998-2000 implementation of the 8th grade Algebra I standard. Four years are recommended by
the CSU, but as we can see, 26% of the fall 2010 freshmen did not take this advice. Since most California students are now taking Algebra I in 8th grade, requiring four additional years in high school would lead, but not force, practically all CSU-bound students to take at least one course beyond Algebra 2. This would, in my opinion, significantly reduce the need for remediation in math at the CSU.

10. Work with our local population. We at CSU, Chico, in the outreach programs and the EAP need to find ways to get more females in Advanced Math classes, more students beyond Algebra 2, and more seniors taking math.

Closing Remarks—The Good News

The good news is that we are living in a time of positive momentum in college-going culture. More Americans want to go to college than ever before. Undergraduate enrollment was 7.5 million in 1970, 15.2 million in 2006, and projected to be 17 million in 2017 (NCES, 2008). Math course-taking has been slowly improving for 30 years. The average Carnegie Units of students nationwide in math has gone from 2.7 in 1982 to 3.6 in 2004, and in Algebra or higher has increased from 1.9 in 1982 to 3.1 in 2005 (Planyt, 2007). Algebra 2 enrollment went from 40% to 67%, analysis/pre-calculus enrollment went from 6% to 28%, and calculus from 6% to 14%. And the percentage of students that complete at least one course “classified as more challenging than Algebra 2” (my Advanced Math) went from 26% to 50% in 2004 (Planyt, 2007). In California, higher level course taking has been on a steady increase. In 2007, 44% of juniors were in a class Algebra 2 or above; in 2011 it was 51% (EdSource, 2011). Standards are rising all over the country. As recently as 2006, only 12 states required going up to Algebra 2 for a
high school diploma, and only four states required going beyond Algebra 2; and now it’s 20, plus the District of Columbia (Achieve, 2011).

California as a state should take advantage of this momentum, and join the national movement not only for higher standards, but also for higher graduation requirements.

On a more local level, the good news is that 70% of the freshmen, more than the CSU statewide average, are coming to CSU, Chico prepared in math, and most (65.5% females and 71.2% males) have taken classes to at least at the level of pre-calculus (Figure 1, Chapter 4). The overall math remedial rate at CSU, Chico is well below the statewide average of 37%. The coursetaking histories of freshmen entering the other 22 CSU campuses (especially those with higher remediation rates) should definitely be investigated.

It’s the 30% of freshmen that are unprepared that we should be worried about—and the majority of them did not take Advanced Math.
REFERENCES


APPENDIX A
APPENDIX B
CLASSIFICATION OF HIGH SCHOOL MATH COURSES

1. Math Course Level Classification Criteria for Burkam and Lee vs. This Study

<table>
<thead>
<tr>
<th>Level</th>
<th>Burkam &amp; Lee study</th>
<th>This study</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No math done</td>
<td>n/a</td>
</tr>
<tr>
<td>2</td>
<td>Nonacademic General 1</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>General 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Basic 1</td>
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<tr>
<td></td>
<td>Basic 2</td>
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</tr>
<tr>
<td></td>
<td>Basic 3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Consumer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Technical</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vocational</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Review</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Low academic pre-algebra</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Algebra, part 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Algebra 1, part 2</td>
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</tr>
<tr>
<td></td>
<td>Geometry, informal</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Middle</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Algebra 1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Geometry, plane</td>
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<tr>
<td></td>
<td>Geometry, plane-solid</td>
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<td></td>
<td>Unified 1</td>
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<tr>
<td></td>
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<tr>
<th>Burkam &amp; Lee study</th>
<th>This study</th>
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<tr>
<td><strong>Level</strong></td>
<td><strong>Level</strong></td>
</tr>
<tr>
<td>Other</td>
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</tr>
<tr>
<td>Pure, Other</td>
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</tr>
<tr>
<td>5 <em>Middle II</em></td>
<td></td>
</tr>
<tr>
<td>Algebra 2</td>
<td>3 Algebra 2</td>
</tr>
<tr>
<td>Unified 3</td>
<td></td>
</tr>
<tr>
<td>6 <em>Advanced I</em></td>
<td></td>
</tr>
<tr>
<td>Algebra 3</td>
<td>4</td>
</tr>
<tr>
<td>Algebra-trigonometry</td>
<td>4</td>
</tr>
<tr>
<td>Algebra-analytical geometry</td>
<td>4 Trig/advanced algebra</td>
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<tr>
<td>Trigonometry</td>
<td>4 Advanced Math (when listed after Algebra 2)</td>
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<td>Trigonometry-solid geometry</td>
<td>4 Advanced topics, finite math</td>
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<td>Analytical geometry</td>
<td>4 Math studies SL, IB Math 3, SMAC math, transition to college math</td>
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<tr>
<td>Linear algebra</td>
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<td>Probability</td>
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<tr>
<td>Probability-statistics</td>
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<td>Statistics</td>
<td>s</td>
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<td>Statistics, other</td>
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<tr>
<td>Independent study</td>
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</tr>
<tr>
<td>7 <strong>Advanced II</strong></td>
<td></td>
</tr>
<tr>
<td>Pre-calculus</td>
<td>4 Pre-calculus trigonometry/pre-calculus, math analysis</td>
</tr>
<tr>
<td>Introductory analysis</td>
<td></td>
</tr>
<tr>
<td>8 <strong>Advanced III</strong></td>
<td></td>
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*continued*
<table>
<thead>
<tr>
<th>Burkam &amp; Lee study</th>
<th>This study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level</td>
<td>Level</td>
</tr>
<tr>
<td>Calculus</td>
<td>5</td>
</tr>
<tr>
<td>Advanced placement calculus</td>
<td></td>
</tr>
<tr>
<td>Calculus-analytical geometry</td>
<td></td>
</tr>
</tbody>
</table>


2. Long, Ireatola, and Conger Criteria

5=Calculus or pre-calculus
4=Advanced algebra/trigonometry/other level 3 course
3=Algebra 2
2=Geometry
1=Algebra 1 or below


3. Planty, Provasnik, and Daniel Criteria

**Nonacademic Level**
Highest completed courses are in general math or basic skills math, such as general math I or II; basic math I, II, or III; consumer math; technical or vocational math; and math review.

**Low Academic Level**
Highest completed courses are preliminary courses (e.g., pre-algebra) or math courses of reduced rigor or pace (e.g., algebra I taught over the course of 2 academic years). Considered to be more academically challenging than nonacademic courses, courses at this level include pre-algebra; algebra I, part I; algebra I, part II; and geometry (informal).

**Middle Academic Level**
The middle academic level is divided into two sublevels, each of which is considered to be more academically challenging than the nonacademic and low academic levels, though the first level is not considered as challenging as the second level.
Algebra I/Geometry Level
Highest completed courses include algebra I; plane geometry; plane and solid geometry; unified math I and II; and pure math.

Algebra 2 Level
Highest completed course is Algebra 2 or unified math III.

Advanced Academic Level
The advanced academic level is divided into three sublevels, each of which is considered more academically challenging than the nonacademic, low academic, and middle academic levels, though the first level is not considered as challenging as the second level, nor the second level as challenging as the third.
Trigonometry/Algebra 2I Level
Highest completed course is Algebra 2I; algebra/trigonometry; algebra/analytical geometry; trigonometry; trigonometry/solid geometry; analytical geometry; linear algebra; probability; probability/statistics; statistics; statistics (other); or an independent study.

Pre-calculus Level
Highest completed course is pre-calculus or an introduction to analysis.

Calculus Level
Highest completed course is Advanced Placement (AP) calculus; calculus; or calculus/analytical geometry.

APPENDIX C
<table>
<thead>
<tr>
<th>Hmong Family and Clan Surnames</th>
<th>Approximate English Translation</th>
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<tbody>
<tr>
<td>Tsab/Tsaab (Cha)</td>
<td>Lis (Lee)</td>
</tr>
<tr>
<td>Tswb (Chue)</td>
<td>Lauj (Lor)</td>
</tr>
<tr>
<td>Tsheej (Cheng)</td>
<td>Muas (Moua)</td>
</tr>
<tr>
<td>Faaj (Fang)</td>
<td>Phab (Pha)</td>
</tr>
<tr>
<td>Haam (Hang)</td>
<td>Thoj (Thao)</td>
</tr>
<tr>
<td>Hawj (Her)</td>
<td>Vaj/Vaaj (Vang)</td>
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<tr>
<td>Khaab (Khang)</td>
<td>Vwj (Vue)</td>
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<td>Koo (Kong)</td>
<td>Xyooj (Xiong)</td>
</tr>
<tr>
<td>Kwm (Kue)</td>
<td>Yaj/Yaaj (Yang)</td>
</tr>
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APPENDIX D
REMEDIAL LEVELS BY ETHNICITY AND GENDER,
SYSTEMWIDE AND CSU, CHICO, FOR
FIRST-TIME FRESHMEN FALL 2010

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th># Freshmen (systemwide)</th>
<th>% Total enrollment</th>
<th>% Remedial in Math (systemwide)</th>
<th>% Total enrollment (CSU, Chico)</th>
<th>% Remedial (CSU, Chico)</th>
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</thead>
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<tr>
<td>American Indian</td>
<td>136</td>
<td>0.3</td>
<td>35.3</td>
<td>0.5</td>
<td>40.0</td>
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<tr>
<td>African American</td>
<td>2,361</td>
<td>5.5</td>
<td>64.4</td>
<td>1.8</td>
<td>22.6</td>
</tr>
<tr>
<td>Mexican American/other Latino</td>
<td>17,126</td>
<td>37.4</td>
<td>49.4</td>
<td>23.3</td>
<td>31.7</td>
</tr>
<tr>
<td>Asian American</td>
<td>5,833</td>
<td>12.3</td>
<td>24.3</td>
<td>7.9</td>
<td>37.0</td>
</tr>
<tr>
<td>Pacific Islander</td>
<td>185</td>
<td>0.4</td>
<td>43.8</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>White non-Latino</td>
<td>14,677</td>
<td>29.5</td>
<td>21.2</td>
<td>56.0</td>
<td>27.4</td>
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<tr>
<td>Filipino</td>
<td>2,216</td>
<td>4.6</td>
<td>30.6</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>Two or more races</td>
<td>2,483</td>
<td>5.1</td>
<td>26.9</td>
<td>5.0</td>
<td>27.0</td>
</tr>
<tr>
<td>Unknown</td>
<td>1,793</td>
<td>3.7</td>
<td>29.8</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>47,885</td>
<td></td>
<td>35.3</td>
<td></td>
<td>29.9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gender</th>
<th># Freshmen</th>
<th># Proficient</th>
<th>% Remedial systemwide 2010</th>
<th>% Remedial CSU, Chico 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>27,432</td>
<td>15,715</td>
<td>42.7</td>
<td>31.9</td>
</tr>
<tr>
<td>Male</td>
<td>20,453</td>
<td>15,258</td>
<td>25.4</td>
<td>26.7</td>
</tr>
</tbody>
</table>
### REQUIRED COURSES FOR 2008 MATH

#### GRADUATION CREDITS

<table>
<thead>
<tr>
<th>State</th>
<th>Math courses (credits)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alabama</td>
<td>Algebra I (1); Geometry (1); Other (2)</td>
</tr>
<tr>
<td>Alaska</td>
<td>Three credits (3)</td>
</tr>
<tr>
<td>Arizona</td>
<td>4 years at least to Algebra 2</td>
</tr>
<tr>
<td>Arkansas</td>
<td>Algebra I; Geometry; Algebra 2, and one higher level (4)</td>
</tr>
<tr>
<td>California</td>
<td>Algebra I</td>
</tr>
<tr>
<td>DC</td>
<td>Algebra I; Geometry; Algebra 2</td>
</tr>
<tr>
<td>Florida</td>
<td>Algebra (1)</td>
</tr>
<tr>
<td>Georgia</td>
<td>Algebra; Euclidean, Algebra 2; Other (4)</td>
</tr>
<tr>
<td>Hawaii</td>
<td>Pre-algebra and higher (3)</td>
</tr>
<tr>
<td>Indiana</td>
<td>Algebra I (2), Algebra 2 (2), Geom. (2); or Integer Math I (6)</td>
</tr>
<tr>
<td>Kansas</td>
<td>Algebraic and Geometric Concepts</td>
</tr>
<tr>
<td>Kentucky</td>
<td>Algebra (1); Geometry (1); Algebra 2 (1)</td>
</tr>
<tr>
<td>Louisiana</td>
<td>Algebra I or equivalent</td>
</tr>
<tr>
<td>Maryland</td>
<td>Algebra/Data Analysis (1); Geometry (1); Other (1)</td>
</tr>
<tr>
<td>Michigan</td>
<td>Algebra (1); Geometry (1); Algebra 2 (1); Other (1)</td>
</tr>
<tr>
<td>Minnesota</td>
<td>Algebra, Geometry, Statistics/Probability (3)</td>
</tr>
<tr>
<td>Mississippi</td>
<td>Algebra (1)</td>
</tr>
<tr>
<td>Montana</td>
<td>Local decision</td>
</tr>
<tr>
<td>Nebraska</td>
<td>Local decision</td>
</tr>
<tr>
<td>New Hampshire</td>
<td>Algebra I or equivalent</td>
</tr>
<tr>
<td>New Mexico</td>
<td>Algebra (1); Other (2)</td>
</tr>
<tr>
<td>New York</td>
<td>Three credits (3)</td>
</tr>
</tbody>
</table>

*continued*
<table>
<thead>
<tr>
<th>State</th>
<th>Math courses (credits)</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Carolina</td>
<td>Algebra (1)</td>
</tr>
<tr>
<td>North Dakota</td>
<td>Two credits (2)</td>
</tr>
<tr>
<td>Oklahoma</td>
<td>Algebra I and two higher level courses (3)</td>
</tr>
<tr>
<td>South Dakota</td>
<td>Algebra (1)</td>
</tr>
<tr>
<td>Tennessee</td>
<td>Algebra; Geometry or Algebra 2</td>
</tr>
<tr>
<td>Texas</td>
<td>Algebra; Algebra 2, Geometry (1 each)</td>
</tr>
<tr>
<td>Utah</td>
<td>Algebra/Applied Math 1; Geometry/Applied Math II</td>
</tr>
<tr>
<td>Virginia</td>
<td>Algebra or higher-level courses (3)</td>
</tr>
<tr>
<td>Washington</td>
<td>Algebra; Geometry; Algebra 2; or Integrated (3)</td>
</tr>
<tr>
<td>West Virginia</td>
<td>Algebra and 2 higher level courses (3)</td>
</tr>
</tbody>
</table>

APPENDIX F
### Detailed Results of Data Collected

**From Fall 2010 CSU, Chico**

Course Sequence vs. Remediation for Fall 2010 CSU, Chico First-Time Freshmen

<table>
<thead>
<tr>
<th>Course sequence</th>
<th>Total</th>
<th>Math ready</th>
<th># Remedial</th>
<th>% Remedial</th>
<th>Average ELM score</th>
<th>% Exempt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algebra 2, senior year</td>
<td>181</td>
<td>61</td>
<td>120</td>
<td>66.3</td>
<td>40.4</td>
<td>12.7</td>
</tr>
<tr>
<td>Algebra 2 ⇨ no 12th grade math</td>
<td>232</td>
<td>109</td>
<td>123</td>
<td>53.0</td>
<td>42.5</td>
<td>26.7</td>
</tr>
<tr>
<td>Algebra 2 ⇨ AP Statistics</td>
<td>44</td>
<td>28</td>
<td>16</td>
<td>36.4</td>
<td>44</td>
<td>47.7</td>
</tr>
<tr>
<td>Algebra 2 ⇨ Statistics</td>
<td>84</td>
<td>54</td>
<td>30</td>
<td>35.7</td>
<td>45.5</td>
<td>41.7</td>
</tr>
<tr>
<td>Advanced Math, senior year</td>
<td>493</td>
<td>359</td>
<td>134</td>
<td>27.2</td>
<td>47.8</td>
<td>45.8</td>
</tr>
<tr>
<td>Advanced, ⇨ no grade 12 math</td>
<td>234</td>
<td>174</td>
<td>60</td>
<td>25.6</td>
<td>45</td>
<td>55.6</td>
</tr>
<tr>
<td>Advanced then Statistics</td>
<td>43</td>
<td>34</td>
<td>9</td>
<td>20.9</td>
<td>47.4</td>
<td>51.2</td>
</tr>
<tr>
<td>Advanced ⇨ AP Statistics</td>
<td>143</td>
<td>130</td>
<td>13</td>
<td>9.8</td>
<td>51.3</td>
<td>79.0</td>
</tr>
<tr>
<td>Calculus</td>
<td>277</td>
<td>261</td>
<td>16</td>
<td>5.8</td>
<td>53.4</td>
<td>83.8</td>
</tr>
<tr>
<td>Algebra 2 ⇨ some other class</td>
<td>17</td>
<td>11</td>
<td>6</td>
<td>35.3</td>
<td>49.1</td>
<td>35.3</td>
</tr>
<tr>
<td>Advanced ⇨ some other class</td>
<td>7</td>
<td>7</td>
<td>0</td>
<td>0.0</td>
<td>74</td>
<td>85.7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,755</strong></td>
<td><strong>1230</strong></td>
<td><strong>527</strong></td>
<td><strong>30.0</strong></td>
<td><strong>45.2</strong></td>
<td><strong>49.9</strong></td>
</tr>
</tbody>
</table>
Course sequence vs. remediation for Fall 2010 CSU, Chico first-time freshmen
<table>
<thead>
<tr>
<th>FTF 2010 summary by gender (all freshmen)</th>
<th>Total</th>
<th>Males</th>
<th>Remedial males</th>
<th>% Remedial</th>
<th>Females</th>
<th>Remedial females</th>
<th>% Remedial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algebra 2, senior year</td>
<td>181</td>
<td>69</td>
<td>43</td>
<td>62.30</td>
<td>112</td>
<td>77</td>
<td>68.80</td>
</tr>
<tr>
<td>Algebra 2 ⇒ no 12th grade math</td>
<td>232</td>
<td>89</td>
<td>49</td>
<td>55.06</td>
<td>143</td>
<td>74</td>
<td>51.75</td>
</tr>
<tr>
<td>Algebra 2 ⇒ AP Statistics</td>
<td>44</td>
<td>17</td>
<td>6</td>
<td>35.29</td>
<td>27</td>
<td>10</td>
<td>37.00</td>
</tr>
<tr>
<td>Algebra 2 ⇒ Statistics</td>
<td>84</td>
<td>31</td>
<td>14</td>
<td>45.16</td>
<td>53</td>
<td>16</td>
<td>30.19</td>
</tr>
<tr>
<td>Advanced Math, senior year</td>
<td>493</td>
<td>226</td>
<td>59</td>
<td>26.10</td>
<td>267</td>
<td>75</td>
<td>28.10</td>
</tr>
<tr>
<td>Advanced ⇒ no 12th grade math</td>
<td>234</td>
<td>104</td>
<td>17</td>
<td>16.35</td>
<td>130</td>
<td>43</td>
<td>33.10</td>
</tr>
<tr>
<td>Advanced ⇒ AP Statistics</td>
<td>143</td>
<td>67</td>
<td>5</td>
<td>7.46</td>
<td>76</td>
<td>8</td>
<td>10.53</td>
</tr>
<tr>
<td>Advanced ⇒ Statistics</td>
<td>43</td>
<td>23</td>
<td>4</td>
<td>17.39</td>
<td>20</td>
<td>5</td>
<td>30.00</td>
</tr>
<tr>
<td>Calculus</td>
<td>277</td>
<td>122</td>
<td>4</td>
<td>3.30</td>
<td>155</td>
<td>12</td>
<td>9.00</td>
</tr>
<tr>
<td>Algebra 2 ⇒ some other class</td>
<td>17</td>
<td>8</td>
<td>3</td>
<td>55.60</td>
<td>9</td>
<td>3</td>
<td>40.00</td>
</tr>
<tr>
<td>Advanced ⇒ some other class</td>
<td>7</td>
<td>5</td>
<td>0</td>
<td>0.00</td>
<td>2</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Total</td>
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<td>761</td>
<td>204</td>
<td>26.81</td>
<td>994</td>
<td>323</td>
<td>32.49</td>
</tr>
</tbody>
</table>
## Fall 2010 Course Sequence by Ethnicity

### FTF 2010 summary by ethnicity (all freshmen):

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>Algebra 2 in senior year</th>
<th>Algebra 2 then AP Statistics then Statistics</th>
<th>Algebra 2 then Statistics then no 12th grade math</th>
<th>Advanced Math then AP Statistics then Statistics</th>
<th>Advanced Math then Statistics then no 12th grade math</th>
<th>Calculus</th>
<th>Algebra 2 then some other class</th>
<th>some other class</th>
<th>Advanced then some other class</th>
</tr>
</thead>
<tbody>
<tr>
<td>American Indian/Alaskan</td>
<td>2/100^a</td>
<td>1/0</td>
<td>2/50</td>
<td>3/0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asian</td>
<td>4/100</td>
<td>5/40</td>
<td>3/33</td>
<td>24/33</td>
<td>12/17</td>
<td>4/0</td>
<td>5/20</td>
<td>11/0</td>
<td></td>
</tr>
<tr>
<td>Hmong</td>
<td>8/68</td>
<td>9/67</td>
<td>2/0</td>
<td>6/67</td>
<td>5/40</td>
<td>3/0</td>
<td>2/50</td>
<td>7/0</td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>2/50</td>
<td>4/50</td>
<td>2/0</td>
<td>6/67</td>
<td>5/40</td>
<td>3/0</td>
<td>2/50</td>
<td>7/0</td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>50/74</td>
<td>60/40</td>
<td>8/25</td>
<td>20/50</td>
<td>117/26</td>
<td>46/22</td>
<td>36/8</td>
<td>9/44</td>
<td>59/10</td>
</tr>
<tr>
<td>Two or more</td>
<td>6/100</td>
<td>10/50</td>
<td>1/0</td>
<td>3/0</td>
<td>30/27</td>
<td>14/29</td>
<td>12/8</td>
<td>2/0</td>
<td>11/0</td>
</tr>
<tr>
<td>White</td>
<td>101/59</td>
<td>127/72</td>
<td>30/40</td>
<td>49/35</td>
<td>272/23</td>
<td>140/24</td>
<td>84/10</td>
<td>21/5</td>
<td>147/2</td>
</tr>
<tr>
<td>Native/Pacific Island</td>
<td>1/0</td>
<td>1/0</td>
<td>1/0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decline to state</td>
<td>10/60</td>
<td>14/64</td>
<td>6/50</td>
<td>22/36</td>
<td>8/25</td>
<td>5/0</td>
<td>4/50</td>
<td>22/5</td>
<td>1/100</td>
</tr>
<tr>
<td>Total</td>
<td>181/67</td>
<td>232/52</td>
<td>44/38</td>
<td>84/35</td>
<td>493/27</td>
<td>234/25</td>
<td>143/8</td>
<td>43/22</td>
<td>277/6</td>
</tr>
</tbody>
</table>

^a Count% remedial

## Parameter Estimates for Logistic Regression

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate</th>
<th>Std. err.</th>
<th>Zstat</th>
<th>p value</th>
<th>Odds ratio</th>
<th>95% low limit</th>
<th>95% upper limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-1.1408</td>
<td>0.590755</td>
<td>-1.93109</td>
<td>0.0535</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>0.03768</td>
<td>0.125727</td>
<td>0.299696</td>
<td>0.7644</td>
<td>1.038399</td>
<td>0.811602</td>
<td>1.328573</td>
</tr>
<tr>
<td>HSGPA</td>
<td>-0.44807</td>
<td>0.162239</td>
<td>-2.76176</td>
<td>0.0057</td>
<td>0.638862</td>
<td>0.464843</td>
<td>0.878028</td>
</tr>
<tr>
<td>SatComp</td>
<td>4.65E-05</td>
<td>8.65E-04</td>
<td>0.053782</td>
<td>0.9571</td>
<td>1.000047</td>
<td>0.998352</td>
<td>1.001744</td>
</tr>
<tr>
<td>SatMath</td>
<td>0.004035</td>
<td>0.001586</td>
<td>2.544128</td>
<td>0.011</td>
<td>1.004043</td>
<td>1.000927</td>
<td>1.007169</td>
</tr>
<tr>
<td>Course Se</td>
<td>0.256819</td>
<td>0.023895</td>
<td>10.74781</td>
<td>&lt;0.0001</td>
<td>1.292811</td>
<td>1.233659</td>
<td>1.354799</td>
</tr>
</tbody>
</table>
## Logistic Regression Results for Chico Service Area Only

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate</th>
<th>Std. err.</th>
<th>Zstat</th>
<th>p value</th>
<th>Odds Ratio</th>
<th>95% Lower limit</th>
<th>95% Upper limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-7.31844</td>
<td>1.196155</td>
<td>-6.1183</td>
<td>&lt;0.0001</td>
<td>3.559027</td>
<td>2.054936</td>
<td>6.164024</td>
</tr>
<tr>
<td>Gender</td>
<td>1.269487</td>
<td>0.280226</td>
<td>4.530229</td>
<td>&lt;0.0001</td>
<td>3.741772</td>
<td>1.934138</td>
<td>7.23881</td>
</tr>
<tr>
<td>HSGPA</td>
<td>1.319559</td>
<td>0.336682</td>
<td>3.9193</td>
<td>&lt;0.0001</td>
<td>3.741772</td>
<td>1.934138</td>
<td>7.23881</td>
</tr>
<tr>
<td>SATComp</td>
<td>-0.00404</td>
<td>0.002025</td>
<td>-1.99364</td>
<td>0.0462</td>
<td>0.995972</td>
<td>0.992028</td>
<td>0.999932</td>
</tr>
<tr>
<td>SATMath</td>
<td>0.011134</td>
<td>0.003994</td>
<td>2.787721</td>
<td>0.0053</td>
<td>1.011196</td>
<td>1.003311</td>
<td>1.019142</td>
</tr>
<tr>
<td>Sequence</td>
<td>0.312117</td>
<td>0.055817</td>
<td>5.591743</td>
<td>&lt;0.0001</td>
<td>1.366314</td>
<td>1.224723</td>
<td>1.524275</td>
</tr>
</tbody>
</table>

*Note:* Dependent variable: ELM=Pass? (Success=1); independent variable(s): Gender, HSGPA, SATComp, SATMath, Sequence.

## Observed vs. Expected Values for Math Ready

<table>
<thead>
<tr>
<th>Course sequence number</th>
<th>High school course sequence</th>
<th>Total</th>
<th>Math ready (observed)</th>
<th>Math ready (expected)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Algebra 2, senior year</td>
<td>181</td>
<td>61</td>
<td>126.881</td>
</tr>
<tr>
<td></td>
<td>Algebra 2 → no grade 12 math</td>
<td>232</td>
<td>110</td>
<td>162.632</td>
</tr>
<tr>
<td>2</td>
<td>Algebra 2 → AP Statistics</td>
<td>45</td>
<td>28</td>
<td>31.545</td>
</tr>
<tr>
<td>3</td>
<td>Algebra 2 → Statistics</td>
<td>82</td>
<td>53</td>
<td>57.482</td>
</tr>
<tr>
<td>4</td>
<td>Pre-Calculus, senior year</td>
<td>493</td>
<td>359</td>
<td>345.593</td>
</tr>
<tr>
<td>5</td>
<td>Pre-Calculus → no grade 12 math</td>
<td>234</td>
<td>175</td>
<td>164.034</td>
</tr>
<tr>
<td>6</td>
<td>Pre-Calculus → AP Statistics</td>
<td>142</td>
<td>130</td>
<td>99.542</td>
</tr>
<tr>
<td>7</td>
<td>Pre-Calculus → Statistics</td>
<td>43</td>
<td>34</td>
<td>30.143</td>
</tr>
<tr>
<td>8</td>
<td>Calculus</td>
<td>277</td>
<td>261</td>
<td>194.177</td>
</tr>
</tbody>
</table>
## COMPARING CHICO SERVICE AREA TO
### REST OF STATE FOR FALL 2010

**Course Sequence vs. Remediation for Fall 2010 Area 2 Students**

<table>
<thead>
<tr>
<th>FTF 2010 Area 2 summary</th>
<th>Total</th>
<th>Math ready</th>
<th># Remedial</th>
<th>% Remedial</th>
<th>% Exempt</th>
<th>Avg. ELM score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algebra 2, senior year</td>
<td>43</td>
<td>9</td>
<td>34</td>
<td>79.1</td>
<td>7.0</td>
<td>37.7</td>
</tr>
<tr>
<td>Algebra 2 ⇒ no 12th grade math</td>
<td>64</td>
<td>24</td>
<td>40</td>
<td>62.5</td>
<td>20.3</td>
<td>41.4</td>
</tr>
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<td>7</td>
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<td>3</td>
<td>42.9</td>
<td>28.6</td>
<td>48.0</td>
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<td>Advanced Math, senior year</td>
<td>93</td>
<td>58</td>
<td>35</td>
<td>37.6</td>
<td>37.6</td>
<td>46.3</td>
</tr>
<tr>
<td>Advanced ⇒ no 12th grade math</td>
<td>56</td>
<td>44</td>
<td>12</td>
<td>21.4</td>
<td>55.3</td>
<td>46.5</td>
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<tr>
<td>Advanced ⇒ AP Statistics</td>
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<td>12</td>
<td>2</td>
<td>14.3</td>
<td>71.4</td>
<td>46</td>
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<tr>
<td>Advanced ⇒ Statistics</td>
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<tr>
<td>Calculus</td>
<td>76</td>
<td>67</td>
<td>9</td>
<td>11.8</td>
<td>73.7</td>
<td>50.8</td>
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## Course Sequence vs. Remediation for Fall 2010 Students from Outside Area 2

<table>
<thead>
<tr>
<th>Course sequence</th>
<th>Total</th>
<th>Math ready</th>
<th># Remedial</th>
<th>% Remedial</th>
<th>% Exempt</th>
<th>Avg. ELM score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algebra 2 in senior year</td>
<td>138</td>
<td>52</td>
<td>86</td>
<td>62.3</td>
<td>14.5</td>
<td>41.5</td>
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<tr>
<td>Algebra 2 ⇒ no 12th grade math</td>
<td>168</td>
<td>85</td>
<td>83</td>
<td>49.4</td>
<td>28.6</td>
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</tr>
<tr>
<td>Algebra 2 ⇒ AP Statistics</td>
<td>37</td>
<td>24</td>
<td>13</td>
<td>34.2</td>
<td>51.4</td>
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<tr>
<td>Algebra 2 ⇒ Statistics</td>
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<td>27</td>
<td>34.2</td>
<td>43.0</td>
<td>44.8</td>
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<tr>
<td>Algebra 2 ⇒ Other</td>
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<td>11</td>
<td>6</td>
<td>41.2</td>
<td>35.3</td>
<td>48.5</td>
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<tr>
<td>Advanced Math in senior year</td>
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<td>301</td>
<td>99</td>
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<td>130</td>
<td>48</td>
<td>26.6</td>
<td>57.9</td>
<td>44</td>
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<td>118</td>
<td>11</td>
<td>8.5</td>
<td>79.1</td>
<td>52</td>
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<tr>
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<td>32</td>
<td>9</td>
<td>22.0</td>
<td>56.1</td>
<td>47.1</td>
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<td>0.0</td>
<td>85.7</td>
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<td>7</td>
<td>3.6</td>
<td>87.1</td>
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<td>389</td>
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<td>52.0</td>
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APPENDIX H
### COURSE SEQUENCE AND REMEDIATION

#### FOR CALIFORNIA REGIONS

<table>
<thead>
<tr>
<th>Course sequence</th>
<th>Total</th>
<th># Remedial</th>
<th>% Remedial</th>
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</thead>
<tbody>
<tr>
<td><strong>Los Angeles area</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Highest math=Algebra 2</td>
<td>77</td>
<td>47</td>
<td>61.04</td>
</tr>
<tr>
<td>Algebra 2 ⇔ Statistics or Other</td>
<td>32</td>
<td>18</td>
<td>56.25</td>
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<td>Highest math=Advanced Math</td>
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<td>55</td>
<td>29.26</td>
</tr>
<tr>
<td>Advanced ⇔ Statistics or Other</td>
<td>33</td>
<td>3</td>
<td>9.09</td>
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<tr>
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<td>4</td>
<td>6.35</td>
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<tr>
<td>Total</td>
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<td>127</td>
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<td><strong>Chico area</strong></td>
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<td>Highest math=Algebra 2</td>
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<td>74</td>
<td>58.30</td>
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<td>Highest math=Advanced Math</td>
<td>149</td>
<td>47</td>
<td>31.5</td>
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<td>Advanced ⇔ Statistics or Other</td>
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<td>2</td>
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<td>76</td>
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<td>10.84</td>
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<td>Total</td>
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<td>152</td>
<td>38.33</td>
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<tr>
<td><strong>San Francisco Bay area</strong></td>
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<td></td>
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<td>Highest math=Algebra 2</td>
<td>111</td>
<td>43</td>
<td>38.74</td>
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<tr>
<td>Algebra 2 + Statistics or Other</td>
<td>42</td>
<td>11</td>
<td>26.19</td>
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<tr>
<td>Highest math=Advanced Math</td>
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<td>39</td>
<td>18.06</td>
</tr>
<tr>
<td>Advanced ⇔ Statistics or Other</td>
<td>66</td>
<td>12</td>
<td>18.18</td>
</tr>
<tr>
<td>Calculus</td>
<td>51</td>
<td>1</td>
<td>1.96</td>
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<tr>
<td>Total</td>
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<td>106</td>
<td>21.81</td>
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*continued*
<table>
<thead>
<tr>
<th>Course sequence</th>
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<th># Remedial</th>
<th>% Remedial</th>
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</thead>
<tbody>
<tr>
<td><strong>Rest of state</strong></td>
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</tr>
<tr>
<td>Highest math=Algebra 2</td>
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<td>62</td>
<td>51.38</td>
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<tr>
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<td>52</td>
<td>15</td>
<td>28.85</td>
</tr>
<tr>
<td>Highest math=Advanced Math</td>
<td>187</td>
<td>51</td>
<td>27.27</td>
</tr>
<tr>
<td>Advanced ⇒ Statistics or Other</td>
<td>66</td>
<td>4</td>
<td>6.06</td>
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<tr>
<td>Calculus</td>
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<td>4</td>
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<tr>
<td><strong>Total</strong></td>
<td>516</td>
<td>136</td>
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APPENDIX I
FALL 2010 REMEDIATION RATES FOR CSU, CHICO

INTERNATIONAL STUDENTS

<table>
<thead>
<tr>
<th>Country</th>
<th># Freshmen</th>
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<td>People’s Republic of China</td>
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<td>7</td>
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</tr>
<tr>
<td>United Arab Emirates</td>
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<tr>
<td>Saudi Arabia</td>
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<td>Kuwait</td>
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<td>India</td>
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<td>0</td>
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