

Assessing the Impact of Developmental Mathematics on College Students

by

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Assessing the Impact of Developmental Mathematics on College Students

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## ABSTRACT

A study was performed to assess the effectiveness of the developmental mathematics program at Youngstown State University. For this study, two cohort groups of developmental mathematics students were selected, and the success rate of both groups in their developmental and subsequent college-level courses was tracked. The results of the cohort study was compared to the success rates found in a population study, to check if the developmental students performed as well in their college-level courses as the population. For every college-level course tracked in this study, there was no statistically significant difference in the passing rate of the cohort groups and the population group.

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## Introduction

An effective developmental mathematics program is necessary at nearly every community college and four-year university. “Nationwide, developmental mathematics courses typically comprise more than half of the mathematics courses offered at two-year colleges and 10-20 percent of the mathematics courses offered at four-year colleges. Seventy-five percent of new students enrolling in two-year colleges must take one or more developmental mathematics course.” (Noel-Levitz, 2006, p. 2). A 1996 study done by the Maryland Higher Education Commission found that “Nearly half (47 percent) of all new students at Maryland public campuses who enrolled directly from high school received some form of remediation.” (Maryland Higher Education Commission, 1996, p. 1). In his 1992 study, Craig Schoenecker found that eighty-five percent of students enrolled in Minnesota community colleges placed into developmental courses.

While the need for developmental mathematics is great, it also poses the greatest challenge to both students and teachers. According to Noel-Levitz “there are few greater barriers to student success in college than the failure to pass courses in developmental mathematics.” (Noel-Levitz, 2006, p. 2). Noel-Levitz also found developmental mathematics courses to be the hardest courses to pass in all of higher education, with basic algebra having the lowest pass rate of all courses.

The purpose of this paper is to assess the effectiveness of the developmental mathematics program at Youngstown State University (YSU) in Youngstown, Ohio.

Boylan and Saxon define successful remediation as meeting the following criteria:

- a. students were able to complete remedial requirements within a reasonable period of time,

- b. students who successfully completed remedial courses were able to pass college-level courses in the same or similar subject areas,
- c. students who successfully completed remedial courses were able to achieve GPAs comparable to students who were not required to participate in remediation, and
- d. students who took remedial courses were retained over time.

(Boylan & Saxon, 2007, p. 2)

While criteria (c) and (d) are obviously of interest to those who are concerned with strategies for increasing overall student success in college, this investigation did not attempt to directly assess the effectiveness of our developmental mathematics program on these two criteria.

## **YSU Mathematics Course Descriptions**

The following excerpts from the Youngstown State University course catalog help to characterize the remedial mathematics program and the college level courses into which most developmental students advance. Math 1500 and Math 1501 are the two courses that comprise the developmental mathematics program.

### **1500 - Number Concepts and Beginning Algebra**

This is a competency based course. Topics include fractions, percentages, signed numbers, linear equations, word problems, graphing linear equations in two variables, integer exponents, and square roots.



### **1501 - Elementary Algebraic Models**

Arithmetic of integers and of rational numbers; linear equations and inequalities in one variable; polynomials, factoring, algebraic fractions, radicals and quadratic equations; linear systems in two variables; graphs [*sic*].

### **1548, 1549 - College Business Mathematics 1, 2**

Solving and graphing equations and inequalities, algebraic operations and functions, matrices and linear systems, linear programming and simplex method, mathematics of finance. Limits, derivatives and integrals with applications [*sic*].

### **2623 - Survey of Mathematics**

Mathematics models emphasizing basic ideas in mathematics and statistics, stressing concept formation rather than manipulative skills.

### **2625 - Mathematical Literacy and Critical Reasoning**

An introduction to contemporary mathematics and its applications [*sic*]. Topics include basic scientific methods and a variety of practical problems that can be modeled and solved by quantitative means.

### **2651, 2652 - Mathematics for Early Childhood Teachers 1, 2**

A conceptual development of mathematics topics underlying today's Pre-K-grade 3 curriculum. Emphasis on multiple approaches, problem solving, and communication of mathematics [*sic*]. Incorporates classroom activities, manipulatives, technology, and activities developmentally appropriate for young children [*sic*]. ("Undergraduate Program," 2008)

Using criteria of the Mathematics Special Professional Interest Network of the National Association for Developmental Education (NADE) (2002), Math 1500 is a

*Lecture/Lab Hybrid (LLH)* model. The course is taught “within a traditional class structure where instructors use part of the class period for presentation of course concepts and part of the period for student work” (NADE, 2002, p. 12) and wherever applicable hands-on activities have been incorporated. Hands-on activities in Math 1500 include the use of algebra tiles for exploring integer arithmetic rules, fraction strips for investigating fraction properties and operations, and other manipulatives suited for studying area, volume and the Pythagorean Theorem.

Math 1501 is also a LLH model, where the in-class student work is done on a computer. In the fall semester of 2004, Math 1501 used an internet based software package that was the first generation precursor to the MyMathLab software currently being used. “There is general consensus that technology should be a supplement to, as opposed to a replacement of, more traditional delivery methods.” (Golfin, Jordan, Hull & Ruffin, 2005, p. 4)

## **Research Methodologies**

The following are two common research methods to assess the effectiveness of developmental mathematics programs.

- i. Track a cohort of students through a portion of their academic careers, as was done by Julie Weissman, Elizabeth Silk, & Carole Bulakowski (1995), Margaret Amick (1996), Jon Kangas & Tony Ma (1992), Karl Boughan (1995), Steve Sworder (2006) and Craig Schoenecker, Lois Bollman, & Jean Evans (1996).
- ii. Study a large student population as was done by Jeffery Seybert & Donald Soltz (1992) and by the National Study of Developmental Education (2007).

For this study, we used both of the above methods. A cohort study was performed, and the results were compared to a population study.

A third research methodology relies on data gathered from surveys as in the study by Victoria Wacek (2002). Surveys were not used in this investigation for the following reasons.

- i. Actual student records, taken from the University data base provide a more reliable and valid means of assessing program effectiveness than data collected from student and teacher surveys or interviews.
- ii. The additional time (and expense) of conducting student and teacher surveys or interviews was not justified by any additional information relevant to our investigation, that might be obtained through these procedures.

The way the cohorts were selected for this study varied from other cohort studies. The studies done by Margaret Amick (1996), Karl Boughan (1995), and Jon Kangas & Tony Ma (1992) selected their cohorts as the group of incoming freshman, or students with no previous college experience for a particular semester. The problem we saw with this method is that it would leave out many non-traditional students from the study. Other studies, such as those done by Julie Weissman et al. (1995), Steve Sworder (2006) and Craig Schoenecker et al. (1996), selected their cohort as the group of all students enrolled in a particular semester, and don't take into account any previous college experience. This presented the problem of some students in the cohort possibly having more knowledge of the subject if they have taken the same course (or another mathematics course) previously. For the selection of our cohorts, we took all of the students enrolled in developmental math for the desired semesters, and removed any

students with prior mathematics courses. This way, we would include non-traditional students, while at the same time ensuring that all of the cohort students are at roughly the same skill level.

Two cohorts were selected, one starting at each of the developmental math courses. Cohort A was comprised of all the students enrolled in Math 1500 during the fall semester of 2004, who had not previously taken Math 1500. Cohort B was comprised of all the students enrolled in Math 1501 during the spring semester of 2005, who had not previously taken Math 1500 or Math 1501. Cohort B was selected one semester after Cohort A, to allow both groups the same amount of time to finish their college level math requirements. Both cohorts were tracked through the end of the fall semester of 2007.

In several of the studies cited above, a student was considered successful in a course if they ultimately passed the course. The studies performed by Kangas and Ma (1992), Seybert and Soltz (1992), Boughan (1995), Schoenecker et. al (1996) and the National Study of Developmental Education (2007) only look at a student's long term success, and make no mention of the number of times a student may have attempted a given course.

The student success criteria of the studies mentioned in the previous paragraph posed a problem for this investigation. If a student is successful in a mathematics course on the second or later attempts, it is unclear as to whether that success can be attributed to what was learned in the developmental course, or to what was learned in their previous attempts at the course. To clarify matters, we decided to not only track student success in

their subsequent courses, but to also determine the percentage of students who were successful on their first attempt in each subsequent course.

Becky Geltz, the Director of Institutional Research at YSU, wrote programs to select the students from the University data base for cohorts A and B and track each student's progress over the time frame of the study (fall 2004 through fall 2007).

The programs written by Becky Geltz were applied to the class rosters for Math 1500 in fall 2004 and the class rosters from Math 1501 in spring 2005 to identify a pool of students from which cohort A and cohort B would be selected. From each roster, all students with previous math experience at YSU were removed. The remaining students, which comprise cohorts A and B, were then tracked through the fall of 2007, to see how many attempted and succeeded in each mathematics course in each student's course of study. The results were then input into a spreadsheet. A detailed description of Geltz' programs is found in the appendix to this thesis.

Hand checks were performed on several of the class rosters to verify that the data extraction programs were functioning as intended.

The population study used in this thesis was based on data gathered by Dr. Gordon Mapley, the former Director on Institutional Research at YSU, and is being used with his permission. The data was drawn from the same data base as was used for the cohorts, and this data was received in the form of an SPSS file. The population included students enrolled in mathematics courses at YSU between the fall semester of 2000 and the fall semester of 2007. Other population studies have been conducted at YSU that looked at the success rate of students in Math 1501. However, the data collected in those studies were collected in a different manner and for a different purpose. The results

stated in this study were not intended to be compared with the results of the previous studies mentioned above.

Since it was not practical to verify the completeness of the population data, this thesis did not consider the data as the entire population of students enrolled in mathematics courses at YSU during the given time period, but instead it was considered a large sample of that entire population.

## **Expected Results**

Based on discussions with the coordinators of both developmental mathematics courses at YSU (Math 1500 and Math 1501), we expected to find that succeeding in Math 1501 is the biggest challenge that developmental mathematics students will encounter in their mathematics education.

## **Data**

The following table shows the data collected for cohort A. For each course in the study, the table includes the number of students who took the course, the number who passed, the percent who passed, the number who passed on the first attempt, and the percent who passed on the first attempt. (Students who took Math 1501 were successful in Math 1500. Students who took a college level mathematics course were successful in Math 1501).

**Table 1: Cohort A Data**

Course	Taken	Passed	Percent Passed	Passed on First Attempt	Percent Passed on First Attempt
Math 1500	170	130	76.47	118	69.41
Math 1501	88	52	59.09	48	54.55
Math 1548	3	2	66.67	2	66.67
Math 2623 or Math 2625	30	22	73.33	20	66.67
Math 2651	4	4	100.00	4	100.00

The following table shows the data collected for cohort B. For each course in the study, the table includes the number of students who took the course, the number who passed, the percent who passed, the number who passed on the first attempt, and the percent who passed on the first attempt. (Students who took a college level mathematics course were successful in Math 1501.)

**Table 2: Cohort B Data**

Course	Taken	Passed	Percent Passed	Passed on First Attempt	Percent Passed on First Attempt
Math 1500	NA	NA	NA	NA	NA
Math 1501	245	146	59.59	140	57.14
Math 1548	32	27	84.38	20	62.50
Math 2623 or Math 2625	68	53	77.94	48	70.59
Math 2651	6	4	66.67	4	66.67

The following table shows the data collected for a population study. For each course in the study, the table includes the number of students who took the course, the number who passed, the percent who passed, the number who passed on the first attempt, and the percent who passed on the first attempt.

**Table 3: Population Data**

Course	Taken	Passed	Percent Passed	Passed on First Attempt	Percent Passed on First Attempt
Math 1500	1472	1023	69.50	947	64.33
Math 1501	5398	3183	58.97	2828	52.39
Math 1548	2507	2006	80.02	1806	72.04
Math 2623 or Math 2625	6374	5196	81.52	4896	76.81
Math 2651	1284	1201	93.54	1152	89.72

The plan of the investigation included comparing percentages from the corresponding rows of Tables 1-3. These comparisons are illustrated by Tables 4-12 to follow. Statistical testing was used to determine which, if any, of the percentages (i.e. proportions) that were compared revealed statistically significant differences.

## Calculating Statistical Significance

The data collected for the two cohort groups were compared to each other to determine if there was any statistical difference between the students who began at Math 1500 and those who began at Math 1501. When testing for significance, the following Null Hypothesis ( $H_0$ ) and Alternative Hypothesis ( $H_A$ ) were used:

$$H_0: p_1 = p_2.$$

$$H_A: p_1 \neq p_2.$$

The Null Hypothesis was then tested using the Two Sample Proportion Test, with an alpha value of 0.05. The formula used to calculate the  $z$ -value is shown below:

$$z = \frac{\hat{p}_1 - \hat{p}_2}{\sqrt{\frac{\hat{p}_1(1 - \hat{p}_1)}{n_1} + \frac{\hat{p}_2(1 - \hat{p}_2)}{n_2}}}$$

Where:

$$\hat{p}_1 = \text{the first sample proportion (cohort A or cohort B)}$$



$\hat{p}_2$  = the second sample proportion (cohort B or the population study)

$n_1$  = the sample size of the first group (cohort A or cohort B)

And

$n_2$  = the sample size of the second group (cohort B or the population study).

The calculated  $z$ -value was then used in a  $z$ -distribution table to determine the corresponding  $p$ -value. If the  $p$ -value was found to be greater than the alpha value (0.05) then the difference is considered not statistically significant and the Null Hypothesis holds. If the  $p$ -value is found to be less than the alpha value, then the difference is considered to be statistically significant, and the Alternate Hypothesis holds. Since it is unknown which sample proportion will be greater, a two-tailed test was used.

The data collected for both cohort groups together were also compared to the national study. For these calculations, the national study success rates were considered the actual success rate. The Null Hypothesis ( $\mathbf{H}_0$ ) and Alternative Hypothesis ( $\mathbf{H}_A$ ) are defined the same as:

$\mathbf{H}_0: p = p_0.$

$\mathbf{H}_A: p \neq p_0.$

The Null Hypothesis was then tested using the One Sample Proportion Test, with an alpha value of 0.05. The formula used to calculate the  $Z$ -value is shown below.

$$z = \frac{\hat{p} - \hat{p}_0}{\sqrt{\frac{\hat{p}_0(1 - \hat{p}_0)}{n}}}$$

Where:

$\hat{p}_0$  = the hypothesized proportion (from the national study)

$\hat{p}$  = the sample proportion (cohort A and cohort B)

And

$n$  = the sample size of both cohort groups.

The calculated  $z$ -value was then used in a  $z$ -distribution table to determine the corresponding  $p$ -value. If the  $p$ -value was found to be greater than the alpha value (0.05) then the difference is considered not statistically significant and the Null Hypothesis holds. If the  $p$ -value is found to be less than the alpha value, then the difference is considered to be statistically significant, and the Alternate Hypothesis holds. Since it is unknown which proportion will be greater, a two-tailed test was used.

The values used to calculate statistical significance, along with the  $z$ -value calculated and the corresponding  $p$ -value are given in the following tables for each comparison made using the Two Sample Proportion Test.

**Table 4: Overall Success Rate of Cohort A Compared to Cohort B**

Course	$\hat{p}_1$	$n_1$	$\hat{p}_2$	$n_2$	$z$	$p$ -value
Math 1500	NA	NA	NA	NA	NA	NA
Math 1501	0.5909	88	0.5959	245	-0.09	0.94
Math 1548	0.667	3	0.8438	32	-0.63	0.53
Math 2623 or Math 2625	0.7333	30	0.7794	68	-0.48	0.63
Math 2651	1	4	0.6667	6	1.73	0.08
Completing GRE	0.1412	170	0.2204	245	-2.11	0.03

**Table 5: First Attempt Success Rate of Cohort A Compared to Cohort B**

Course	$\hat{p}_1$	$n_1$	$\hat{p}_2$	$n_2$	$z$	$p$ -value
Math 1500	NA	NA	NA	NA	NA	NA
Math 1501	0.5455	88	0.5714	245	-0.42	0.67
Math 1548	0.6667	3	0.625	32	0.15	0.89
Math 2623 or Math 2625	0.6667	30	0.7059	68	-0.38	0.70
Math 2651	1	4	0.6667	6	1.73	0.08
College Level	0.7027	37	0.6792	106	0.27	0.79

**Table 6: Overall Success Rate of Cohort A Compared to the Population**

Course	$\hat{p}_1$	$n_1$	$\hat{p}_2$	$n_2$	$z$	$p$ -value
Math 1500	0.7647	170	0.695	1472	2.01	0.04
Math 1501	0.5909	88	0.5897	5398	0.02	0.98
Math 1548	0.6667	3	0.8002	2507	-0.49	0.62
Math 2623 or Math 2625	0.7333	30	0.8152	6374	-1.01	0.31
Math 2651	1	4	0.9354	1284	9.42	<0.01

**Table 7: First Attempt Success Rate of Cohort A Compared to the Population**

Course	$\hat{p}_1$	$n_1$	$\hat{p}_2$	$n_2$	$z$	$p$ -value
Math 1500	0.6941	170	0.6433	1472	1.36	0.17
Math 1501	0.5455	88	0.5239	5398	0.40	0.70
Math 1548	0.6667	3	0.7204	2507	-0.20	0.84
Math 2623 or Math 2625	0.6667	30	0.7681	6374	-1.18	0.25
Math 2651	1	4	0.8972	1284	12.13	<0.01
College Level	0.7027	37	0.7727	10165	-0.93	0.35

**Table 8: Overall Success Rate of Cohort B Compared to the Population**

Course	$\hat{p}_1$	$n_1$	$\hat{p}_2$	$n_2$	$z$	$p$ -value
Math 1500	NA	NA	NA	NA	NA	NA
Math 1501	0.5959	245	0.5897	5398	0.19	0.85
Math 1548	0.8438	32	0.8002	2507	0.67	0.50
Math 2623 or Math 2625	0.7794	68	0.8152	6374	-0.71	0.48
Math 2651	0.6667	6	0.9354	1284	-1.40	0.16

**Table 9: First Attempt Success Rate of Cohort B Compared to the Population**

Course	$\hat{p}_1$	$n_1$	$\hat{p}_2$	$n_2$	$z$	$p$ -value
Math 1500	NA	NA	NA	NA	NA	NA
Math 1501	0.5714	245	0.5239	5398	1.47	0.14
Math 1548	0.625	32	0.7204	2507	-1.11	0.27
Math 2623 or Math 2625	0.7059	68	0.7681	6374	-1.12	0.26
Math 2651	0.6667	6	0.8972	1284	-1.20	0.23
College Level	0.6792	106	0.7727	10165	-2.05	0.04

**Table 10: Overall Success Rate of the Total Cohort Compared to the Population**

Course	$\hat{p}_1$	$n_1$	$\hat{p}_2$	$n_2$	$z$	$p$ -value
Developmental	0.6521	503	0.6122	6870	1.81	0.07
College Level	0.7832	143	0.8267	10165	-1.25	0.21

**Table 11: First Attempt Success Rate of the Total Cohort Compared to the Population**

Course	$\hat{p}_1$	$n_1$	$\hat{p}_2$	$n_2$	$z$	$p$ -value
College Level	0.6853	143	0.7727	10165	-2.23	0.03

The values used to calculate statistical significance, along with the  $z$ -value calculated and the corresponding  $p$ -value are given in the following table for each comparison made using the One Sample Proportion Test.

**Table 12: Overall Success Rate of the Total Cohort Compared to the National Study**

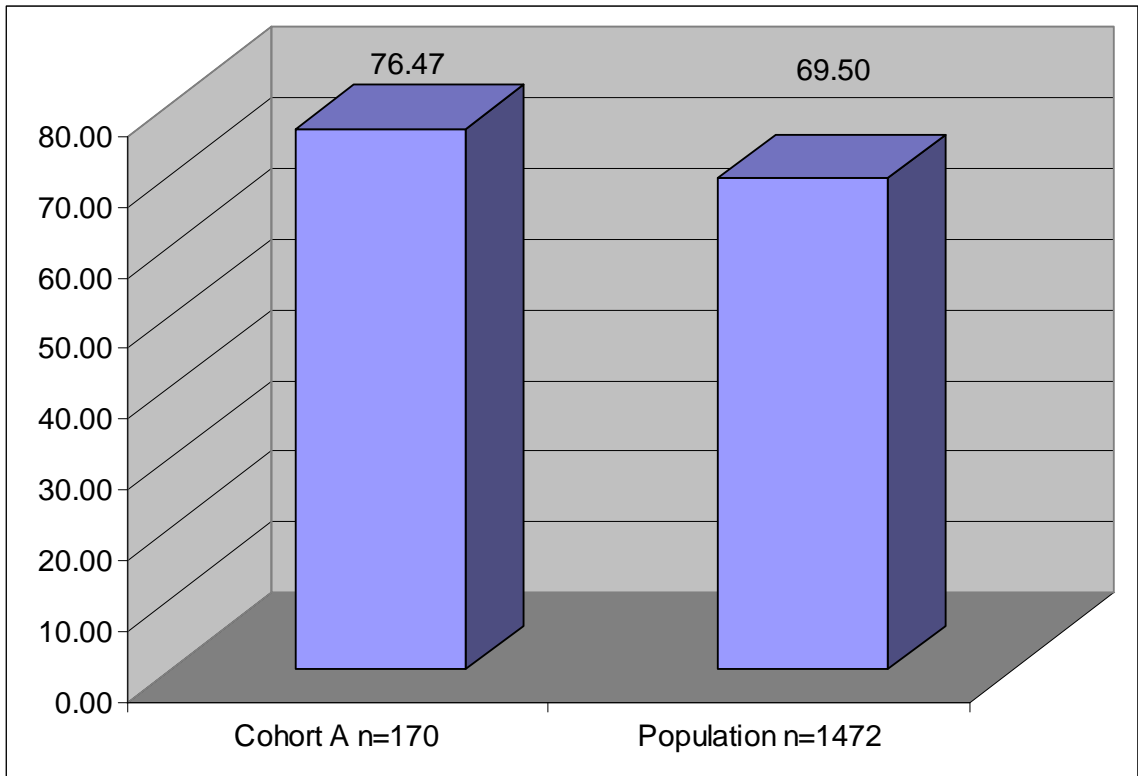
Course	$\hat{p}$	$\hat{p}_0$	$n$	$z$	$p$ -value
Developmental	0.68	0.652	503	1.318344	0.18684
College Level	0.58	0.7832	143	-5.89693	<0.0001

The calculated  $z$ -value and  $p$ -value and whether the difference is considered statistically significant will be given whenever observed success rates of the two groups are compared.

## **Math 1500: Number Concepts and Beginning Algebra**

The cohort data were used to calculate the passing rate for Math 1500. This rate is shown in the following table, comparing the cohort A success rate to the success rate of the population study.

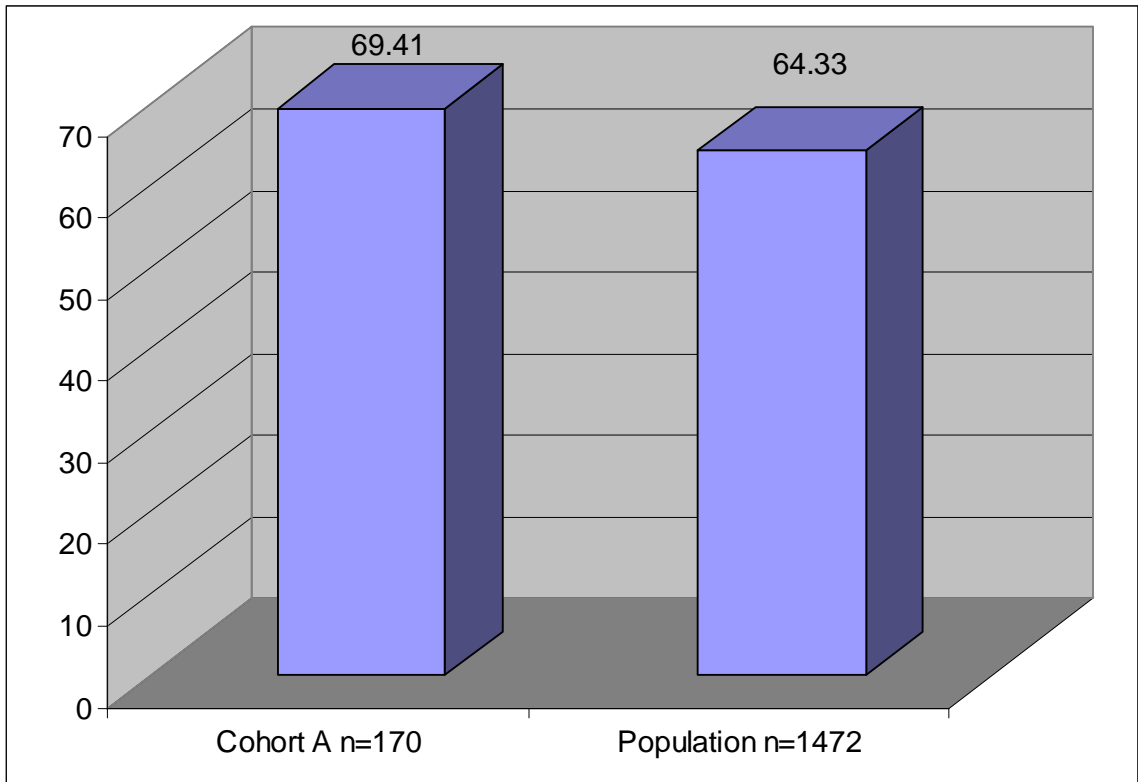
**Figure 1: Percentage Successful in Math 1500**



The difference between the cohort group success rate and the population success rate is considered significant ( $z=2.01, p=0.04$ ).

The percentage of cohort A students who passed Math 1500 on their first attempt was compared to the population, and the results are shown in the following table.

**Figure 2: Percentage Successful on First Attempt in Math 1500**

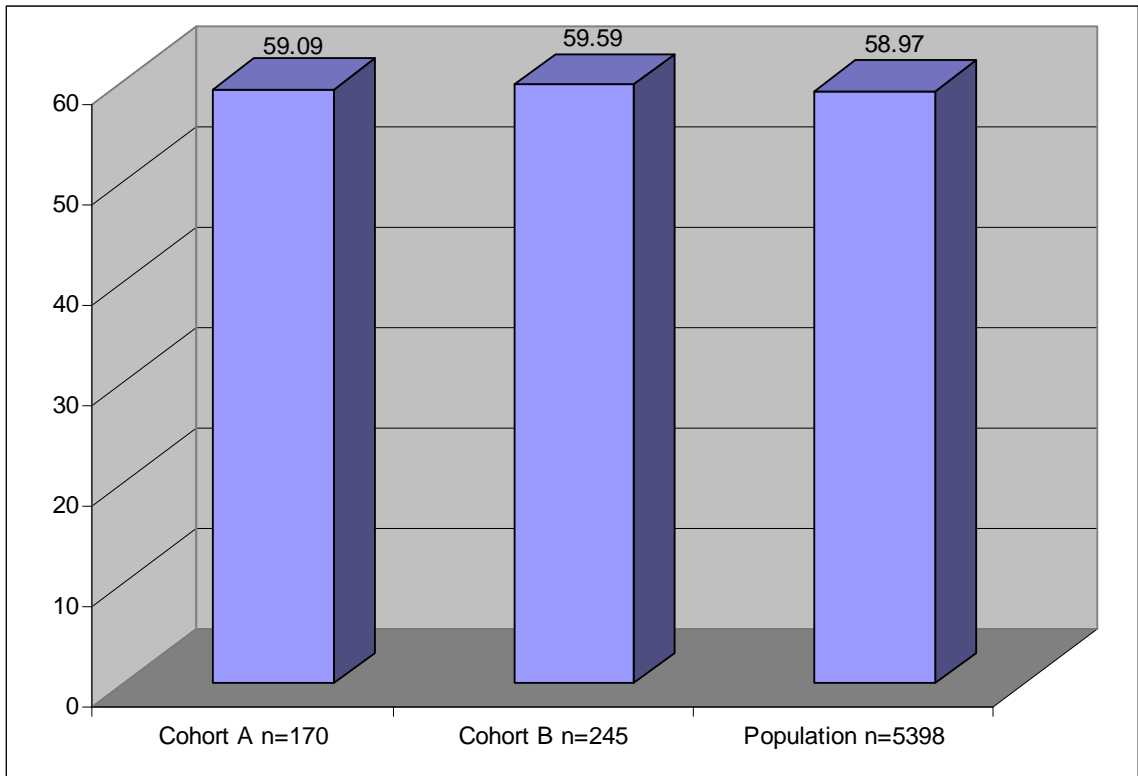


The difference between the cohort group success rate and the population success rate is not considered significant, ( $z=1.36$ ,  $p=0.17$ ).

### **Math 1501: Elementary Algebraic Models**

The cohort data were used to measure how effectively Math 1500 prepared students to take the follow up course, Math 1501. The percentage of students in the cohort who successfully took Math 1501 after being successful in Math 1500 was compared to the percentage of cohort students who were successful in Math 1501 and never took Math 1500. The results are shown in the following table, which also includes the population pass rate of Math 1501.

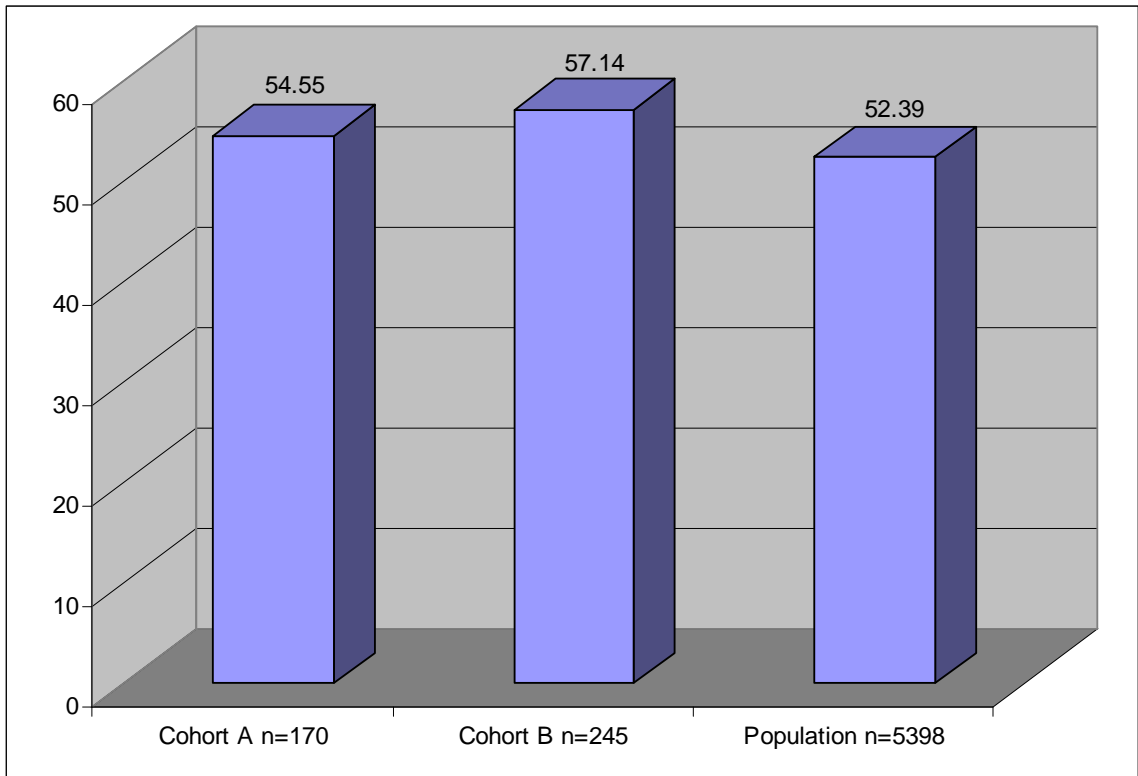
**Figure 3: Percentage Successful in Math 1501**



There was no statistically significant difference between any of the passing rates shown in the table. The difference in the Math 1501 pass rate for cohort A and cohort B is not considered significant ( $z=0.08$ ,  $p=0.94$ ). The difference in the Math 1501 pass rate for the population is not considered statistically significant from the pass rate of cohort A ( $z=0.02$ ,  $p=0.98$ ), or cohort B ( $z=0.19$ ,  $p=0.85$ ).

The percentage of the cohort A students who passed Math 1501 on their first attempt was compared with that of the cohort B students and the population study. The results are shown in the following table.

**Figure 4: Percentage Successful on First Attempt in Math 1501**

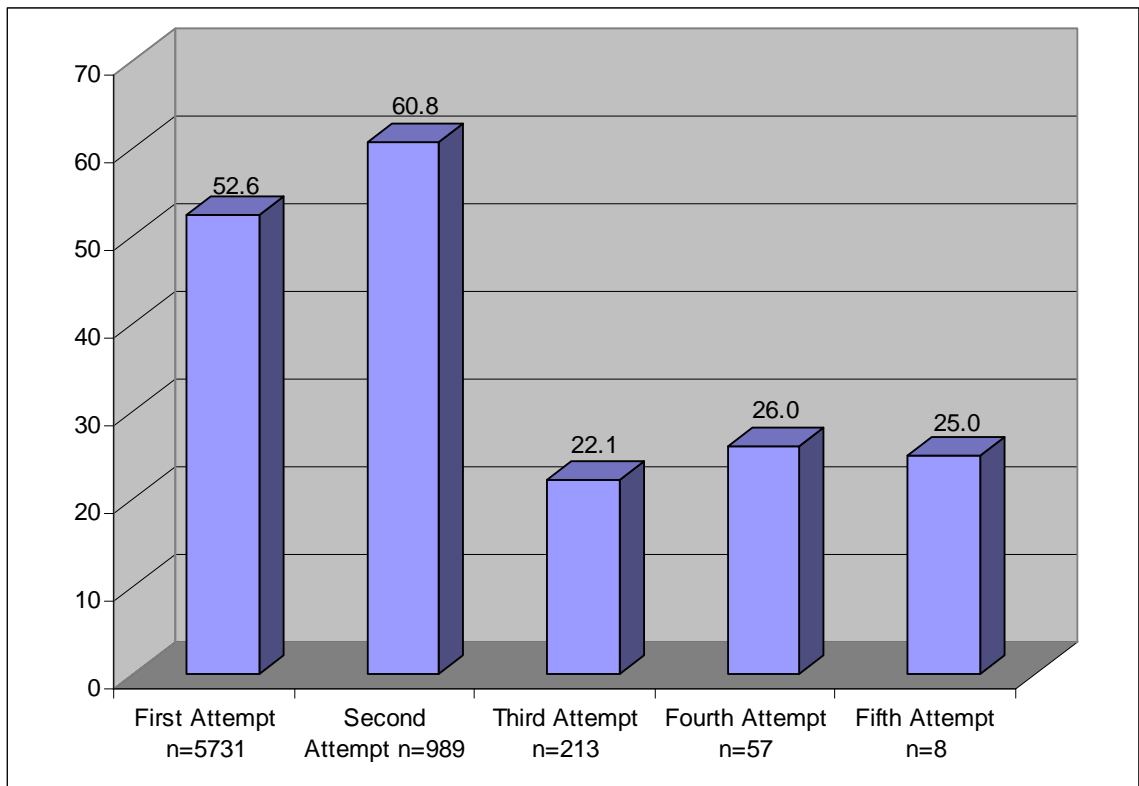


There was no statistically significant difference between any of the passing rates shown in the table. The difference in the Math 1501 first attempt pass rate for cohort A and cohort B is not considered significant ( $z=0.42$ ,  $p=0.67$ ). The difference in the Math 1501 first attempt pass rate for the population is not considered statistically significant from the pass rate of cohort A ( $z=0.40$ ,  $p=0.70$ ), or cohort B ( $z=1.47$ ,  $p=0.14$ ).

Using the population data, calculations were performed to determine the success rates of the population of students who took Math 1501 based on their total number of attempts in the course. The results are shown in the following table.



**Figure 5: Percentage Successful in Math 1501 vs. Number of Attempts**



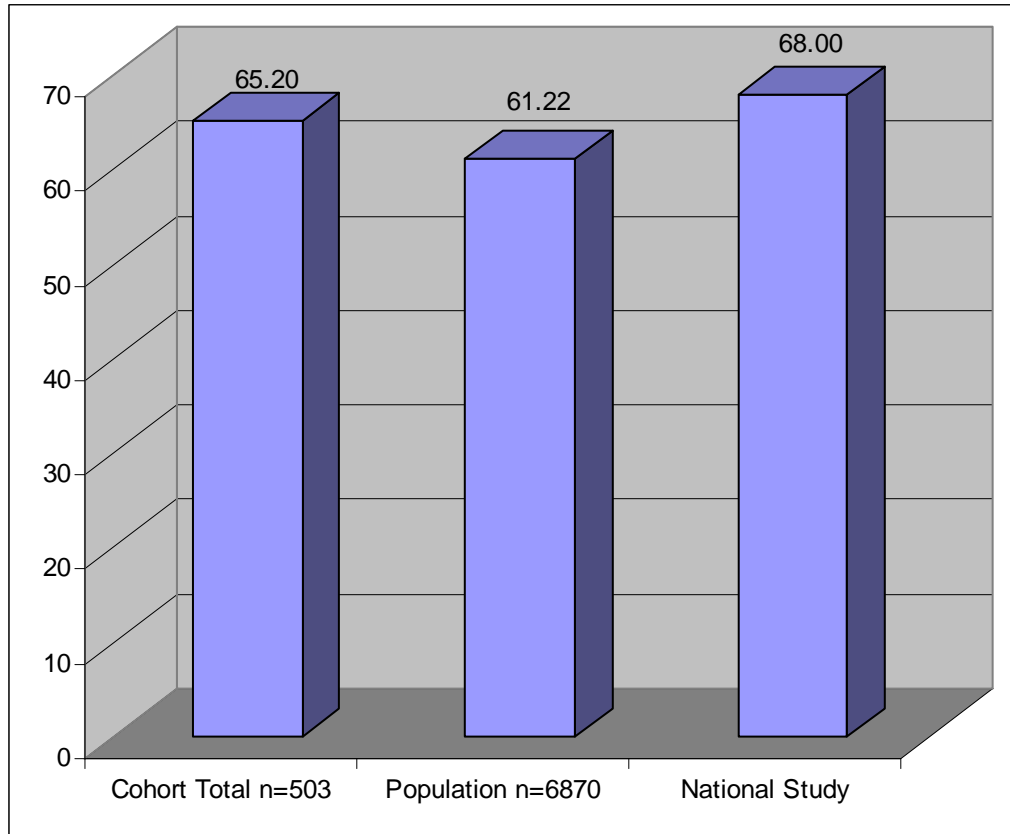
The table indicates that students are far more likely to be successful in Math 1501 on their first or second attempt. Students, who do not succeed by their second attempt at the course, find their chances of success in later attempts to be quite small. These data may be relevant to the issue of whether to limit the number of times a student can attempt a particular developmental math course, as is done in some colleges.

### **Cohort Student Success in Developmental Mathematics**

The overall success of cohort students in their developmental courses (both Math 1500 and Math 1501) was calculated and compared to the population average and the average taken from the National Study of Developmental Education (2007) which found that among developmental students at community colleges sixty-eight percent of math

students were successful in their developmental math courses. The results are shown in the following table.

**Figure 6: Percentage Successful in Developmental Mathematics**



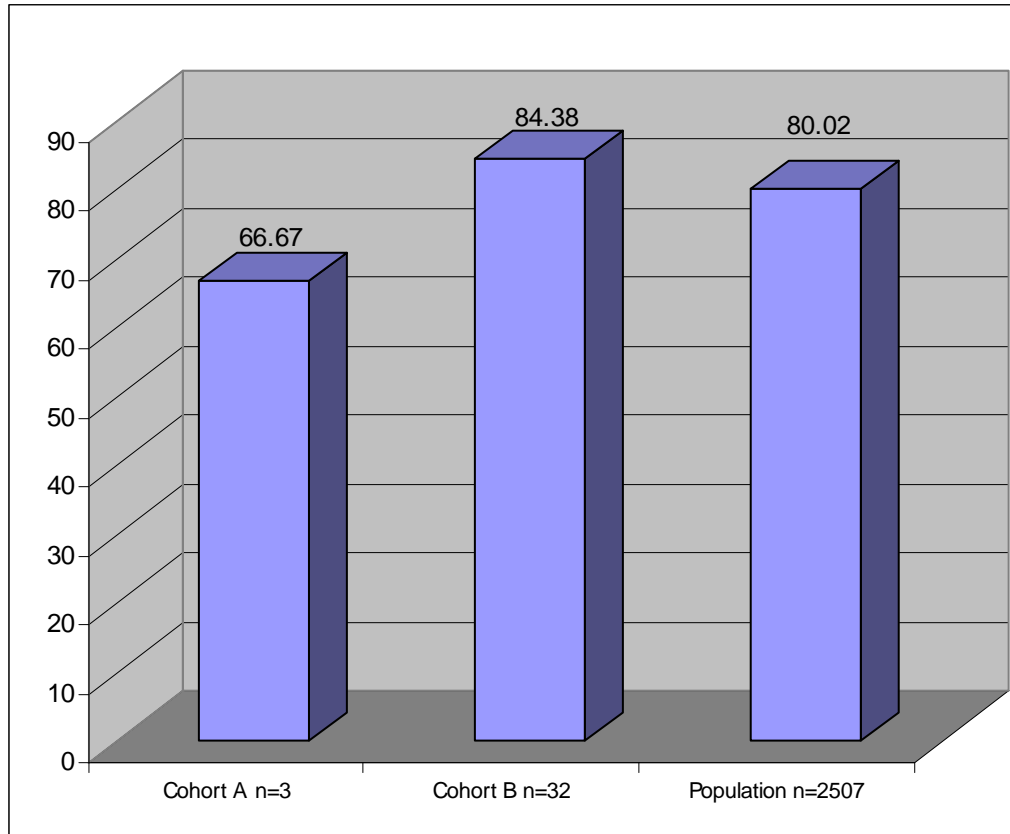
The cohort total is not considered statistically different than the population ( $z=1.81, p=0.07$ ) or the National study ( $z=1.32, p=0.19$ ).

### **Math 1548: College Business Mathematics 1**

The cohort data were used to calculate the percentage of students who were ultimately successful in Math 1548 (College Business Mathematics 1). These percentages are shown in the following table, comparing each cohort success rate with the population success rate. The cohort A data are not very meaningful since the actual

number of students in this category is so small ( $n=3$ ). This table only compares students who attempted Math 1548.

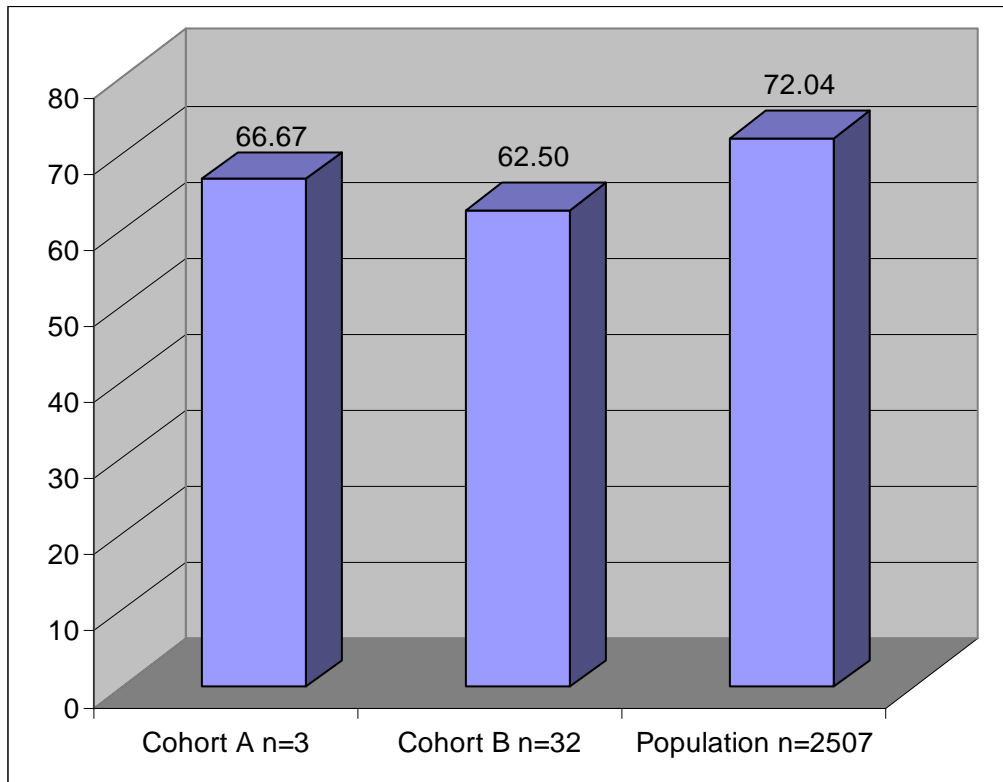
**Figure 7: Percentage Successful in Math 1548**



The table indicates that cohort A students were least likely to be successful in Math 1548. However, there are no significant differences between the success rates of the two cohort groups ( $z=0.63$ ,  $p=0.53$ ). There is also no statistically significant difference when comparing the population pass rate with cohort A ( $z=0.49$ ,  $p=0.62$ ) or with cohort B ( $z=0.67$ ,  $p=0.50$ ).

The percentage of cohort students who passed Math 1548 on their first attempt was calculated, and compared to the population. The results are shown in the following table.

**Figure 8: Percentage Successful on First Attempt in Math 1548**



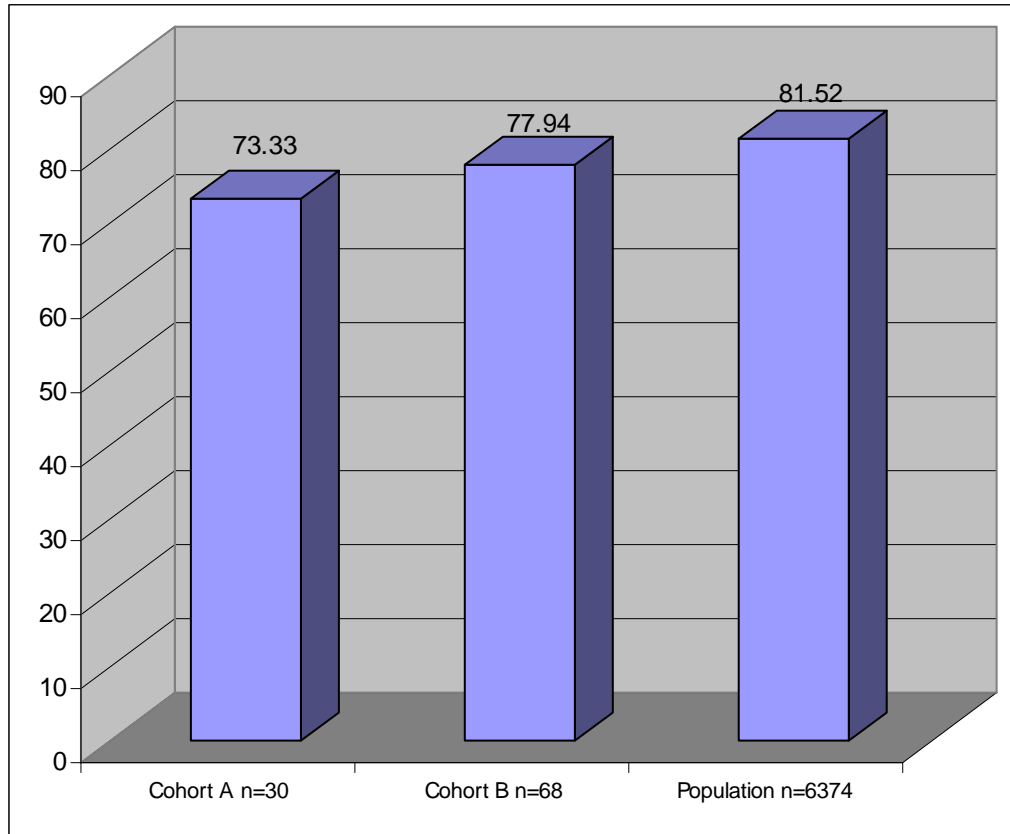
The table indicates that the cohort B students were the least likely to be successful in Math 1548 on their first attempt. However, there is no statistically significant difference in the passing rates. The first attempt pass rates of cohort A and cohort B are not considered statistically significant ( $z=0.15$ ,  $p=0.89$ ). There is also no statistically significant difference when comparing the population pass rate with cohort A ( $z=0.20$ ,  $p=0.84$ ) or with cohort B ( $z=1.11$ ,  $p=0.27$ ).

### **Math 2623: Survey of Mathematics & Math 2625: Mathematical Literacy and Critical Reasoning**

The cohort data were used to calculate the percentage of students who were ultimately successful in Math 2623 (Survey of Mathematics) or Math 2625 (Mathematical Literacy and Critical Reasoning). These percentages are shown in the following table, comparing the success rate of students from each cohort with the success

rates of the population. This table only compares students who attempted Math 2623 or Math 2625.

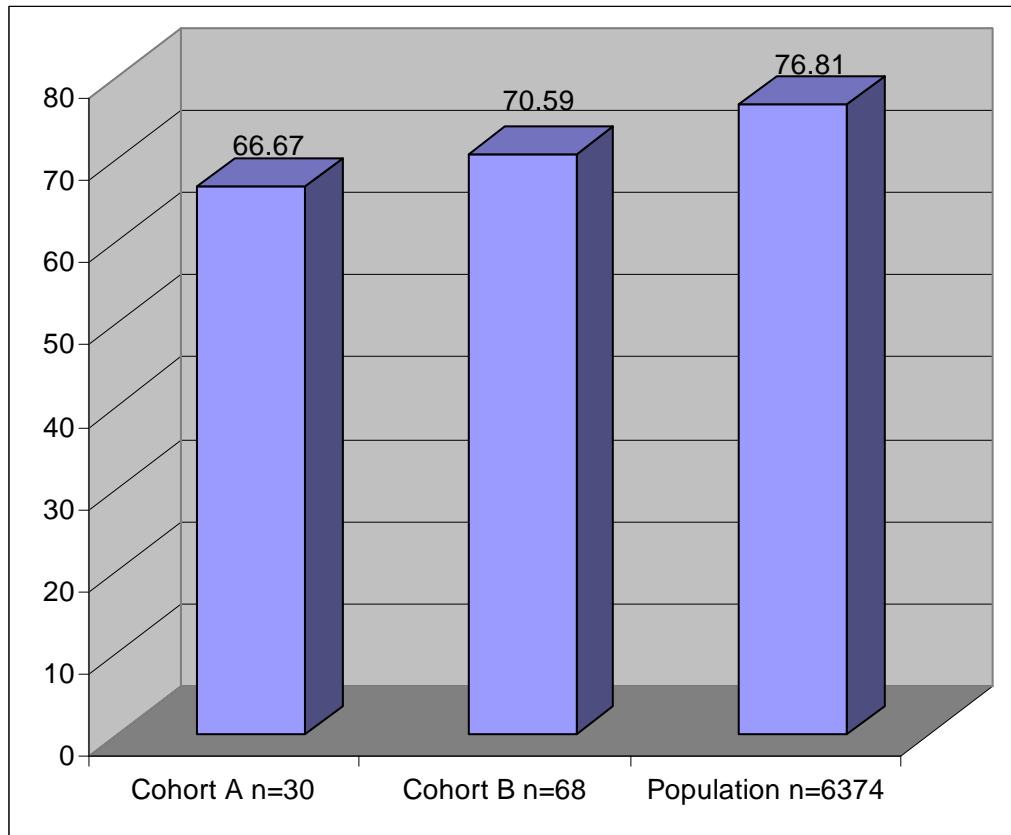
**Figure 9: Percentage Successful in Math 2623 or Math 2625**



The table indicates that cohort A students were least likely to be successful in Math 2623 or Math 2625. However, there is no statistical significance difference between any of the success rates in Math 2623 or Math 2625 shown in the table. The difference in the pass rate of the two cohort groups is not considered statistically significant ( $z=0.48$ ,  $p=0.63$ ). There is also no statistically significant difference when comparing the population pass rate with cohort A ( $z=1.01$ ,  $p=0.31$ ) or with cohort B ( $z=0.71$ ,  $p=0.48$ ).

The percentage of cohort students who passed Math 2623 or Math 2625 on their first attempt was calculated, and compared to the population. The results are shown in the following table.

**Figure 10: Percentage Successful on First Attempt in Math 2623 or Math 2625**



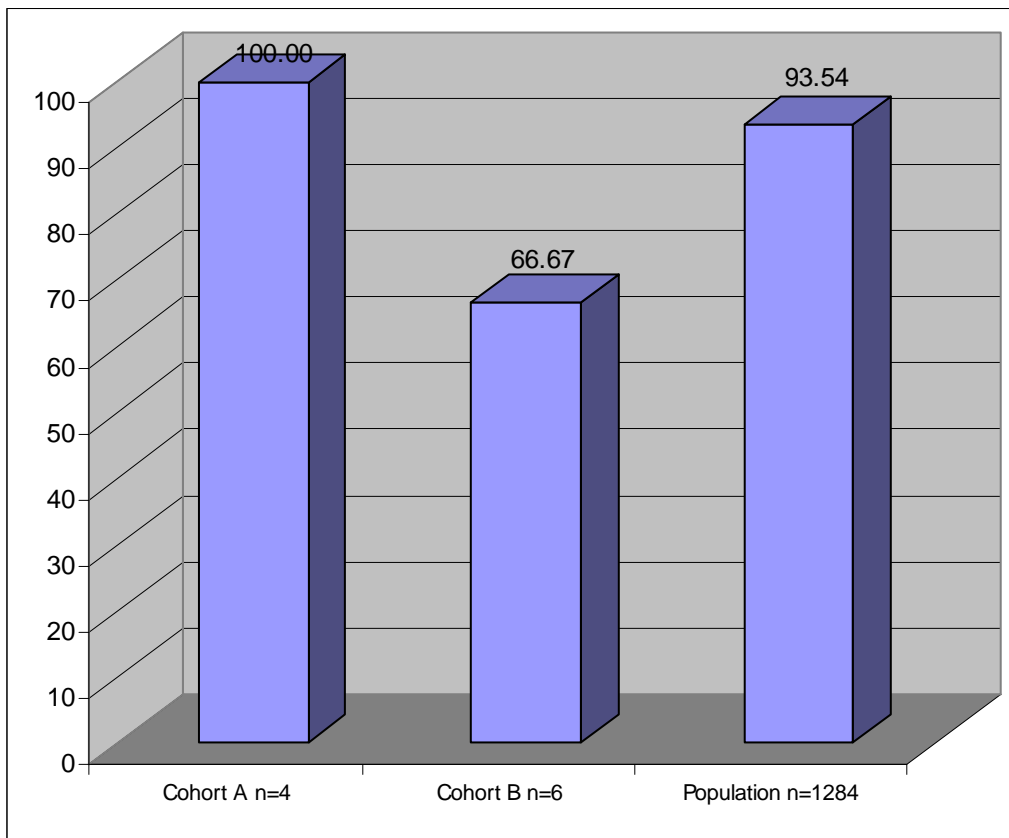
The table indicates that the cohort A students were the least likely to be successful in Math 2623 or Math 2625 on their first attempt. However, there is no statistical significance difference between any of the first attempt success rates in Math 2623 or Math 2625 shown in the table. The difference in the pass rate of the two cohort groups is not considered statistically significant ( $z=1.18$ ,  $p=0.25$ ). There is also no statistically significant difference when comparing the population pass rate with cohort A ( $z=1.01$ ,  $p=0.31$ ) or with cohort B ( $z=1.12$ ,  $p=0.26$ ).

# Math 2651: Mathematics for Early Childhood Teachers 1

The cohort data were used to calculate the percentage of students who were ultimately successful in Math 2651 (Mathematics for Early Childhood Teachers 1).

These percents are shown in the following table, comparing the success rate of the cohort students with the success rate of the population. This table only compares students who attempted Math 2651.

**Figure 11: Percentage Successful in Math 2651**



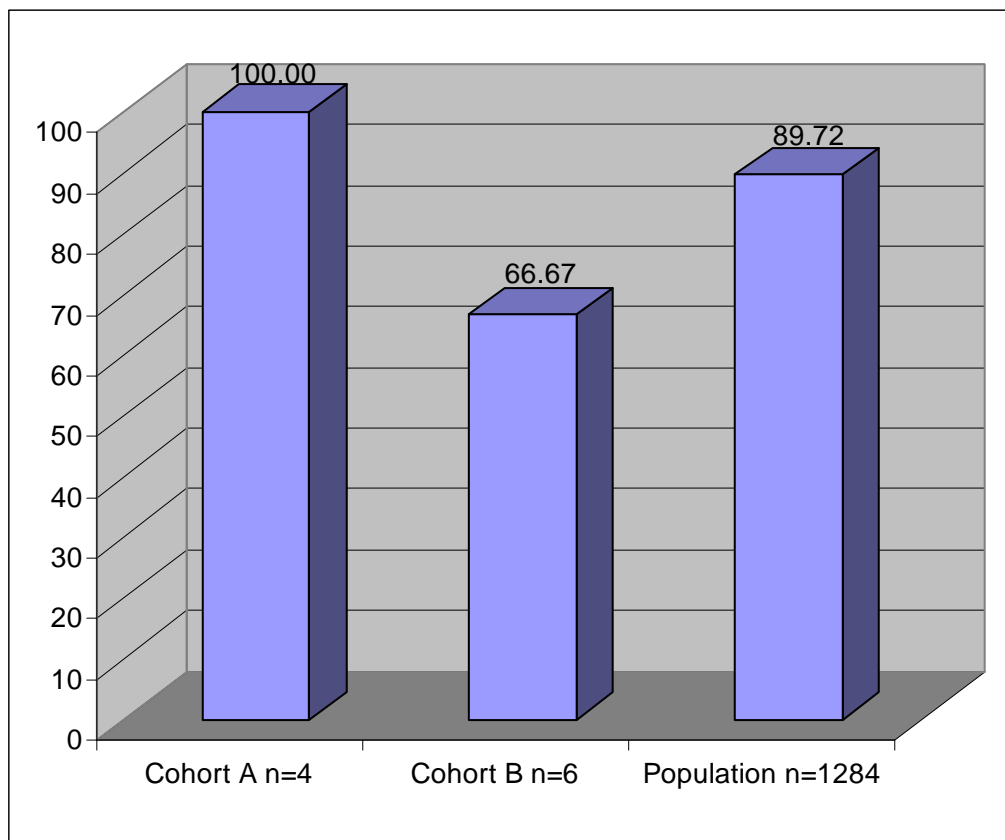
The table shows that cohort B students were least likely to be successful in Math 2651. When comparing the Math 2651 pass rate of cohort A to the Math 2651 pass rate of cohort B we find the difference to not be statistically significant ( $z=1.73, p=0.08$ ).

When comparing the Math 2651 population success rate to cohort A there is a statistically significant difference ( $z=9.42, p<0.01$ ). When comparing the Math 2651 population

success rate to cohort B, there is no statistically significant difference ( $z=1.40$ ,  $p=0.16$ ). However, the sample sizes for the cohort A and cohort B students who went on to take Math 2651 (4 and 6 respectively) are too small to make a meaningful comparison.

The percentage of cohort students who passed Math 2651 on their first attempt was calculated, and compared to the population average. The results are shown in the following table.

**Figure 12: Percentage Successful on First Attempt in Math 2651**



The table indicates that cohort B students were least likely to be successful in Math 2651 on their first attempt. When comparing the Math 2651 pass rate of cohort A to the Math 2651 pass rate of cohort B we find the difference to not be statistically significant ( $z=1.73$ ,  $p=0.08$ ). When comparing the Math 2651 population success rate to

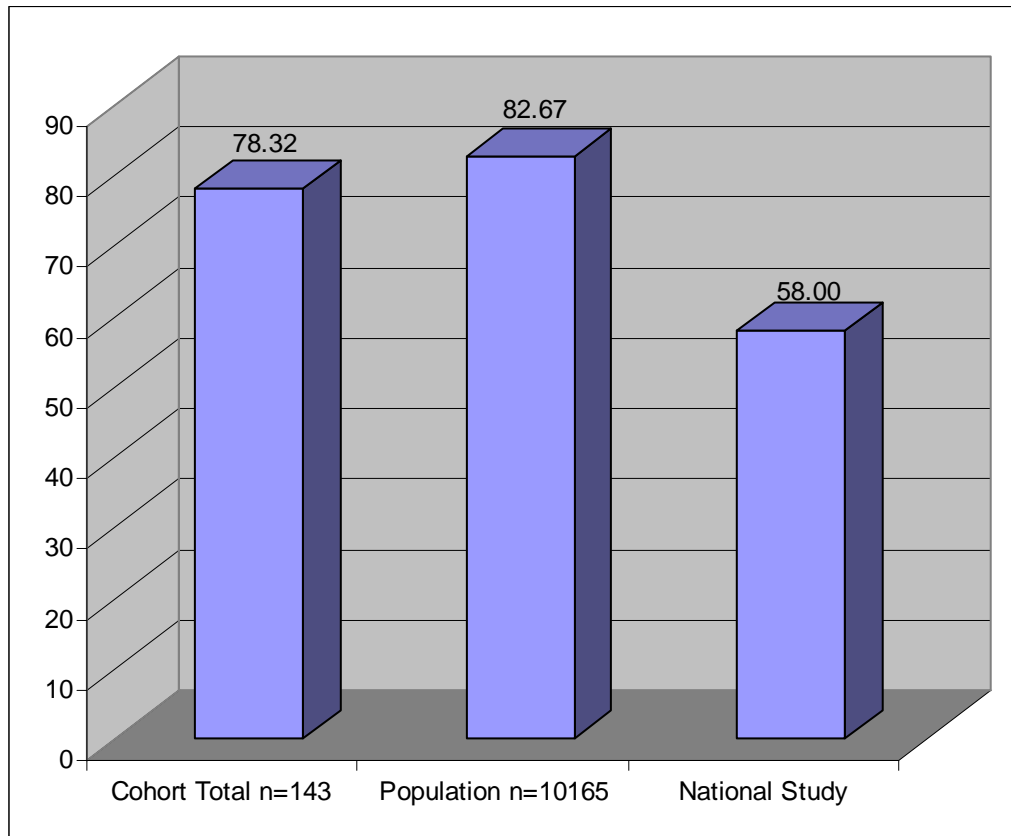


cohort A there is a statistically significant difference ( $z=12.13, p<0.01$ ). When comparing the Math 2651 population success rate to cohort B, there is no statistically significant difference ( $z=1.20, p=0.23$ ). However, the sample sizes for the cohort A and cohort B students who went on to take Math 2651 (4 and 6 respectively) are too small to make a meaningful comparison.

## **Cohort Student Success in First College Level Mathematics Course**

The cohort data were used to calculate the percent of students who were ultimately successful in their first college level mathematics course. These percentages are shown in the following table, comparing the success rate of both cohorts with the success rate of the population and the National study. This table only compares students who attempted Math 1548, Math 2623, Math 2625 or Math 2651.

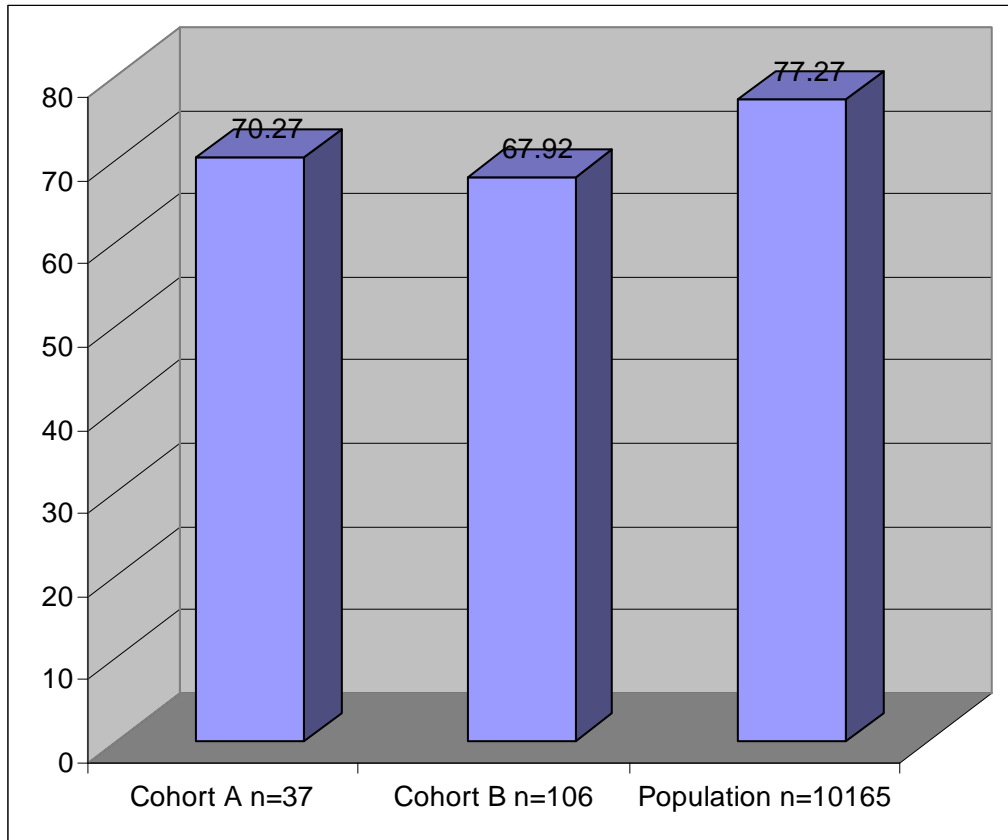
**Figure 13: Percentage Successful in First College Level Mathematics Course**



There was no statistically significant difference between the first college level mathematics course success rate for the cohort total and the population ( $z=1.25$ ,  $p=0.21$ ). However, the cohort first college level mathematics course success rate was significantly higher than that found in the national study ( $z=5.90$ ,  $p<0.01$ ).

The percentage of cohort students who passed their first college level mathematics course on their first attempt was calculated, and compared to the population average. The results are shown in the following table.

**Figure 14: Percentage Successful on First Attempt in First College Level Mathematics Course**



The table indicates that the cohort students who started at Math 1501 were the least likely to be successful in their first college level mathematics course on their first attempt. The difference between cohort A and cohort B is not statistically significant ( $z=0.27, p=0.79$ ). The difference between cohort A and the population is also not considered statistically significant ( $z=0.93, p=0.35$ ). The difference between cohort B and the population is considered statistically significant ( $z=2.05, p=0.04$ ).

Of the 170 students in cohort A who began taking their developmental math courses in Math 1500 in the fall semester of 2004, 14% of them (24 students) ended up completing all of their college math requirements by the end of the fall semester of 2007. Of the 245 students in cohort B who began taking their developmental math courses in

Math 1501 in the spring semester of 2005, 22% of them (54 students) ended up completing all of their college math requirements by the end of the fall semester of 2007. The difference is considered to be statistically significant, ( $z=2.11$ ,  $p=0.02$ ). One possible reason for this difference is that cohort A had one more obstacle to overcome. Also, more than 30% of cohort A did not complete Math 1500 on their first attempt. This means that those 52 students who did not pass Math 1500 in the fall semester of 2004 would not have been eligible to start Math 1501 in the spring semester of 2005, and would therefore not have had as much time to complete their requirements as cohort B.

## **Results and Comparisons to Other Studies**

When comparing our data to the National Study of Developmental Education, we see that while YSU cohort students pass their developmental math courses at approximately the same rate, those who do are successful in their subsequent college level courses at a higher rate.

Schoenecker et al. (1996) found that more than 65% of developmental mathematics students at Minnesota community colleges successfully completed their remedial requirements. Schoenecker also found “There were virtually no significant differences among any of the three groups when the course specific measures, the pass rates in the college composition course and the next higher mathematics course, were analyzed.” (Schoenecker et al., 1996, p. 18). The results of the Minnesota study are very similar to our results.

Boughan (1995) found that only 14% of developmental math students at Prince George’s Community College (PGCC) in Maryland successfully completed their developmental math requirements. However, he did find that “those few PGCC

developmental students who do manage to fulfill their remedial program requirements find their chance of success almost equalized compared with non-developmental students”. (Boughan, 1995, p. 8). He found that successful developmental students were only 8% less likely to “score academic successes”. When comparing the results of the PGCC study to the YSU study, we see that the YSU cohort students have a higher success rate in developmental math than the students in the PGCC study. And, like the PGCC students, those who do are equally likely to be successful in their college level course as the population.

Seybert and Soltz (1992) conducted a similar study at Johnson County Community College (JCCC) in Overland Park, Kansas. They found that over 59% of developmental mathematics students were successful in their developmental courses. They also found that the success rate of the developmental students in their College Algebra course was 61.3%, only slightly less than the school-wide average of 63.5%. Compared to the JCCC study, the YSU cohort students had a higher success rate in both their developmental and college level mathematics courses.

Sworder (2006) found that 52% enrolled in Intermediate Algebra at Saddleback College in the fall semester of 2002 were successful. He also found that nearly two-thirds of the students who were successful in Intermediate Algebra, and then enrolled in a subsequent college level mathematics course, were successful. YSU cohort students have a higher success rate in both their developmental and college level mathematics courses than the students in the Saddleback College study.

The Maryland Higher Education Commission (1996) found that between 67% and 80% of Maryland college students passed their first college-level mathematics course

after successfully completing remediation. The commission also found that 84% of students who did not require remediation passed their first college-level mathematics course. The YSU cohort students' success rate in their first college level mathematics course falls within the range found in the Maryland Higher Education Commission study.

Boylan and Saxon (1998) found that between 75% and 85% of Texas community college students who successfully completed developmental mathematics or English courses were successful in their first college-level course in the same subject. The success rate of the YSU cohort students falls within the range found in the Boylan and Saxon study.

## **Conclusion**

When compared to the other studies cited in this thesis, the success rates of the YSU cohort students were never significantly lower, and in some cases were significantly higher than the results found in the other studies.

As expected, success in Math 1501 was the biggest challenge for both of the cohort groups and the population, with the lowest success rates for both overall success and first attempt success of any of the courses in this study. However, the students in this study who did pass Math 1501 had a higher success rate in their first college-level mathematics courses than they had in Math 1501. Since there was no statistically significant difference when comparing the success rates of the cohorts to the population, this would indicate that the developmental mathematics program at YSU adequately prepared the cohort students for their subsequent mathematics courses.

Students who were not successful in Math 1501 by their second attempt are unlikely to ever successfully pass the course.

## Appendix

The cohort of students used for this thesis came from a tracking project for developmental math. The project tracked two groups of developmental math students, one group who began their studies in Math 1500 and another group who began in Math 1501. The following algorithms were used in the program created by Becky Geltz to develop and track the cohorts.

For each Math 1500 class roster in the fall semester of 2004:

1. Delete all students from consideration who withdrew from the selection before the fourteenth day of the semester.
2. Delete any student who took Math 1500 prior to the fall semester of 2004.
3. Check if student has succeeded (received a grade of A, B, C, or CR (credit)) in Math 1500 as of the end of the fall semester of 2007. (Student may have tried multiple times.)
  - a) List how many students in the Math 1500 cohort.
  - b) List how many eventually succeeded in Math 1500 as of the end of the fall semester of 2007.
4. Check if student, who eventually succeeded in Math 1500, has tried Math 1501 and, if so, have they succeeded as of the end of the fall semester of 2007. (Student may have tried multiple times).
  - a) List how many of these students attempted Math 1501.
  - b) List how many of these students succeeded in Math 1501 as of the end of the fall semester of 2007.

5. Check if student, who eventually succeeded in Math 1501, has tried Math 2623 or Math 2625 and, if so, have they succeeded as of the end of the fall semester of 2007. (Student may have tried multiple times).
  - a) List how many of these students attempted Math 2623 or Math 2625.
  - b) List how many of these students succeeded in Math 2623 or Math 2625 as of the end of the fall semester of 2007.
6. Check if student, who eventually succeeded in Math 1501, has tried Math 2651 and Math 2652 and, if so, have they succeeded as of the end of the fall semester of 2007. (Student may have tried multiple times).
  - a) List how many of these students attempted Math 2651 and Math 2652.
  - b) List how many of these students succeeded in Math 2651 and/or Math 2652 as of the end of the fall semester of 2007.
7. Check if student, who eventually succeeded in Math 1501, has tried Math 1548 and Math 1549 and, if so, have they succeeded as of the end of the fall semester of 2007. (Student may have tried multiple times).
  - a) List how many of these students attempted Math 1548 and Math 1549.
  - b) List how many of these students succeeded in Math 1548 and/or Math 1549 as of the end of the fall semester of 2007.

For each Math 1501 class roster in the spring semester of 2005:

1. Delete all students from consideration who withdrew from the selection before the fourteenth day of the semester.
2. Delete any student who took Math 1500 prior to the spring semester of 2005.
3. Delete any student who took Math 1501 prior to the spring semester of 2005.



4. Check if student has succeeded (received a grade of A, B, C, or CR (credit)) in Math 1501 as of the end of the fall semester of 2007. (Student may have tried multiple times.)
  - a) List how many students in the Math 1501 cohort.
  - b) List how many eventually succeeded in Math 1501 as of the end of the fall semester of 2007.
5. Check if student, who eventually succeeded in Math 1501, has tried Math 2623 or Math 2625 and, if so, have they succeeded as of the end of the fall semester of 2007. (Student may have tried multiple times).
  - a) List how many of these students attempted Math 2623 or Math 2625.
  - b) List how many of these students succeeded in Math 2623 or Math 2625 as of the end of the fall semester of 2007.
6. Check if student, who eventually succeeded in Math 1501, has tried Math 2651 and Math 2652 and, if so, have they succeeded as of the end of the fall semester of 2007. (Student may have tried multiple times).
  - a) List how many of these students attempted Math 2651 and Math 2652.
  - b) List how many of these students succeeded in Math 2651 and/or Math 2652 as of the end of the fall semester of 2007.
7. Check if student, who eventually succeeded in Math 1501, has tried Math 1548 and Math 1549 and, if so, have they succeeded as of the end of the fall semester of 2007. (Student may have tried multiple times).
  - a) List how many of these students attempted Math 1548 and Math 1549.

- b) List how many of these students succeeded in Math 1548 and/or Math 1549 as of the end of the fall semester of 2007.

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