Math Course Completion and STEM Degrees at the University of New Mexico

GATEWAY

STEM Gateway Program
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STEM Gateway
Report 1.1

UNM

FOR RELEASE WITHIN THE UNIVERSITY OF NEW MEXICO ONLY

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Contents

PART ONE: OVERVIEW AND KEY FINDINGS

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INTRODUCTION

One goal of the STEM Gateway program is to develop a better understanding of the educational experiences of our STEM students as they proceed through their studies at UNM.

For this study, we collected data answering the question, "What UNM math courses did recent UNM STEM graduates complete en route to their degrees?" Our goal in answering this question was to better define which math courses should be considered as gateway courses for STEM programs. However, the implications of this data extend beyond this original question.

While the findings of this study will prove useful to understanding some of the math completion patterns of STEM degree recipients at UNM, the broader value of this study is in the implications and questions for future consideration developed by the analysis focus group (starting on page 6).

This report concludes with a literature review designed to accomplish two goals:

1. In order to better understand where UNM's students come from, this literature review summaries national challenges surrounding mathematics education at the K-12 level.
2. To gain a glimpse into best practices, this literature review categorizes the improvement systems utilized by colleges and universities to increase student performance in college level mathematics courses.

SUMMARY OF KEY FINDINGS

A large percentage of recent STEM graduates who began at UNM as first-time full-time freshmen completed MATH 120 or MATH 121.

Population of students from first-time full-time freshman cohorts	Completed MATH 120 at UNM	Completed MATH 121 at UNM
All STEM Degree Recipients	18.5%	41.22%
All Engineering Degree Recipients	9.84%	21.31%
All Arts & Sciences STEM Degree Recipients	23.02%	51.55%
Arts & Sciences: Biology Degree Recipients Only	27.86%	56.76%
Arts & Sciences: STEM Degree Recipients other than Biology	12.22%	40%

More than 40% of the STEM graduates in this cohort began math at the level of college math or lower. Assumptions that UNM STEM students are better prepared in mathematics than students in other disciplines may be unfounded. Adding in an unknown number of UNM students who took MATH 121 at CNM or at other two-year colleges, it is likely that far more than half of STEM students are not calculus ready when they arrive at the University of New Mexico.

LIMITATIONS OF THIS STUDY:

- This study is limited to one graduation cohort
- This cohort does not take into consideration math courses that students may have completed at CNM or other transfer institutions while still enrolled full-time at UNM (swirlers)
- This information is limited only to students who started as first-time freshmen and UNM, and does not include students who transferred in from other institutions (transfers)
- While this information shows courses completed by students, it does not show the pathways through math taken by these students. For instance, what order did they take math classes in? At what points in their educational careers? How did they perform in subsequent math or STEM classes? How often were math courses repeated?
- This information does not include failed attempts at math courses, only completions

INTERNAL RELEASE ONLY:

The following data is provided to UNM internal stakeholders only. It is collected and reported for use in program improvement at the University of New Mexico.

ANALYSIS PROCESS

As part of an analysis focus group process, selected UNM faculty and staff met to discuss the information included in this study, specifically:

- Implications of these findings
- Questions raised for further research

Participants included the following individuals:

- Carolina Aguirre, Director, STEM UP Program
- Patrick Coulombe, Graduate Assistant, STEM Gateway Program
- Vicky Dueer, Institutional Researcher, STEM Gateway Program
- Stephanie Hands, Director of Academic Advising, College of Arts & Sciences
- Joseph Ho, Research Professor, Chemistry, and Director of Chemical Education
- Sushilla Knottenbelt, Visiting Assistant Professor, Chemistry
- Kate Krause, Professor, Economics, and Interim Dean, University College
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- Danielle Rudder, Graduate Assistant, STEM Gateway Program
- Tim Schroeder, Project Director, STEM Gateway Program
- Kevin Stevenson, Associate Director for Finance & Development, Center for Education Policy Research

Note: The observations reported from the analysis focus groups do not reflect the views of all participants. Some observations were supported by consensus, while others reflect individual perspectives only.

GENERAL OBSERVATIONS:

This study illustrates two important educational values that may be coming into conflict at the University of New Mexico.

- On one hand, UNM is committed to **closing achievement gaps** in New Mexico. For students from poor high schools that lack educational resources, this means providing a period of "catch up" where they can adjust to the culture of university education while taking lower-level math courses. These students have sometimes been advised to enroll in smaller or less rigorous freshman course loads in order to avoid being overwhelmed with their coursework during this difficult transition. This often leads these students to accumulate more credits than required for their degree, and to take longer to graduate.
- On the other hand, state and federal leaders are pushing universities to **reduce the time to graduation for students**. For all students, this means getting through their pre-requisite and core courses quickly, and into their degree programs as soon as possible. From this perspective, advisors are encouraged to advise students into math courses and other rigorous core courses early in their educational careers and to matriculate students into their degree programs sooner.
- Within both of these two perspectives are hidden assumptions that may not have been thoroughly researched. For instance, do students from underperforming high schools actually perform better at UNM when they wait to take their math courses and/or challenging STEM core courses until the second semester? Are these students more likely to graduate if they matriculate into their degree programs later? Have degree requirements become more numerous and complicated over the last ten years (including the expectations for pre-requisites), thereby resulting in longer pathways to degree completion and less time for students to experiment with different majors or transition to college?

Other Observations:

- High school students do not realize how difficult STEM degrees are to complete. This is likely contributing to attrition at UNM.
- We do not seem to have a solid grasp on what happens to our students when they leave UNM without earning degrees. Do they drop-out, stop-out or transfer? Do they return to college later in life? If so, do they return to UNM or to other colleges?
- We do not have a reliable system for predicting which new students are likely to stay within their intended majors. Since course pathways through degrees are so different even during the first few semesters, it is crucial for UNM to understand what factors identify a student as matriculation-ready as soon as possible. These factors are likely not limited to pre-college academic preparation.
- One challenge in advising is that once a student meets with their advisor and registers, they are then free to drop/add at will. Thus, students who have been advised correctly may still take courses out of sequence.
- This study could be useful in exploring what courses should be required for each degree, and for examining hidden course requirements (pre-requisites and remedial coursework).
- UNM needs to develop a clear centralized website that details all of the course pathways for STEM degrees (including pre-requisites, core courses, program courses and suggested/required electives).

QUESTIONS FOR FUTURE CONSIDERATION:

This study does not demonstrate the pathways that students take through their math courses. For instance:

- In what order do students take the math courses?
- How many times are specific courses repeated due to failed attempts? How long did it take them to get through their math sequence?
- For students who started at the lower math levels, how long did it take them to complete their degrees compared to students who started in calculus?
- Did students who took their math courses later in their college career perform better or worse than students who took math their first few semesters?
- Did students who repeated math courses take longer to complete their degrees than students who did not repeat? Are math repeaters less likely to actually complete their degrees? Do math repeaters take longer to matriculate into their degree programs?
- How do grades impact student pathways through math courses? For instance, do students who earn "C" grades in lower level UNM math courses perform poorly in higher level math courses or math-intensive courses? Are "C" math students less likely to complete STEM degrees? Are they more likely to take more time to complete their degrees?

Other Questions for Future Consideration:

- This study examines math course completion trends for students who have *completed* STEM degrees. How would the math completion rates differ for students who originally intended to earn STEM degrees, but then switched majors into other non-STEM programs?
- This study considers only math courses completed *at UNM*. How would the math completion numbers differ when including courses transferred in from other colleges, such as CNM?
- This study does not include health science degrees or STEM education degrees (due to the nature of STEM-Gateway funding, these areas were not considered in this study). However, this population is sizeable. Many students in STEM courses are actually working towards completing these other degrees. How would the math completion rates differ when including health science and STEM education degrees?
- How significant are math disconnects to attrition when compared to other factors? For instance, is difficulty completing a math course/requirement an impediment to degree completion more often than financial difficulties? In a broader context, to what degree does academic ability impact degree completion as compared to other factors such as self-efficacy, financial resources and peer support networks?
- For this cohort of students, how did the class-size of the individual math courses relate to course completion rates? For instance, do larger classes have lower completion rates than smaller classes?
- To what extent are students running out of lottery or scholarship money prior to completing their degrees? To what extent is this connected to their beginning level of math, or the number of times they repeat math courses?
- What do these math course completion numbers look like when split out by gender, age, ethnicity and SES?
- How can we better utilize ACT supplemental questions/responses in evaluating our students' pre-college expectations and preparation? How do answers on these

questions relate to degree completion and time-to-degree completion at UNM? How is this information used in advising individual students?

- If students are opting to take their math courses at CNM, do they perform better academically? For instance, how do the success rates for math courses at UNM compare to those for similar courses at CNM? How do students who took lower level math courses at CNM fare in higher level math courses and STEM courses at UNM, compared to students took all of their courses at UNM?
- In each individual math course, what is the percentage of enrolled students per major? For instance, how many students who enroll in MATH 121 are history majors versus biology majors or nursing majors? How do success rates in MATH courses vary by major?
- How would these math course completion numbers look when overlaid with math placement data?
- How is this math course completion information impacted by major-switchers? For instance, did STEM graduates originally start as a history majors, and so began with one set of math courses? Upon switching to a STEM major, did they go back and pick up additional math courses?
- How important is success in high school STEM courses to predicting success in college STEM courses? For instance, if a student took chemistry in high school are they more likely to pass their first chemistry course at UNM?
- How do we define a student at UNM as STEM? For instance, are they considered STEM when they first declare an interest in a STEM degree? Or when they matriculate into a STEM degree program?
- How many lower level math courses are taught by TAs or part-time instructors? Is there a difference in course completion rates based on type of instructor (TA, Lecturer, Professor, etc.)?
- Does enrollment in MATH 106, 107 and 110 significantly and positively impact student completion in their companion courses? If so, should these courses be enhanced? Should they be required for students? If required, how would this impact time to

degree completion for most students? How would the requirement impact those students who do not need the additional math support?

- Why did STEM students take MATH 129? For instance, did they take the course as an elective, or as easy credits to keep scholarships?

Future STEM Gateway Research

The following two questions were raised during the focus group process. These questions form the basis of an upcoming research project by STEM Gateway, scheduled for release during the Fall of 2012:

- When a student drops out of UNM or switches out of STEM majors, what courses were they most recently enrolled in? How did they fare in those courses? Are we seeing a pattern where specific courses appear to lead students out of UNM or out of STEM?
- How does the student profile of STEM degree completers compare to students who began in STEM majors but then dropped out or switched majors? For instance, were STEM completers more academically prepared before attending UNM? Were STEM completers less likely to be first generation or low-SES students? Did STEM completers take larger or more rigorous course loads during their freshman semesters?

DATA DEFINITIONS

Source of data:

- ORD files, FCT Demog and StuCrsewGrades
- ODS files, Academic Outcomes

The study was based on the following parameters:

- Fall cohorts from 2000-2010 of First-time Freshman who were granted a Bachelor of Science or a Bachelor of Arts in one of our 18 STEM majors during the 2010-2011 academic year. Freshman cohorts were chosen because they are a regularly tracked cohort at UNM used to compute retention and graduation rates. Additionally, as a population, they have high school demographic information on file that students, such as transfers, do not.
- Next those first-time freshmen with degrees granted were tracked with their undergraduate math and statistics courses taken between entry and graduation. Many students take courses multiple times. These results represent the most recent time a student took and completed a course with a grade of "C" or better.
- Only students with a "confirmed" degree flag in Academic Outcomes were included in our analyses. All other codes which indicate otherwise were eliminated.
- First minors that were one of our 18 STEM majors were tracked for all BS recipients.

DEGREE REQUIREMENT CODING

Students' initial math placements depend upon their ACT/SAT scores and can range from Math 100 to Math 180. Some students may be able to start right out in Calculus, whereas others may have to start lower and work their way up to it. In addition, Math 123 (Trigonometry) is a prerequisite for Calculus, so if a student wants to skip Trig and go right to Calculus they have to pass a Trig exam first (regardless of their ACT/SAT scores).

Coding:

P = students may start out placed in this class prior to beginning calculus, but it doesn't count as a core class
P/C = students may start out placed in this class prior to beginning calculus, it *does* count as a core class, but they may or may not take it depending on where they begin their placement
C = core classes from calculus forward
R = higher-level classes that are required but don't count as core classes

Variations are noted using the format “*#” (ranging from *1 to *12), and the meanings of these codes are listed at the bottom of each spreadsheet. For example, some programs require either Math 314 or Math 321. For these majors, the Math 314 and 321 columns are coded as R*7, and at the bottom it says, "*7: Students are required to take Math 314 *or* Math 321."

PART TWO: SUMMARY TABLES

GRAND TOTAL, ALL DEGREES

Number of Bachelors Degree Recipients from First-Time Freshman Cohort	427

COURSE COMPLETION

SUB	NUMBER	COUNT	PCT	SUB	NUMBER	COUNT	PCT
ISM	100	10	2.34%	MATH	327	15	3.51%
MATH	106	3	0.70%	MATH	338	3	0.70%
MATH	107	11	2.58%	MATH	356	2	0.47%
MATH	110	7	1.64%	MATH	375	18	4.22%
MATH	111	5	1.17%	MATH	393	3	0.70%
MATH	112	2	0.47%	MATH	401	19	4.45%
MATH	116	3	0.70%	MATH	402	9	2.11%
MATH	120	79	18.50%	MATH	412	13	3.04%
MATH	121	176	41.22%	MATH	415	1	0.23%
MATH	123	115	26.93%	MATH	421	3	0.70%
MATH	129	16	3.75%	MATH	431	3	0.70%
MATH	150	130	30.44%	MATH	439	5	1.17%
MATH	162	139	32.55%	MATH	441	7	1.64%
MATH	163	144	33.72%	MATH	463	1	0.23%
MATH	180	197	46.14%	MATH	464	3	0.70%
MATH	181	187	43.79%	MATH	472	2	0.47%
MATH	264	134	31.38%	MATH	499	2	0.47%
MATH	301	2	0.47%	STAT	145	93	21.78%
MATH	305	6	1.41%	STAT	345	64	14.99%
MATH	306	3	0.70%	STAT	425	1	0.23%
MATH	308	2	0.47%	STAT	427	7	1.64%
MATH	311	40	9.37%	STAT	428	7	1.64%
MATH	312	42	9.84%	STAT	440	5	1.17%
MATH	313	21	4.92%	STAT	445	4	0.94%
MATH	314	93	21.78%	STAT	453	2	0.47%
MATH	316	119	27.87%	STAT	461	5	1.17%
MATH	317	1	0.23%	STAT	470	2	0.47%
MATH	318	7	1.64%	STAT	472	2	0.47%
MATH	319	5	1.17%	STAT	474	1	0.23%
MATH	321	24	5.62%	STAT	479	1	0.23%
MATH	322	7	1.64%	STAT	481	2	0.47%

MINOR COMPLETION

MINOR	COUNT	PCT
Astrophysics	1	0.23%
Biology	9	2.11%
Chemistry	73	17.10%
Computer Science	3	0.70%
Earth & Planetary Sciences	5	1.17%
Environmental Science	3	0.70%
Mathematics	14	3.28%
Physics	3	0.70%
Statistics	2	0.47%

ARTS & SCIENCES, ALL STEM DEGREES

Number of Bachelors Degree Recipients from First-Time Freshman Cohort	291

COURSE COMPLETION

SUB	NUMBER	COUNT	PCT	SUB	NUMBER	COUNT	PCT
ISM	100	8	2.75%	MATH	327	5	1.72%
MATH	106	3	1.03%	MATH	338	3	1.03%
MATH	107	10	3.44%	MATH	356	1	0.34%
MATH	110	6	2.06%	MATH	375	13	4.47%
MATH	111	4	1.37%	MATH	393	2	0.69%
MATH	112	2	0.69%	MATH	401	19	6.53%
MATH	116	1	0.34%	MATH	402	9	3.09%
MATH	120	67	23.02%	MATH	412	12	4.12%
MATH	121	150	51.55%	MATH	415	1	0.34%
MATH	123	48	16.49%	MATH	421	3	1.03%
MATH	129	13	4.47%	MATH	431	3	1.03%
MATH	150	65	22.34%	MATH	439	3	1.03%
MATH	162	47	16.15%	MATH	441	6	2.06%
MATH	163	51	17.53%	MATH	463	1	0.34%
MATH	180	186	63.92%	MATH	464	2	0.69%
MATH	181	185	63.57%	MATH	472	2	0.69%
MATH	264	38	13.06%	MATH	499	2	0.69%
MATH	301	2	0.69%	STAT	145	88	30.24%
MATH	305	5	1.72%	STAT	345	26	8.93%
MATH	306	2	0.69%	STAT	425	1	0.34%
MATH	308	2	0.69%	STAT	427	7	2.41%
MATH	311	23	7.90%	STAT	428	7	2.41%
MATH	312	20	6.87%	STAT	440	5	1.72%
MATH	313	18	6.19%	STAT	445	4	1.37%
MATH	314	16	5.50%	STAT	453	2	0.69%
MATH	316	23	7.90%	STAT	461	5	1.72%
MATH	317	0	0.00%	STAT	470	2	0.69%
MATH	318	3	1.03%	STAT	472	2	0.69%
MATH	319	4	1.37%	STAT	474	1	0.34%
MATH	321	22	7.56%	STAT	479	0	0.00%
MATH	322	6	2.06%	STAT	481	2	0.69%

MINOR COMPLETION

MINOR	COUNT	PCT
Astrophysics	1	0.34%
Biology	9	3.09%
Chemistry	73	25.09%
Computer Science	2	0.69%
Earth & Planetary Sciences	2	0.69%
Environmental Science	3	1.03%
Mathematics	4	1.37%
Physics	1	0.34%
Statistics	2	0.69%

ARTS & SCIENCES, BIOLOGY ONLY

Number of Bachelors Degree Recipients from First-Time Freshman Cohort	201

COURSE COMPLETION

SUB	NUMBER	COUNT	PCT	SUB	NUMBER	COUNT	PCT
ISM	100	7	3.48%	MATH	327	0	0.00%
MATH	106	1	0.50%	MATH	338	0	0.00%
MATH	107	5	2.49%	MATH	356	0	0.00%
MATH	110	5	2.49%	MATH	375	1	0.50%
MATH	111	3	1.49%	MATH	393	0	0.00%
MATH	112	1	0.50%	MATH	401	1	0.50%
MATH	116	1	0.50%	MATH	402	1	0.50%
MATH	120	56	27.86%	MATH	412	1	0.50%
MATH	121	114	56.72%	MATH	415	0	0.00%
MATH	123	18	8.96%	MATH	421	0	0.00%
MATH	129	8	3.98%	MATH	431	0	0.00%
MATH	150	35	17.41%	MATH	439	2	1.00%
MATH	162	16	7.96%	MATH	441	1	0.50%
MATH	163	18	8.96%	MATH	463	0	0.00%
MATH	180	155	77.11%	MATH	464	0	0.00%
MATH	181	151	75.12%	MATH	472	0	0.00%
MATH	264	5	2.49%	MATH	499	0	0.00%
MATH	301	0	0.00%	STAT	145	72	35.82%
MATH	305	1	0.50%	STAT	345	4	1.99%
MATH	306	0	0.00%	STAT	425	0	0.00%
MATH	308	0	0.00%	STAT	427	3	1.49%
MATH	311	1	0.50%	STAT	428	3	1.49%
MATH	312	2	1.00%	STAT	440	1	0.50%
MATH	313	1	0.50%	STAT	445	0	0.00%
MATH	314	4	1.99%	STAT	453	0	0.00%
MATH	316	3	1.49%	STAT	461	0	0.00%
MATH	317	0	0.00%	STAT	470	0	0.00%
MATH	318	0	0.00%	STAT	472	0	0.00%
MATH	319	0	0.00%	STAT	474	0	0.00%
MATH	321	1	0.50%	STAT	479	0	0.00%
MATH	322	0	0.00%	STAT	481	0	0.00%

MINOR COMPLETION

MINOR	COUNT	PCT
Astrophysics	0	0.00%
Biology	1	0.50%
Chemistry	72	35.82%
Computer Science	0	0.00%
Earth & Planetary Sciences	2	1.00%
Environmental Science	3	1.49%
Mathematics	1	0.50%
Physics	0	0.00%
Statistics	2	1.00%

ARTS & SCIENCES WITHOUT BIOLOGY

Number of Bachelors Degree Recipients from First-Time Freshman Cohort: 90

COURSE COMPLETION

SUB	NUMBER	COUNT	PCT
ISM	100	1	1.11%
MATH	106	2	2.22%
MATH	107	5	5.56%
MATH	110	1	1.11%
MATH	111	1	1.11%
MATH	112	1	1.11%
MATH	116	0	0.00%
MATH	120	11	12.22%
MATH	121	36	40.00%
MATH	123	30	33.33%
MATH	129	5	5.56%
MATH	150	30	33.33%
MATH	162	31	34.44%
MATH	163	33	36.67%
MATH	180	31	34.44%
MATH	181	34	37.78%
MATH	264	33	36.67%
MATH	301	2	2.22%
MATH	305	4	4.44%
MATH	306	2	2.22%
MATH	308	2	2.22%
MATH	311	22	24.44%
MATH	312	18	20.00%
MATH	313	17	18.89%
MATH	314	12	13.33%
MATH	316	20	22.22%
MATH	317	0	0.00%
MATH	318	3	3.33%
MATH	319	4	4.44%
MATH	321	21	23.33%
MATH	322	6	6.67%
MATH	327	5	5.56%
MATH	338	3	3.33%
MATH	356	1	1.11%
MATH	375	12	13.33%
MATH	393	2	2.22%
MATH	401	18	20.00%
MATH	402	8	8.89%
MATH	412	11	12.22%
MATH	415	1	1.11%
MATH	421	3	3.33%
MATH	431	3	3.33%
MATH	439	1	1.11%
MATH	441	5	5.56%
MATH	463	1	1.11%
MATH	464	2	2.22%
MATH	472	2	2.22%
MATH	499	2	2.22%
STAT	145	16	17.78%
STAT	345	22	24.44%
STAT	425	1	1.11%
STAT	427	4	4.44%
STAT	428	4	4.44%
STAT	440	4	4.44%
STAT	445	4	4.44%
STAT	453	2	2.22%
STAT	461	5	5.56%
STAT	470	2	2.22%
STAT	472	2	2.22%
STAT	474	1	1.11%
STAT	479	0	0.00%
STAT	481	2	2.22%

MINOR COMPLETION

MINOR	COUNT	PCT
Astrophysics	1	1.11%
Biology	8	8.89%
Chemistry	1	1.11%
Computer Science	2	2.22%
Earth & Planetary Sciences	0	0.00%
Environmental Science	0	0.00%
Mathematics	3	3.33%
Physics	1	1.11%
Statistics	0	0.00%

ENGINEERING

Number of Bachelors Degree Recipients from First-Time Freshman Cohort	122

COURSE COMPLETION

SUB	NUMBER	COUNT	PCT	SUB	NUMBER	COUNT	PCT
ISM	100	2	1.64%	MATH	327	10	8.20%
MATH	106	0	0.00%	MATH	338	0	0.00%
MATH	107	1	0.82%	MATH	356	1	0.82%
MATH	110	1	0.82%	MATH	375	5	4.10%
MATH	111	1	0.82%	MATH	393	1	0.82%
MATH	112	0	0.00%	MATH	401	0	0.00%
MATH	116	2	1.64%	MATH	402	0	0.00%
MATH	120	12	9.84%	MATH	412	1	0.82%
MATH	121	26	21.31%	MATH	415	0	0.00%
MATH	123	67	54.92%	MATH	421	0	0.00%
MATH	129	3	2.46%	MATH	431	0	0.00%
MATH	150	65	53.28%	MATH	439	2	1.64%
MATH	162	92	75.41%	MATH	441	1	0.82%
MATH	163	93	76.23%	MATH	463	0	0.00%
MATH	180	11	9.02%	MATH	464	1	0.82%
MATH	181	2	1.64%	MATH	472	0	0.00%
MATH	264	96	78.69%	MATH	499	0	0.00%
MATH	301	0	0.00%	STAT	145	5	4.10%
MATH	305	1	0.82%	STAT	345	38	31.15%
MATH	306	1	0.82%	STAT	425	0	0.00%
MATH	308	0	0.00%	STAT	427	0	0.00%
MATH	311	17	13.93%	STAT	428	0	0.00%
MATH	312	22	18.03%	STAT	440	0	0.00%
MATH	313	3	2.46%	STAT	445	0	0.00%
MATH	314	77	63.11%	STAT	453	0	0.00%
MATH	316	96	78.69%	STAT	461	0	0.00%
MATH	317	1	0.82%	STAT	470	0	0.00%
MATH	318	4	3.28%	STAT	472	0	0.00%
MATH	319	1	0.82%	STAT	474	0	0.00%
MATH	321	2	1.64%	STAT	479	1	0.82%
MATH	322	1	0.82%	STAT	481	0	0.00%

MINOR COMPLETION

MINOR	COUNT	PCT
Astrophysics	0	0.00%
Biology	0	0.00%
Chemistry	0	0.00%
Computer Science	1	0.82%
Earth & Planetary Sciences	3	2.46%
Environmental Science	0	0.00%
Mathematics	10	8.20%
Physics	2	1.64%
Statistics	0	0.00%

PART THREE: LITERATURE REVIEW

By Danielle Rudder

High School Preparedness

Students are graduating from high school unprepared for post-secondary education at an alarmingly high rate, and many researchers agree that the U.S. is facing a college readiness crisis (ACT, 2004; Bradley & Blanco, 2010; Conley, 2007; Kaye, Lord, & Bottoms, 2006). The U.S. Department of Education reported that in 2007-2008, 36% of first-year undergraduates in four-year institutions required remedial coursework; for students entering two-year colleges, this figure rose to 42%. (U.S. Department of Education, 2011). American College Testing (ACT) reported in 2004 that this deficit in college readiness had not shown any significant improvement in the previous decade. In addition, students who require remedial post-secondary mathematics coursework are considered to be at risk regarding their academic success, retention, and perseverance during their college educations (Ali & Jenkins, 2002).

Studies emphasize the importance of mathematics college readiness in gaining college admission (Olson, 2006) and in college graduation rates (Adelman, 2006; Hall & Ponton, 2005). Mathematics college readiness can be defined as "a student's ability to be successful in college-level mathematics courses without the need for remedial or developmental coursework" (McCormick & Lucas, 2011, p. 5). In a 2007 report, ACT correlated benchmark scores for mathematics readiness with grades in college entry-level mathematics courses. They determined that a score of 22 was correlated with a 75% chance of earning a grade of C or better, and a 50% chance of earning a grade of B or better (ACT, 2007; Kaye, Lord, & Bottoms, 2006). Nationally, the average ACT math scores have changed little from 2001 to 2011, ranging from a low of 20.6 in 2002 and 2003 to a high of 21.1 in from 2007 to 2011 (ACT, 2011a). In the U.S., only 45% of graduating high school students are prepared for college-level mathematics coursework (ACT, 2011b). In New Mexico, the average math ACT score in 2011 was 19.5 (ACT, 2011c), with 68% of students being unprepared for college-level mathematics coursework (ACT, 2011b). According to the New Mexico Public Education Department, 34% of Albuquerque 11th grade students were proficient in math in 2011. Minority students faired worse, with 28.3% of Hispanic students, 27.7% of American Indian students, and 26.8% of African American students being proficient in math. Among economically disadvantaged students, 21.7 % were proficient in math. The Albuquerque proficiency rates are slightly higher than the New Mexico statewide proficiency rates, as 31.9% of New Mexico 11th grade students were proficient in math in 2011 (NMPED, 2011).

One proposed reason for the deficits seen in the mathematical abilities of high school students is the lack of a standardized national curriculum. In the U.S., individual teachers generally determine their instructional methods and the content they teach (Desiomone, Smith, Baker, & Ueno, 2005). This results in great variation in course content and instructional approaches, with much of this variation being within rather than between schools (Newmann, King, & Youngs, 2000). Compared to other countries, the U.S. may have a less consistent and coherent mathematics curriculum (Schmidt, Houang, & Cogan, 2002).

Deficits in mathematical skills among high school students also may stem from a lack of conceptual instruction among high school mathematics teachers. Many instructors rely heavily upon computational and procedural instruction, employing routine drill and practice (Desiomone, Smith, Baker, & Ueno, 2005). This type of procedural learning tends to result in short-term memorization of facts rather than an understanding of the deeper mathematical concepts underlying these procedures (Baroody & Benson, 2001; National Council of Teachers of Mathematics, 2000; Romberg, 2000). In addition, studies show that many elementary and middle school teachers (grades K-8) possess weak mathematical knowledge, hold mathematical misconceptions, and are themselves unable to complete college-level mathematics problems (Ball & Bass, 2000; Matthews & Ding, 2011; Matthews & Seaman, 2007). Research establishes that the mathematical knowledge of teachers affects the performance of their students (Hill & Ball, 2005; Matthews & Ding, 2011; Van Dooren, Verschaffel, Onghena, 2002). Thus, students may enter high school with an inadequate understanding of mathematical concepts, a condition which may be exacerbated by a high school emphasis on procedural rather than conceptual instruction. These issues, combined with the lack of a standardized mathematics curriculum and the wide variation in mathematics course content, results in large numbers of students requiring remedial mathematics coursework upon entering college.

A proposed solution to the aforementioned problems is the adoption of the Common Core State Standards (CCSS), an initiative led by the National Governors Association Center for Best Practices and the Council of Chief State School Officers. According to the CCSS website,

> The standards are informed by the highest, most effective models from states across the country and countries around the world, and provide teachers and parents with a common understanding of what students are expected to learn. Consistent standards will provide appropriate benchmarks for all students, regardless of where they live.
>
> These standards define the knowledge and skills students should have within their K-12 education careers so that they will graduate high school able to succeed in entry-level, credit-bearing academic college courses and in workforce training programs. The standards
>
> - Are aligned with college and work expectations;
> - Are clear, understandable and consistent;

- Include rigorous content and application of knowledge through high-order skills;
- Build upon strengths and lessons of current state standards;
- Are informed by other top performing countries, so that all students are prepared to succeed in our global economy and society; and
- Are evidence-based. (CCSS, 2012).

Key points in the CCSS for mathematics can be found in Appendix A.

According to the Center on Education Policy, the Common Core State Standards were released in June 2010. As of January 2012, 45 states and the District of Columbia had adopted the CCSS in English language arts and mathematics (CEP, 2012). From October through December of 2011, CEP conducted a survey of the participating states. They received responses from 37 states and the District of Columbia. CEP did not disclose the responses of the individual states in their survey results, instead reporting the results in aggregate form. They found that most states viewed the CCSS as more rigorous than their current standards, and very few states anticipated changing their decision to adopt the CCSS. However, states were facing challenges in implementing the new standards. These challenges included the need for substantial changes in curriculum and instruction, a lack of adequate financial resources to implement the CCSS, the preparation of teachers for the new standards, and technology challenges in implementing online assessments aligned with the CCSS (including providing an adequate number of computers in schools, having adequate internet access and bandwidth in schools, and having access to expertise to address technology-related difficulties). Three states had had adopted the CCSS, but indicated that they may reverse that decision. All three states cited insufficient funds for implementation, and one state also cited public opposition and a change in political leadership as reasons for questioning their decision to implement the CCSS (CEP, 2012).

States are taking steps to address some of these challenges. These include revising current curriculum materials or creating new ones, aligning the content of teacher preparation programs with the CCSS, conducting statewide professional development programs and changing professional development materials to help teachers master the new standards, and creating educator evaluation systems that hold teachers accountable for student mastery of the CCSS. Nearly all of the surveyed states that had adopted the CCSS were involved in long-term planning for implementation and were aligning their curricula and assessments with the standards, and 27 states were planning special initiatives to ensure that the lowest-performing schools in their states would fully implement the CCSS. However, while 28 of the surveyed states that had adopted the CCSS were requiring their districts to implement the CCSS, only 15 intended to require districts to develop long-term, comprehensive plans for local implementation. In addition, although most of the surveyed states that had adopted the CCSS indicated that they were forging partnerships with colleges and universities to implement the standards, only 16 of the surveyed states said they planned to align undergraduate admissions requirements or first-year undergraduate core curricula with the CCSS (CEP, 2012).

New Mexico adopted the CCSS in 2010, and began designing an implementation plan in 2010-2011. The state began initial implementation of the CCSS in 2011-2012. As of February 2012, the state anticipated initial implementation of the CCSS for grades K-3 in 2012-2013, initial implementation for grades K-12 in 2013-2014, and full implementation in 2014-2015 (APS, 2012). According to the September 2010 meeting minutes from the Math and Science Advisory Council and New Mexico Experimental Program to Stimulate Competitive Research, there were issues regarding access to data within the New Mexico Public Education Department (PED), which made it difficult to hold teachers accountable. Other difficulties included a lack of funding to implement the CCSS, backlash regarding the costs of implementation and the perception that "we already test kids too much," significant changes to the current assessments posing continuity issues, and the uneven distribution of highly effective teachers throughout the state. Finally, they stated that the PED had not been aggressive in engaging rural schools, which put New Mexico at a disadvantage in the Race to the Top competition for federal funding to implement the CCSS.

Advising and Transfer

According to the American Association of Community Colleges (2012), 44% of all U.S. undergraduates and 43% of all first-time freshmen were community college students in the fall of 2009. Enrollment in two-year colleges increased by 34% between 1999 and 2009, representing more than 7.5 students in the fall of 2009 (Bell, 2012; Snyder & Dillow, 2011). Minority students are heavily represented in community colleges. In 2009, 54% of American Indian undergraduates were attending community colleges, comprising 1.2 % of the enrollees at two-year institutions; 51% of Hispanic undergraduate students were attending community colleges, comprising 17% of the enrollees at two-year institutions (American Association of Community Colleges, 2012; Snyder and Dillow, 2011). While approximately 36% of students at two-year colleges plan to transfer to four-year institutions (Provasnik & Planty, 2008), only 21% will transfer to a four-year institution within five years of enrolling in a community college (National Center for Education Statistics, 2011).

Although community colleges traditionally have been responsible for preparing students to transfer to four-year institutions, the responsibility for successful transfer is becoming shared by the four-year institutions themselves (Berger & Malaney, 2003; Kuh, Kinzie, Schuh, Whitt & Associates, 2005). The receiving four-year institutions are responsible for orienting and advising transfer students (Kerr, King, & Grites, 2004); however, these students often are ignored in retention efforts (Kuh, et al., 2005) and basic orientation activities (Herman & Lewis, 2004). In addition, transferring credits from two-year colleges to four-year institutions can be problematic, due in part to the lack of a standardized transfer system to ensure a seamless transfer of credits from community colleges to universities (Fisher, 2006; Mupinga, Wagner, & Wilcosz, 2009). Some states are taking steps to address this issue. For example, in 2009, California's public college and university systems formed a joint Community College Transfer Task Force to consider reforms to the transfer process, thereby increasing the number of students transferring from two-year to four-year universities. They formed the following conclusions:

- The transfer pathway(s) must be **transparent** and easy for students, faculty, and advisers to understand.
- In exchange for successfully completing a defined transfer pathway, students must receive a **guarantee** that their courses will automatically transfer and be counted toward general education (GE) and major preparation requirements at public four-year institutions in the state.

- In developing transfer pathways, care must be taken to strike a **balance** between curricular standardization and faculty/institutional autonomy (Kisker, Cohen, & Wagoner, Center for the Study of Community Colleges, 2010, p. iii).

They identified several barriers to the implementation of standardized articulation agreements, including variation among academic calendars, underprepared community college students, limitations on university capacity, lack of statewide coordination, lack of funding, and a "slow but steady disinvestment in California public education by the federal government and philanthropic foundations, reportedly due to beliefs that the state's problems are too entrenched and that there is not a significant desire – on the part of legislators or educators – to engage in significant systemic reforms" (Kisker, Cohen, & Wagoner, Center for the Study of Community Colleges, 2010, p. vi).

Other states have implemented statewide articulation agreements with success. For example, the Higher Education Articulation Agreement in Texas is recognized as a model of integrated, coordinated public post-secondary education (Brazier, 2010). The Texas legislature passed Senate Bill 148 in 1997. This bill mandated the creation of a transferrable core curriculum, which applies to any baccalaureate degree at any Texas public university (Texas Higher Education Coordinating Board, 2008). The Illinois Board of Higher Education, the Illinois Community College Board, and the Illinois Transfer Coordinators launched Illinois Articulation Initiative (IAI) in 1993 (Illinois Community College Board, 2005). The IAI is a statewide transfer agreement and is transferable among 100 or more participating Illinois colleges or universities. Participating institutions agree to accept a "package" of IAI general education courses that are comparable to university general education requirements, although course-to-course transfer is not guaranteed (iTransfer.org, n.d.). Numerous other states have enacted legislation to facilitate student transfer from two- to four-year institutions. Detailed state-by-state information can be found in Appendix B.*

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College and University Mathematics Course Redesign

There is evidence that the traditional sequence of remedial mathematics coursework may hinder progress towards attaining a degree (Edgecombe, 2011). According to a report from The Community College Research Center, among 141,590 students who were placed into remedial mathematics courses, 27% never enrolled in the recommended course, 29% exited their sequences after failing or withdrawing from a course, 11% exited their sequences without failing any courses, and 33% successfully completed their sequences (Bailey, Jeong, & Cho, 2008). This demonstrates that the majority of students who did not complete their mathematics sequences did not leave their sequence because they failed a class. Instead, the majority of students who did not complete their sequences never enrolled in the first recommended remedial class, or successfully completed one or more remedial classes but failed to enroll for the next course in their sequence. Of those who did enroll in the first recommended course, 40% exited their sequence after failing or withdrawing from a course, 15% exited their sequences without failing any courses, and 45% successfully completed remediation. Of students who were placed into mathematics courses that were three or more levels below core college coursework, only 17% completed remediation (Bailey, Jeong, & Cho, 2008).

In addition, 63% of students who completed remedial mathematics sequences enrolled in subsequent required core mathematics courses, and of those who enrolled in core courses, 79% passed. The result is that only 50% of students who successfully completed remedial mathematics sequences went on to pass a core mathematics course, with failure to enroll being a greater barrier than course withdrawal or course failure. Bailey, Jeong, and Cho note that,

> The high pass rate is encouraging, but developmental education completers are already a selected group of students who have successfully navigated their often complicated sequences. When considered from the beginning of the sequence, only 20% of students referred to math remediation and 37% of those referred to reading complete a gatekeeper [core] course in the relevant subject area within three years (2008, p. 11).

They also noted that 17% of students who were placed into remedial mathematics courses disregarded the recommended placement and enrolled directly into core mathematics courses. Although they passed the courses at slightly lower rates than those not referred to remediation, about 72% of students passed, whereas 27% of students who complied with remedial placement went on to complete a core course. The authors concluded that "the developmental education obstacle course creates barriers to student progress that outweigh the benefits of the additional learning that might accrue to those who enroll in remediation" (Bailey, Jeong, & Cho, 2008, p. 13).

Research indicates that the traditional remedial education sequence presents structural obstacles that impair student progress (Edgecombe, 2011). Students exit at each level of the sequence, which steadily reduces the pool of students who persist to core coursework (Hern, 2010). As a result of the impact of non-enrollment, some universities are restructuring the remedial coursework sequence to streamline the delivery of course content, minimize the number of exit points, and allow students to accelerate the completion of coursework or skip the remedial course sequence entirely (Edgecombe, 2011). This is in line with research demonstrating that students are more likely to complete college when they progress more quickly toward a credential (Bowen, Chingos, & McPherson, 2009).

Course restructure is among the most popular acceleration models, encompassing compressed courses, paired courses, and curriculum redesigns that replace one or more classes at the remedial or core level (Edgecombe, 2011). Compressed courses allow students to complete multiple remedial courses in one semester by compressing a single course into a half-semester segment, immediately followed by the next course in the sequence, which is also compressed into half of a semester. The problem of students failing to enroll for the next course in their sequences is reduced because students register for both compressed courses at the beginning of the semester (Edgecombe, 2011). The compressed format reduces the amount of classroom time dedicated to review, thus allowing more time for in-depth coverage of new and challenging material (Bragg & Barnett, 2008). Research indicates that learning outcomes for compressed courses are as good as, or better than, learning outcomes for traditional semester-length courses (Bragg, 2009; Brancard, Baker, & Jensen, 2006; Sheldon & Durdella, 2010).

Paired courses generally link remedial and core courses, allowing students to complete remedial and college-level coursework simultaneously. This enables them to accrue core credits sooner than if they were required to complete remedial coursework prior to enrolling in core courses, and helps to eliminate exit points resulting from failure to enroll in subsequent courses (Edgecombe, 2011). In addition, students generally complete paired courses in the same cohort, which encourages persistence through a feeling of connectedness and is associated with stronger social relationships and improved retention (Engstrom & Tinto, 2008; Karp, 2011).

While curricular redesign takes numerous forms, it generally decreases the number of courses that students are required to take so that remedial education coursework can be completed more quickly. Often, redundant content is eliminated and multiple remedial courses are consolidated into a single-semester course. Some colleges and universities have opted to eliminate the remedial course sequence altogether, instead creating a single remedial bridge course designed specifically to prepare students for core coursework. Whereas students earn only institutional credit for the traditional remedial coursework, these bridge courses count towards students' degree requirements, which may have a positive impact on student effort (Edgecombe, 2011). Preliminary research indicates that this format increases completion rates as compared to the traditional format (Hern, 2010; South Texas College, 2010).

Mainstreaming is another strategy being employed to accelerate student progress. Mainstreaming entails bypassing the remedial course sequence and placing students directly into core courses. Often, students who are placed into higher-level remedial courses are academically indistinguishable from peers who are placed into the first core course in a sequence (Calcagno & Long, 2008). As with some other acceleration strategies, mainstreaming reduces the stigma associated with remedial placement and therefore positively impacts student motivation, enthusiasm, and academic performance (Bailey, 2008). Some institutions require mainstreamed students to participate in supplemental support in the form of additional instruction through required companion classes or lab sessions. In some cases, students receive credit for both the core and supplemental courses and must achieve passing grades in both in order to enroll in subsequent courses in their sequences (Edgecombe, 2011). As with other acceleration methods, there is evidence that mainstreaming underprepared students improves their academic outcomes (Adams, Gerhart, Miller, & Roberts, 2009; Jenkins, Speroni, Belfield, Jaggars, & Edgecombe, 2010).

Despite the promise of accelerated models of college education, there are numerous obstacles to implementation. Some colleges and universities have strict policies mandating that students complete the remedial course sequences into which they are placed before they are allowed to enroll in core-level coursework (Edgecombe, 2011). These institutions do not allow students to skip the recommended remedial coursework and self-place into core courses. Some of these institutions may allow students to place out of remedial coursework and into core courses via standardized tests such as ACCUPLACER or COMPASS. However, there is evidence that these tests often fail to place student into a course level that is appropriate for their ability (Bailey, 2008; Collins, 2008; Hughes & Scott-Clayton, 2011).

Student recruitment is another barrier to the implementation of accelerated course offerings. Difficulties with student recruitment can arise from students' lack of awareness regarding these courses, ineffective marketing of accelerated course options by advisors, or complicated registration processes (e.g., dual course enrollment or paired courses). Issues with student recruitment can lead to problems with course capacity. If recruitment is insufficient, institutions may have to cancel accelerated classes because they cannot fill the required minimum number of seats. At the other end of the spectrum, high-demand compressed courses may have limits on the numbers of students they can accommodate, meaning that some students will be unable to participate (Edgecombe, 2011).

Faculty resistance to accelerated course models presents another barrier. Many faculty believe that accelerated models are inappropriate for students who require remedial education, instead believing that the exact opposite is needed: that students placed into remedial courses require slower-paced instruction over a longer period of time. Other reasons for faculty resistance include the belief that compressed courses reduce academic standards and concerns regarding the increased workload required to teach redesigned material in an unfamiliar format (Edgecombe, 2011).

Additional barriers to implementation include concerns over funding and institutional logistics. Course redesign requires an initial investment in planning and training, staff and faculty time, the production of new educational materials, and the acquisition of the necessary technological supports. Compressed courses with class periods of up to five hours may create conflicts in course and room scheduling. Mainstreaming models that require a small subset of students to enroll in a concurrent supplemental course or lab may find that institutions are hesitant to allocate classroom space for classes with so few students (Edgecombe, 2011). Finally, a lack of flexibility in student information systems can be problematic as the new accelerated models may not fit with the record-keeping systems already in place (Biswas, 2007).

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