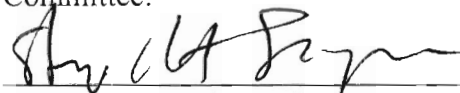


EFFECTIVE MATHEMATICS PLACEMENT TESTING STRATEGIES: A STUDY
OF MATHEMATICS PLACEMENT TEST RETAKE POLICY AT A TWO-YEAR
PUBLIC COMMUNITY COLLEGE IN FLORIDA

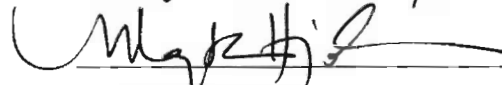
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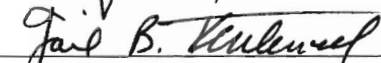
Sanford A. Geraci
A Dissertation
Submitted to the
Graduate Faculty
of
George Mason University
in Partial Fulfillment of
The Requirements for the Degree
of
Doctor of Arts
Community College Education


Committee:

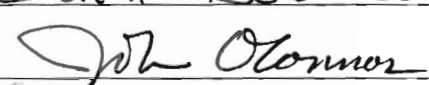


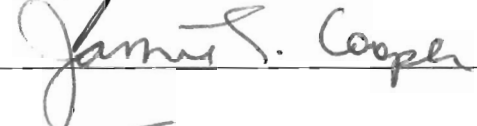
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Effective Mathematics Placement Testing Strategies: A Study of Mathematics Placement
Test Retake Policy at a Two-Year Public Community College in Florida

A dissertation submitted in partial fulfillment of the requirements for the degree of
Doctor of Arts at George Mason University

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DEDICATION

I would like to dedicate this research paper to my family. I give special dedication to my father Sandy Geraci, my mother Margaret Geraci, my sisters Lisa Nuland, Susan Geraci, and Vicki Lohman, and my late brother Joey Geraci for supporting me through this process.

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ABSTRACT

EFFECTIVE MATHEMATICS PLACEMENT TESTING STRATEGIES: A STUDY OF MATHEMATICS PLACEMENT TEST RETAKE POLICY AT A TWO-YEAR PUBLIC COMMUNITY COLLEGE IN FLORIDA

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George Mason University, 2008

Dissertation Director: Dr. Stephen Saperstone

Placement testing in college is important partly because initial placement recommendations may be followed by further placement recommendations based on retakes of the placement test. This study examines a particular mathematics retake policy at a community college in Florida which allows students to retest on the mathematics placement test every 90 days. As a result, students may be placed into a particular course and then retake the placement test before the semester ends. It is an increasingly known practice among students that if their retake placement scores place them in a higher course, students sometimes withdraw from their current course and take the higher level course the following semester – without finishing the course into which they were originally placed.

Analysis of the data collected reveals that students who retake the placement exam and test into a subsequent developmental course do worse in the subsequent course

than those students who initially placed into that higher level course. Although a relatively small number of students retake the placement test, the study further shows that most of those students do not perform better as a result of the placement retake, and the number that performs better is insignificant. These findings are based on analysis of the sample proportions.

Recommendations include changing the college's retake policies. The most significant recommendation permits retakes only before initial enrollment, suggests placing students based on the average of their pre-enrollment placement and retake(s) scores, and defines a stricter time limit on how long placement scores are accepted. The recommendations can serve as an example for other colleges nationwide.

1. Introduction

Personal Interest

Placement testing began to interest me when I began teaching mathematics. It is very frustrating as a math professor when students are not properly placed. I wondered if improving placement testing policies would lessen the failure rate of students whom I felt were improperly placed. In particular, while teaching a Business Calculus course I realized that many of the students in the course were ill prepared. I later realized that the condition leading to failure could be a result of the placement testing policies at that college.

My interest increased when mathematics professor Dr. Saperstone, Chair of my dissertation committee, pointed out the many different mathematics placement testing policies and the magnitude of the problems that arise in placement testing that could be resolved with good placement policies.

Purpose of the Study

The first purpose of this study was to identify whether or not the current college mathematics placement test retake policy at Broward Community College (BCC hereafter) properly serves the students. Second, the study makes recommendations on revisions of the retake policy at the institution. For instance, based on the data, it may be

better to have no placement test retakes permitted, keep the present retake policy, keep the current retake policy with stipulations or additional educational resources in place, lengthen the current retest waiting period, or perhaps modify the retake policy in some way in order that students not be permitted to take advantage of the retake policy. The study's ultimate placement testing revision recommendations can be used not only to help improve mathematics placement testing at BCC, but can serve as an example throughout the nation.

The Problem

Proper placement of students into mathematics courses should be the goal of placement testing – and improper placement may have negative implications for students since proper placement should increase student success. Currently at BCC, students can retake the same mathematics placement test every 90 days. Approximately 2.4% of the students who take the college's mathematics placement test retake it. The placement test scores are valid for two years and the highest placement score achieved is used for placement.

In particular, one may suspect that by allowing retakes of its placement test every 90 days, BCC creates a problem and in too many instances contributes to students performing worse in successive math courses. However, this study reveals that the reason allowing retakes every 90 days may be undesirable is that students commonly take the placement test, drop or fail the course that they were originally placed into, retake the placement test and receive a higher grade, and then register for the next course. Those

who take the successive course as a result of the retest perform significantly worse in the latter course than those who originally placed into that course. Thus this policy may hurt the students by causing underachievement in successive math courses since they never finished the course into which they were originally placed. Additionally, this practice is in conflict with the institution's prerequisite policies.

Retaking the placement test is much more common at BCC at the developmental level for two reasons. First, receiving a passing grade, a failing grade, or a withdraw have the same ramifications since developmental courses do not count in the students' grade point averages. So, a student's main interest is more likely making it to the next course by either retaking the placement test or passing the course that he or she was originally placed into. Second, students not at the developmental level may be more serious about their education, and thus will not as commonly withdraw from the course into which they were originally placed.

Thus, this study examined BCC's mathematics placement policy with regards to retake policies and the corresponding proportions of students' pass rates in order to make observations and recommendations about placement testing retake policies, both to develop improved placement techniques at BCC and to minimize the problem of improper placement, with the ultimate goal of ensuring academic success.

Limitations

There were several limitations in this research project. First, because this study was conducted at one community college, the limitation occurs when one tries to interpret

this study's results and use these results to make generalizations about all community colleges' retake testing policies. However, since the data collected for this study was from a large community college in the United States and the samples are random, representative, and sufficiently large, more general inferences can be made as long as the reader keeps these limitations in mind.

Additionally, individual students' circumstances may also affect this study's outcomes – some of which can be taken into consideration while creating a revised policy, but others cannot. For example, when taking the test or retest, the student may have had less sleep, be dealing with personal problems, be ill, or may have had a major life crisis. To control individual variables of this nature, the study was designed such that the sample sizes were relatively large compared to the number of students who would have such individual circumstances.

Any study risks one or more of two types of errors. First there is mathematical error, which can be built into the hypotheses and formulae within the statistical analysis. Next, there is human error, which may range from how the data is gathered to a clerical error during grade entry. Wherever possible, the researcher has taken steps to prevent or minimize such errors.

Lastly, institutional practices such as how the specific institution treated a grade of W (withdraw) and how success and failure in a course were defined needed to be clearly articulated in order to meet such challenges of the study.

Significance of the Study

Learning mathematics is cumulative in nature. Once a student misses a particular math concept or is placed into a math course which is too difficult, he or she may be lost and perform worse in every course thereafter. As a result, students need to be properly placed. This study is important because it determined the mathematics placement test retake policy at BCC is not appropriate. The study also compared ramifications and consequences of altering or eliminating the retake policy. The results can be used by other 2- and 4-year colleges to study their own mathematics placement policies.

Equally important, evaluating the process of student placement into mathematics curriculum at all two-year colleges should be ongoing (American Mathematical Association of Two Year Colleges (AMATYC, 2002). No studies that examined BCC's mathematics placement test retake policies were discovered, as there has been no such study at BCC. According to AMATYC's Standards for Introductory Mathematics, "The effectiveness of any mathematics program depends on its ongoing revision and revitalization based on regular evaluations" (AMATYC, 1997). Therefore, the very fact that this study occurred helps BCC meet AMATYC's criteria.

Most importantly, this study's results can help modify the mathematics placement test taking guidelines in ways that will increase BCC's retention rate.

Organization of the Study

The study's focus was to determine whether or not students who retake the BCC mathematics placement test and place higher than their original placement do worse in

the subsequent course than those who originally placed into that particular course. The student sample was randomly drawn from the population to determine what proportion actually took advantage of the retake policy, took the subsequent course based on the retest results, and successfully passed that course. The study examined students testing into remedial mathematics from July 2003 to July 2006. Here, the relevant developmental mathematics courses at BCC are grouped in pairs of successive courses. In each group of two courses, the students taking the higher level course were broken up into two subgroups: those students who originally placed into that course and those who originally placed into the prerequisite course, retook the computerized placement test (CPT), and placed into the higher course. The first group served as the control group and the second was the experimental group. The students' final grades for both groups in the subsequent course were analyzed. Additionally, the study examined the proportion of students who performed better and the proportion of students who performed worse as a result of retaking the placement test and registering for the subsequent course. Hypothesis testing (95% confidence level) was used to determine if the placement test for each course and on the whole contributed to students' academic performance.

For the purpose of the study, success in the subsequent course was defined as earning a grade of A, B, C, credit (CR), or satisfactory (S). A grade of D, F, incomplete (I), no grade (NG), audit (X, XC), or withdraw (W) was counted as unsuccessful. These definitions were used to identify success because they are quantitative values for data analysis. However, the reader must be aware that these quantitative measures do not

completely define a successful student. Some qualitative characteristics of success include student qualities such as perseverance or study skills.

Definition of Terms and Acronyms

ACT: ACT stands for American College Testing program. The ACT is one of America's most widely accepted college entrance exams. It assesses high school students' general educational development and their ability to complete college-level work. In certain cases BCC, as well as many other institutions, use ACT scores as a placement test for college (American College Testing Program, 2007).

AMATYC: AMATYC stands for The American Mathematical Association of Two-Year Colleges, a national association devoted to providing a national forum for the improvement of mathematics instruction in the first two years of college (AMATYC, 2002).

BCC: BCC stands for Broward Community College, a public two-year community college in Broward County, Florida. BCC has four main large campuses and several satellite campuses (Broward Community College, 2006).

CPT: CPT stands for Computerized Placement Test and is the name of the computer-based placement test Broward Community College and other various colleges use when students do not have recent SAT or ACT scores. The CPT was created by Accuplacer, a division of The College Board.

FTYCMA: FTYCMA stands for Florida Two-Year College Mathematics Association, a statewide association devoted to providing a statewide forum for the improvement of mathematics instruction in the first two years of college (FTYCMA, 2007).

GPA: GPA stands for grade point average, a weighted average that indicates the student's overall performance. It may be used as a form of college placement.

PAC: PAC stands for Placement and Assessment Committee, a national standing committee within AMATYC that analyzes placement and assessment policies (AMATYC, 2006).

Placement Test: A placement test encompasses procedures developed to initially place incoming freshman into a college curriculum. Throughout this study, often the phrase placement test may be interpreted as an overall placement assessment. This process may be a combination of one or more different placement techniques including a college placement test, high school standardized achievement test scores, grade point average, recommendations, etc. (AMATYC, 2006).

SAT: SAT stands for the Scholastic Aptitude Test administered by The College Board. The SAT is one of America's most widely accepted college entrance exams, and assesses students' high school education and their ability to do college-level work (College Board, 2007).

Success: Success (or successful) regarding a student's academic standing in a particular course was defined by the researcher as receiving a grade of A, B, C, credit (CR), or satisfactory (S).

Unsuccessful: Unsuccessful (or failure) regarding a student's academic standing in a particular course was defined as receiving a grade of a D, F, incomplete (I), no grade (NG), audit (X, XC), or withdraw (W).

Report of Findings

Upon analysis of the sample proportions for each pair of courses in the study, students who were unsuccessful in their originally prescribed course, retook the placement test, and then took the next successive course as a result of a higher retest, performed significantly worse in the latter course than those who had originally placed into that particular course. Additionally, analysis of relevant proportions revealed that the proportion of students who performed academically better as a result of the retake was significantly smaller than the proportion of students who performed academically worse as a result of the retake.

Based upon the results, it is recommended that BCC's mathematics placement test retake policy be revised so that students cannot retest after initial enrollment. It is also recommended that students be allowed to take the placement test up to three times prior to enrollment with the average of these scores used for placement. These changes may help minimize the many negative impacts of the current retake policy.

A detailed explanation of the results and recommendations follow in the Research Results and Findings chapter, along with explicit rationales for these findings.

2. Literature Review

Consistent with ongoing practices, colleges and universities must assess students in various disciplines in order to properly place students into the course most appropriate for them. Many academic deans have different opinions on the way this assessment should be carried out in order to optimize student benefit. Standardized testing has been a very important part of educational systems since their inception. One important type of standardized test is the test that students take upon entering a college or university, which is generally given to properly place a student based on his or her abilities as measured by the test. Since placement testing is such an important part of the educational system, these tests need to be valid and reliable.

Topics related to placement testing vary in nature. Some topics include how placement test scores are affected by gender, age, race, religion, and creed. For example, lower income and minority groups usually score lower on placement tests. Other topics compare and contrast different student groups, such as how students with standard high school diplomas versus students with general education diplomas score on the placement tests (Hills, Hirsch, & Subhiyah, 1990). Still other studies focus on the efficiency of placement methods such as standardized assessment scores, analysis of grade point average, and the more commonly used computerized college placement tests (1990).

Mathematics Placement Testing

In particular, due to mathematics' cumulative and linear structure, it is extremely crucial to control the validity and reliability of placement assessments for mathematics courses. If a student is improperly placed in a mathematics course, it may snowball through his or her entire math and science education. On the other hand, properly placed students may have a better college experience. When these tests are valid and reliable, the scores obtained can be used to make predictions of student success, assess a student's background in a particular topic, properly place students into courses, and provide various other inputs that can help the educational decision making process.

College mathematics placement assessment has many varieties. Some of these include an internal college placement test created by the college or department, an internal college placement test created by the state or some other governing agency, an internal college placement test created by a contracted third party or company, recent ACT scores, recent SAT scores, total high school GPA, high school GPA in select math courses, recommendation of the math department or math faculty, and many more. In other instances, college math departments use home-grown tests which focus on traditional high school curriculum (Gordon, 2005). If this is the case, Gordon recommends that math departments make two versions of the test: one for the traditional high school student and one for the student coming out of a standards-based program.

In some institutions, the mathematics placement system depends on a combination of techniques. Agras, an active member of the Florida Two-Year College Mathematical Association, emphasizes that placement techniques should even include

unconventional styles such as personal interviews by the math department, take-home tests, and tests that are not multiple choice (2002). For example, Shoreline Community College offers an option for students to take a nontraditional paper-and-pencil essay type placement test which is essay and not multiple choice (Shoreline, 2006). The American Mathematical Association emphasizes that college faculty should develop policies and procedures to be used to place students (AMATYC, 2002). Emphasizing the same point, AMATYC (1997) says “Mathematics Faculty should carry the primary responsibility for program evaluation” (1997). Furthermore, AMATYC recommends that this process analyze multiple measures such as high school and college records, scores on college entrance exams, and scores on placement tests (2002).

When a particular school develops its placement system, especially for mathematics, many steps need to be taken to ensure that the test is doing its job – to determine which course an entering student should be placed into so that he or she will be successful in the sense that the course will not be too difficult or contain material that requires knowledge of mathematics that the student had not previously learned. An appropriate amount of hard work means that the course should also be challenging. All those involved in the placement and assessment process should be well versed in the program’s elements (AMATYC, 2002). More importantly, process evaluation should be ongoing (2002). Elsewhere AMATYC states that “The intent of any evaluation should be to make recommendations for improvement and updating, while retaining the effectiveness aspects of the program” (1997). Since this evaluation and analysis should

be ongoing, studies like this researcher's will help BCC and other colleges attain that AMATYC criteria.

Placement Testing Inconsistencies

Self selection is an important function of a placement test in an open admissions setting such as a community college. This means giving students who would be rejected from college admittance based on their previous placement test score a chance to find out for themselves whether they are sufficiently interested in college, and also gives such students a chance to determine if they are capable of college-level academic work (Hills et al., 1990).

Many researchers have contributed to the knowledge base that exists for placement testing. For instance, Hills, Hirsch, and Subhiyah of Florida State University define placement as "A process by which students are assigned to courses commensurate with their past achievements, or corresponding to their learning styles, in order to facilitate expeditious further learning" (1990). They further explain that one should not confuse placement testing with diagnostic testing, which is a very specific and detailed kind of testing to determine why a student has a particular learning problem. The underlying idea is that students differ in their levels of preparation, interests, adeptness to learning, organization, and so on (1990). Thus, a reliable placement test would consider all of these ideas. Ideally, students need to be placed into the learning situation which is best for them. A placement test cannot simply test for the level of successful development in previous or developmental courses. For example, an unreliable placement test to see if

a student is ready for differential calculus might be the final exam for analytic geometry, which would not measure how fast he or she learned the material but simply whether he or she learned it (1990).

Hills et al. emphasize that placement should be on the basis of achievement and leaning style (1990). They claim that the optimum learning situation for a student depends on what he has already learned. Thus, placement should be in the sense that the student has mastered all of the prerequisite learning but has not mastered anything that will be taught (1990). They equally stress that the way or style in which the student learns is a critical issue in placement; in other words, placement on the idea of learning style. For example, a student may be suffering in math not because he does not have the prior knowledge, but instead because he requires several exposures to critical skills such as communication in numbers, because many colleges only place on the basis of achievement. Hills et al. stress that in order to place students based on learning style, one must develop or find placement instruments which indicate into what style of instruction an individual should be placed (1990). These are much more challenging to create than an achievement-based placement test. In Florida, a major problem is that most two-year colleges acknowledge little or no connection between the Florida Comprehensive Assessment Test (FCAT), a recently implemented mastery test that must be passed in order to graduate from high school in Florida, which measures critical thinking skills, and the College Placement Test (CPT), which is a mathematical skills test (Agras, 2002).

Placement testing for a particular institution can be managed several ways, including by the independent institution itself or a particular campus of the institution. At

the institution, mathematics placement can be managed through a testing center or even through the mathematics department itself. On the other hand, the testing process can also be managed at the system-wide level. This may mean that the placement testing's administration and regulations are either managed by the community college system or the state itself. If institutions operated independently, a wide variety of placement procedures would be expected to result (Hills et al., 1990). One drawback of this inconsistent setup is that students who were placed in pre-college work on one campus may have placed into collegiate-level work on another. Conversely, students who were regarded as having met pre-college requirements on one campus may transfer to another campus with higher standards and be reassigned to pre-college work (1990). If the institutions had a system-wide placement testing scheme or a placement program that was part of a well-coordinated system, relatively few different placement procedures would be expected to develop, as whatever placement scheme works best would be used in all institutions. This approach would maintain the consistency needed from campus to campus (1990). All in all, Hills, Hirsch, and Subhiyah feel that placement procedures should be mandated system-wide to achieve the most benefit (1990).

There are many procedures that institutions use when placing students into college mathematics courses. Students can be placed based on grades, recommendations, standardized test scores, placement test scores, or a combination of many of these methods. A placement test is not necessarily always the usual "test." In some cases, institutions simply use recent ACT or SAT scores as a college entrance placement device. In these cases, the time at which the student tests for college placement occurs during one

instance in high school. This practice is sometimes scrutinized because these standardized tests were not developed for this purpose. Sometimes these test scores are used only if they are less than two years old (Broward Community College, 2006; Santa Fe Community College, 2006). Because the school is not actually giving a test, but instead is using recent test or exam scores, a more proper term for a college placement test might be a college placement *assessment*. In other cases, the college may use students' high school math grade point averages for placement. If this is the case, the placement occurs throughout several years of high school.

More commonly, college placement occurs at the college and is usually in the form of a placement test when the student begins college. These tests occur in several varieties as well. Some institutions' exams are pencil-and-paper while others have a computerized placement test. These computerized placement devices are generally placement tests created by independent companies such as Accuplacer and ACT Compass.

College placement at the high school level can occur in several varieties. In some instances the actual grade for the prerequisite class is observed and used for placement. Sometimes an overall GPA or a mathematics GPA may be used. Placement during high school may be appealing to all types of colleges for several reasons (Hills et al., 1990). First, waiting for placement during or before the college term adds to the confusion of the already complicated pre-semester and beginning-of-semester chaos (1990). Thus, allowing the high schools to do the testing alleviates the college of the burden. Second, it may be more cost-effective for the institution. However, placement testing in high school

may not be appealing to all colleges since a large number of students – particularly at community colleges – are distant from their high school education. Additionally, many students do not succeed in high school, but do succeed in college (Hills et al., 1990). As a result, relying on high school grades or testing would defeat the purpose of the “open-door” policy that community colleges offer. Also, satisfactory grades in high school math courses do not necessarily indicate adequate preparation for college-level courses (1990). Along the same reasoning, math courses taught at different high schools (or even in different sections at the same school) are not the same. Furthermore, the amount of time since the student’s last math course could hinder placement assessment. Another recent problem is that the college’s placement test usually does not include technology, but the student’s high school experience did (Gordon, 2005). Lastly, sometimes students do not remember all of the material that they learned in high school and their “skills have grown rusty” (2005). All in all, placement based on high school performance is controversial: Some accept this practice while others feel it can lead to inconsistencies in the placement process (2005).

On the contrary, placement testing at the beginning of college may be more beneficial for two-year colleges and competitive four-year institutions than placement at the high school. Clearly, high schools are spared this tedious task when the colleges do the work. Also, allowing the high schools to do the placement wastes resources because not all of the students who participated in the placement process may go to college (Hills et al., 1990). Most importantly, the college probably knows best how to assess the

students to place them into their particular college. The high school test would be geared for placement at any college and thus may lose integrity.

Placement based on recommendations is often used when a faculty member knows the student's academic history, performance, or aptitude. Hills et al. claim, "Recommendations are notorious for their uselessness except under special conditions" (1990). Anyone can write a recommendation letter and anyone can get a recommendation from somebody. On the other hand, placement based on recommendations may be a good tactic if the person making the placement decision has known the person making the recommendation for a long time, and thus can evaluate the recommendation's validity (1990). Additionally, if students can examine the recommendations written for them, these recommendations become useless because students can screen them before submitting them. One remedy for this is to not allow the student to see the recommendation (1990). The major problem with placement based on recommendation is that this technique can not be standardized (1990).

Placement based on test scores is generally one of the best methods since that can be used to standardize the procedure (Hills et al., 1990). Additionally, the test score is quantitative, which creates consistency and accuracy (1990). Historically, placement based on test scores has been widely used and is the most common method of placement (1990). There are many reasons for this. First, there is a strong theoretical foundation for measuring test scores and the degree of error can be estimated with precision (1990). Unlike placement based on test scores and as noted earlier, placement based on grades involves much more error since there is little consistency in grading from one teacher to

another. Therefore, the degree of error in using testing for placement is much less, and much more measurable than the degree of error in placement based on grades or recommendations (1990). Another attractive characteristic of placement based on test scores is that there is no bias or judgment involved in scoring: “A very significant feature of achievement based placement testing is that several different forms of the same test can be made to be equivalent so that there scores can be interchanged with confidence” (1990).

Some institutions use a placement test created by a third party. However, these tests cannot function well for those whose scores are not extremely high or extremely low due to the inconsistencies in the different forms of high school standardized achievement tests like the SAT and ACT (Hills et al., 1990).

Many institutions use a combination of several of these placement measures, or have a system such that a different measurement technique would be used for different circumstances (Hills et al., 1990). For instance, if the student’s SAT or ACT scores are recent (as defined by the institution’s placement center), then the college may accept these scores for placement. Otherwise, the student would need to take the college placement test (Regina Johnson, personal communication, October 17, 2005). In other cases, the institution’s placement center creates a formula to use the results of one or more of the many different placement tests (Hills et al., 1990). Each student would receive a single score consisting of a weighted average of their scores from a combination of the placement measures. At institutions using this method, a large amount of data analysis needs to be used to develop these formulas to assure they are doing the job of

placement efficiently (1990). In some cases, the institution even creates different formulas or different cutoff criteria for different genders, cultural groups, or age groups (1990).

In modern testing theory, placement based on institutional computerized placement test scores seems to be the most accepted and most reliable method, sometimes referred to as a CPT test. A CPT has several advantages. First, it may be cost-effective for the institution once the test is established. Also, computers can easily generate different test items for different students, each of which measures the same outcome. Additionally, scoring the tests and managing the scores becomes automated (Hills et al., 1990). Sometimes, the software used may also be integrated with the college registrar's computer system for efficient management and placement (1990).

However, this type of placement system does require ample computer resources. When colleges implement such a program, they need to ensure that their placement guidelines or regulations are properly placing students under given cost constraints. Implementing such a program involves decision theory (Hills et al., 1990). The institution must maximize the program's efficiency under given financial constraints, which entails using probability and statistical theory in analyzing the costs and benefits (1990). One can calculate the total expected value for the placement procedure using a decision tree, also known as a tree diagram, to weight the probabilities of each outcome. In this scheme, probabilities for outcomes for success and placement are used (1990). Then, each outcome has a cost and benefit associated with it. Using this data, one can find the overall expectation of their institution's placement strategy (1990).

Assessment Methodologies

Setting cutoff scores for a placement test or process may be challenging. Hills et al. emphasize several assessment methodologies (1990). This process may be mandated by the institution or even at the state level (1990). There must be agreement and consistency in this decision. Generally, cutoff scores and placement criteria are created in two commonly used fashions. The first method is that a student who does not achieve a particular “cutoff” score would be placed into remedial mathematics, and all students in this group would take the same preparatory mathematics. However, a more commonly used technique is when placement may be at a number of different levels: Different scores on the assessment would be used to determine into which level of mathematics the student would be placed (1990). Professionals agree that setting these cutoff scores is quite tricky and may involve a lot of analysis and research (1990). Furthermore, there is always a significant amount of error in using cutoff scores to place students (1990). This error must also be analyzed and minimized in order for the test to be valid and reliable. Finally, in order to assure these cutoff scores are properly placing students, there must be agreement on standards (1990).

Since setting cutoff scores is so challenging and has such a great impact on the placement test’s reliability, there are many methods and theories which can be characterized by their method of computing the assessment’s overall score. Then, this score is compared to the predetermined cutoff criteria.

The first technique is the judgment method, when one or more faculty member or other experts are asked to decide on minimum cutoff scores (Hills et al., 1990). The main advantage of this method is its simplicity.

Another technique is the Nedelsky method (Hills et al., 1990), named after the first person who published it. It is most appropriate when the measure used is a test with multiple choice items (1990). In this method, faculty identifies for each test item which choices the student should recognize as definitely incorrect. Then, the minimum passing level for that item is determined by calculating the chance that such a student would get the item right by randomly guessing at the other choices. Next, the overall score is simply the sum of the scores for each question (1990). The Angoff method is a variation of the Nedelsky method that can be used with any test, not just multiple choice tests (1990).

The Ebel method uses a two-dimensional grading scheme that rates each question according to relevance and difficulty (Hills et al., 1990). Each item has a weighted percentage in this two-dimensional grid. The number of correct items in each cell of the grid is then multiplied by its weight or percentage. The scores are then summed to compute an overall score (1990).

The Jaeger method was developed originally for the North Carolina Minimum Competency Test but is much more widely used today (Hills et al., 1990). This method breaks the test questions into many competency groups. Each student must pass each competency group at a certain cutoff level to master that competency. The student is placed based on which competencies were mastered (1990). The Norm-referenced

method is a variation of the Jaeger method but actually sets a cutoff score based on each competency mastered (1990).

Empirical methods seem to be the most appropriate, i.e., using empirical information on students such as scores on placement tests, grades, ratings, group memberships, etc. (Hills et al., 1990). Then all the data is gathered and entered into a mathematical formula to compute an overall score. The empirical method primarily incorporates a combination of many of the previously mentioned methods into one scheme (1990).

All of these noted methods are not conclusive. There are many other less commonly used methods such as the Decision-Theoretic method, the Aptitude-Treatment Interaction method, the Reading Power method, and many other holistic methods (Hills et al., 1990). The important thing is to assure the chosen method for placing the students based on their score and the cutoff score is well planned, well analyzed, and consistent.

Relevant Studies Conducted

Analyzing efficiency should be carried out any time one is dealing with such a critical system with so many variables. Mathematics placement at a college is one such process. Several studies have been done to analyze the effectiveness of mathematics placement systems in place at many colleges around the country, including those done by Armstrong (1994), Bashford (1998), Rodgers and Wilding (1998), Latterell and Regal (2003), and Risser and Davis (1965). These studies contributed to the current theory on placement and assessment.

Armstrong conducted such a study in 1994 at the San Diego Community College District to analyze the validity of placing students into various mathematics courses based on standardized test scores. The study analyzed the relationship between math placement test scores and student performance through correlation and regression methods, using course grades as criterion to measure performance (1994).

Armstrong claims that one of the study's challenges was to determine how to count a grade of "withdraw" (W) (1994). When examining success rates and failure rates, should a W be counted as a failing grade or should it not be counted at all? (1994). If the W was due to personal circumstances, then perhaps it should be not counted at all. On the other hand, perhaps it should be counted as a failing grade if the W was a withdraw due to poor performance. The best practice would be to get the student's mid-semester grade from the instructor prior to the withdraw in order to determine how to use the W for analysis purposes (1994). Because this is not very practical since that data is not available in many cases, Armstrong decided to exclude W grades from the analysis due to its weak relationship to the predictors. Another option would be to analyze the W grades separately (1994).

In the fall of 1994, Armstrong collected data from 2294 community college math students within the district. A grade of a C or higher counted as success, a grade lower than a C was considered failure; grades of W or I (incomplete) were excluded. These marks were obtained through the college's office of institutional research. Armstrong conducted his study in such a way that a different correlation coefficient was computed for each course that students could be placed in. When examining the findings of all of

the courses, he determined that “The test scores show acceptable criterion related validity evidence when correlated with the criterion variable of final grade in mathematics” (1994). This was confirmed through examining the correlation coefficient between student test scores and their final grade in the course that each particular student was placed into.

Bashford (1998) conducted another study in 1996 and 1997 at Miami-Dade Community College, now known as Miami Dade College. This study was unique because it measured whether there was a significant difference in the mathematics placement program from 1996 to 1997 (1998). The study came about as a result of Florida raising the placement cutoff criteria from 1996’s to new cutoff scores in 1997. Accordingly, Bashford wanted to decide if the cutoff scores for the computerized placement test were adequately placing students better or worse after the law change. Bashford obtained records from institutional research on CPT scores, initial course placements, and end course outcomes. Contrary to Armstrong’s study, only the percentages of students who passed each course were noted. There was no mathematical correlation used in this study. For the two-year period, the percentage of students from the sample who passed the CPT was compared to examine if the percentages increased or decreased. As part of the results, Bashford noted that there were a lot of other uncontrolled variables in the study. Although her study consisted of all disciplines, the mathematics placement correlations yielded interesting results. These results were classified by college preparatory mathematics or college-level mathematics. In the college prep courses, the cutoff ranges did not change from 1996 to 1997 but the overall pass rate increased. For the college-

level courses, the cutoff scores increased from one year to the next and there were modest increases in the student pass rates in those courses affected.

In another study done in 1998 by Rodgers and Wilding at University of Southern Indiana, a multi-variable formula was created for placement purposes using regression techniques and used a combination of both placement test score and high school SAT score. The study then went on to see if the formula used for placement was more or less effective than using placement scores alone (1998). A major difference in this study from Armstrong's (1994) is that Rodgers and Wilding counted W as a failing mark (recall, Armstrong excluded W grades from the study). Like Bashford (1998) in using only pass percentage rates and not correlation methods, Rodgers and Wilding's study yielded more effective placement by using the mathematical formula.

A study done at the University of Minnesota by Latterell and Regal in 2003 compared using high school ACT test scores for placement to using a placement test created by the school. Again, using only pass percentages for each cutoff group, they determined that "Using the ACT score would be about equivalent" (2003).

Although an older study, in 1965 Risser and Davis conducted a study at Pasadena City College to determine which predictor would be best for placement into a given course. The predictors included overall GPA, final grades in math courses taken, and score on an appropriate placement exam. In short, correlation was highest when using grades earned in previous math courses, and lowest when using a placement test (1965).

Retake Policies

According to the community colleges researched in preparation for this study, policies cited on their websites indicated that retake policies for college placement tests vary from school to school. Some schools may not allow retaking placement tests at all; others may allow retakes with no stipulations. Some institutions allow retakes but only so many times per set time period. Additionally, how the institution handles the grade for the overall placement based on the first score and the retake scores also differs from college to college. Some schools use the highest grade of all the student's scores, others use the lowest score. Finally, some schools use some kind of average of all placement scores received over a given time period. In some institutions the student may retake only a portion (i.e. math or verbal) of the placement test. Other institutions may charge a small fee for retakes.

Sworder (1990) conducted a study at Saddleback Community College in South Carolina examining whether or not colleges should require students to retake the mathematics portion of the placement test if students do not immediately register for the recommended course in the term following the initial placement test. The author conjectured that perhaps if students delay enrollment, their knowledge of the material may change or they may forget some of the math. Over a four semester period, Sworder observed the semester grades of several students who delayed registering for a math course after they took the mathematics placement test. He also observed the grades of several students who immediately registered and took the math course that they were placed into. Ironically, his results indicated that those students with delayed registration

in the placed course did not do any worse than those students who did not delay their registration (1990). Based on these results, Sworder found that colleges should not require students to retake the placement test if they choose to wait some time after taking the placement test and before taking the course that they placed into (1990). This does not suggest that the retake has little value, though, since others may argue that waiting some time after taking the placement test before enrolling in the prescribed course may cause students to forget the math that they actually knew while taking the placement test and contribute to students performing worse.

Another study conducted by Pearlman at Palm Beach Community College in 1977 studied the effect of retesting. In particular, Pearlman was interested in alternative methods of instruction that would improve retention, including retesting. Her results indicated that allowing students to retest improved retention rates (Pearlman, 1977).

A study conducted by Sawyer and Welch (1990) from 1983 to 1987 at American College in Iowa examined the frequency of multiple testing, the characteristics of the examinees who retest, and the effects of retesting on placement test scores. Sawyer and Welch determined that most students who did not place into college-level courses did retake the placement test on at least one occasion. Their results indicated modest increases in scores from the students' first test to the retake. There were modest decreases in placement scores in some cases, although not very often. Results indicated that only those whose initial score was close to college-level placement had a reasonable chance of placing higher on the retake (1990). This is probably because retake scores generally increased – but not substantially.

Thus, retake policies at colleges vary quite a bit. For this study, the most important characteristic of the retake policy is allowing a retake on the mathematics portion of the placement test, excluding the cases where the original test score has expired according to a predetermined rule (usually ranging from one to three years). For example, Mesa San Diego Community College allows no retakes under any circumstances (2006). Santa Fe Community College (2006) and Naugatuck Valley Community College (2006) allow no retakes on the initial placement test, although students may appeal this decision based on unusual circumstances. Shoreline Community College (2006) allows exactly one retake on the placement test. Kapi'Olani Community College (2006) allows a retake every 120 days, but a student cannot take a retake placement test while enrolled in the course. Shelton State Community College (2006) allows students to retest after 90 days but only with documentation of remediation. Northern Virginia Community College (2006a) allows a retake only one time with written permission from a division chair or academic dean, and must be at least one year from the original placement test date. Miami Dade Community College (2006) states that a student can only retake the placement test once prior to enrollment in the placed course. Palm Beach Community College (2006) allows students who originally placed into college-level mathematics to do one retake; students who placed into remedial mathematics cannot retake the placement test at all. North Seattle Community College (2006) allows students to retake the test once with no stipulations, but beginning with the second retake the student may only retest every 90 days. Students may retake the placement test exactly once every calendar year at Sinclair Community College (2006)

and Blue Mountain Community College (2006). Most relevant to this study, Broward Community College (BCC) (2006) allows students to retake the mathematics placement test every 90 days with no stipulations at all. In short, all colleges the researcher examined have a retake policy for their mathematics placement tests, but these policies vary greatly from college to college.

Summary

Placement testing's history, many different theories, and inconsistent retake policies have contributed to its reliability and evolution at institutions throughout the nation. Each institution's current policies need to be assessed and analyzed on a regular basis to insure that the placement test properly places students and adheres to an ever-changing student body. The goal of this research project was to do exactly that at BCC.

3. Research Methodology

This is a quantitative study as opposed to a qualitative study. Accordingly, this study uses statistics to compare various proportions relative to other proportions.

Research Population and Demographics

The population studied was a subset of the student body at Broward Community College (BCC). BCC's student body is multicultural, with 8,823 international students representing 152 countries (Broward Community College, 2006). Many of these freshman- and sophomore-level college students attend part-time. Finally, over half of the student body consists of nontraditional college students (i.e. not the typical 18- to 19-year-olds in their freshman year). Since the retake placement testing this study examines primarily occurs at the developmental mathematics level, the population can be defined as nontraditional students with little or no college experience.

Background of the Study

Because the college's student population changes each semester, research must constantly be done in the field of placement testing in order to keep up with these demographic changes. Such issues as an aging student body, and one which increasingly has a first language other than English, warrant such continuous research.

To determine if BCC's mathematics retake policy may be a factor in student success, this study focused on examining placement test policies with the results targeted toward helping change policy in an effort to better assist the students. As a result, the staff at the BCC testing center, the BCC Vice President of Academic Affairs, and the BCC Institutional Research staff were all approached, and BCC's mathematics testing and assessment process was explored. Based on the feedback received from these staff members, research on BCC's mathematics retake policy for the college placement test seemed to be in great demand. The staff felt that a research project may help decide if the current retake policy is or is not causing students to perform worse in their courses.

At BCC, the CPT is used for placement into remedial level mathematics courses if the student does not have SAT or ACT scores that are less than two years old (Broward Community College, 2006). If the student's SAT or ACT score is less than two years old, then the student would need at least a 440 on the math for SAT or at least a 20 on the ACT in order to place out of developmental math (Broward, 2006). If the student does not meet these criteria – which is usually the case since the community college attracts primarily developmental and returning adult students – then the student must take the Accuplacer Computerized Placement test or CPT (2006). The CPT test contains 12 questions and is adaptive, meaning successive questions are generated based on how the student answered the previous question or questions. Students can get a score on this test ranging from 0 to 120, with each question worth approximately 10 points. However, the test's adaptive properties allow the computer to generate scores that are not exactly linear

(Broward Community College, 2006). For example, one student may end with a 20 question test while another student may end with a 22 question test.

The cutoff scores are designed to place students into the mathematics course that would be best for him or her. If a student scores anywhere from 0 to 32 out of 120, he or she places into Pre-Algebra (MAT 0012). Scores from 33 to 71 lead to placement into Beginning Algebra (MAT 0024), and 72 to 82 Intermediate Algebra (MAT 1033). Students who score 83 or higher are not placed into remedial mathematics courses, but instead automatically place into College Algebra (MAC 1105). At this point, some students may feel that they should be placed into a course which is higher than College Algebra. This is very rare since most students taking the CPT do so because they have no recent SAT or ACT scores and have not been in school for a while. However, in these rare instances, students are directed to the math department to take an abridged version of the final exam for the previous course that they would like to place out of and therefore place into the following sequential course. These abridged tests are already prepared and on file in the math department. They contain 30 questions and the student must earn an 81% to be placed into the successive course.

At BCC, the CPT placement score is good for two years (Broward Community College, 2006). While this is typical for most institutions, some institutions have various other constraints for the life of a CPT score. For example, Northern Virginia Community College's ACT Compass placement test is good for only one year (2006b). Swaying the other way, Shelton State Community College in Tuscaloosa, Alabama has a computerized placement test that is good for up to three years, after which time students

must retest if they choose to register (2006). Students at BCC may currently retake the CPT every 90 days and can retake only the mathematics portion if they choose (Broward Community College, 2006).

Certain competencies are expected to be mastered in order to be placed into a particular course at BCC. One can master these competencies by either taking the prerequisite course or by demonstrating mastery on the College Placement Test. The competencies that determine the cutoff scores on the placement test are consistent with the competencies that the state and college require the students to master in order to be placed into the next successive course (Broward Community College, 2006). These particular competencies are very important to understand while discussing the analysis of the entire placement process (Appendix A).

Research Questions

The following questions were to be answered through the research:

1. How does the success rate in the subsequent course compare for students who were unsuccessful in the prescribed course based on the first placement test score, retook the college placement test, and went on to take the subsequent course, versus the success rate of those students who were originally placed into that particular subsequent course and remained in it?

The answers to the following sub-questions may help to answer the above question:

- a. How many students took the BCC College Placement Test in mathematics only once?
 - b. What was the final grade in the prescribed course for the students who took the placement test only once?
 - c. How many students retook the BCC College Placement Test in mathematics and placed higher than their original placement?
 - d. If the placement was higher and the student was unsuccessful in the prescribed course and enrolled in the recommended course, what was that course grade?
2. Are the proportions referred to in research question 1 significantly different – i.e., different enough to warrant a change to the mathematics placement testing policy?
 3. Does BCC’s retake policy for the college placement test generally contribute to students performing academically better or worse?
 4. How can BCC maximize retention as a result of better placement practices?

Data Collection

Following approval of George Mason University’s Office of Sponsored Programs and Human Subjects Review Board, BCC administration granted the researcher permission to access the related college records and endorsed that the findings can be published.

The researcher initiated a request for specific data from BCC's Decision Support Systems staff. This department has a dual role at the college as they integrate the Information Technology with the institutional research. The Decision Support Systems staff gathered the data by running search algorithms on BCC's mainframe and then gave the raw data to the researcher. Data were gathered for July 1, 2003 through July 1, 2006 for all students placing into remedial and intermediate level mathematics according to course.

For each course, the data were broken into two groups. Those who originally placed into that course and those that retook the placement test and tested into that course. For each of these two groups (for each course), the placement test score and the associated grade in that course were documented. No identifiers, names, or ID numbers were collected. There simply existed paired data (i.e. a placement score and a grade) for each of the two sub-groups for each course. The data were collected using random sampling techniques.

Data Analysis

Various populations were analyzed by using sampling techniques. The data for the samples were summarized. More importantly, the sampling distributions of the proportions were used to assess confidence levels on the true population proportions.

BCC divides mathematics developmental courses from college-level courses (Appendix B). Students who test into college-level mathematics (i.e. MAC 1105 and above) were not analyzed for two reasons. First, because the majority of students who

take the placement test place into developmental courses (i.e. MAT 0012, MAT 0024, and MAT 1033), there was not a large enough sample of those who test into college level. More importantly, those who place into college-level courses do not necessarily go on to take College Algebra. Instead, they seek departmental advisement and get placed based on a departmental exam or other factors such as high school courses taken, recent standardized test scores, or a departmental exam.

The first part of the study was to determine if students who were unsuccessful in their originally placed course, retook the placement test, and placed into the next successive course did worse in that successive course. The population proportions measured were those students who successfully completed the course that they were placed into for each group of students (i.e. the group of students who originally placed into that particular course and the group of students who retested into that particular course). Such proportions for each course were quantified. Then, for each course under study, the proportions of each of the two groups (retest versus non-retest) were compared to see if there was enough evidence (based on the sample proportions) to conclude that the true population proportion for the group of students who retested is less than that of the group of students who did not retest.

The goal of the study's second part was to determine if more students were actually being properly placed as a result of the placement test retake policy than misplaced. Furthermore, the proportion of students who actually did perform better as a result of the retake policy was quantified. Even if the number of students who perform better is less than the number of students who perform worse, it still may be only fair to

the students to maintain the policy of retakes if a significant number of people are performing better as a result of such a standard practice. In this part of the study, for each course two subgroups of students were created from those students who did retake the placement test: students who retook the placement test and did not successfully complete the course that they were placed into on the retake, and students who retook the placement test and did successfully complete the course that they placed into. Statistical techniques were used to estimate the proportions for these two groups, and then the proportions of these two populations were compared.

4. Research Results and Findings

Introduction

This study examined the placement of Broward Community College (BCC) students into beginning and intermediate math based on their math CPT scores. Only students at BCC who tested from July 1, 2003 to July 1, 2006 were included. During this timeframe, out of 32,308 students, 9,151 (28.3%) tested into MAT 0012 (Pre-Algebra), 16,249 (50.3%) tested into MAT0024 (Beginning Algebra), and 6,908 (21.4%) tested into MAT1033 (Intermediate Algebra). Furthermore, out of 14,360 students who were analyzed, 14,014 (97.6%) students took the placement test once and took the prescribed course, while 346 (2.4%) students retook the placement test and tested into and took the next subsequent course following the original prescribed course.

This study examined the final grade distribution of four groups of students based on their original placement scores:

- Group S - Students who originally tested into and took MAT 0024 (Table 1).
- Group T - Students who originally tested into MAT 0012 and were unsuccessful, yet retook the placement test, then placed into and went on to take MAT 0024 (Table 2).
- Group U - Students who originally tested into and took MAT1033 (Table 3).

- Group V - Students who originally tested into MAT0024 and were unsuccessful, yet retook the placement test, then placed into and went on to take MAT1033 (Table 4).

An important factor is that students' placement does not always lead to enrollment into the courses. Furthermore, students who did not take the recommended course by fall 2006 have not been included in this study.

Here, the samples consist of those students at BCC during the given timeframe from which the data was collected. In each case (i.e. MAT 0024 and MAT 1033), the two pairs of sample data from each course were summarized and based on the data from the two samples, and formal methods of hypothesis testing were used to draw inferences about the corresponding underlying populations of students at BCC during any period of time.

The incidence rate at which retakes occurred among the students who take the placement test was also noted. That is, of these students who actually retake, the number of students who performed better as a result of the retake and the number of students who did not perform better as a result of the retake were analyzed. The sample data given in the next section indicate that this study is clearly justified.

Analysis of Those Finishing Beginning Algebra (MAT 0024)

Table 1 shows the final grade distribution for MAT 0024 for students whose original test scores placed them in MAT 0024. Of the 10,481 students who completed the course, 57.3% ($n = 6,006$) did so with a passing grade of A, B, C, CR, or S.

Table 1.		
Final Grade Distribution for Students Who Tested Into and Took MAT 0024 (Group S)		
Grade	N	%
A	1,795	17.1%
B	2,224	21.2%
C	1,944	18.5%
CR	42	0.4%
S	1	0.0%
Total Successful	6006	57.3%
D	447	4.3%
F	2,885	27.5%
I	1	0.0%
NG	12	0.1%
W	1,130	10.8%
Total Unsuccessful	4475	42.7%
Total	10,481	100.0%

Note. CR = credit, S = satisfactory, I = incomplete, NG = no grade, W = withdraw. $N = 10,481$.

Table 2 shows the grade distribution for students who placed into MAT 0012, were unsuccessful, and then went on to take MAT 0024 as a result of a retest. Only 17.6% ($n = 18$) completed the course with a passing grade of A, B, or C.

Table 2.		
Final Grade Distribution for MAT 0024 Students Who Tested Into and Were Unsuccessful In MAT 0012 (Group T)		
Grade	N	%
A	2	2.0%
B	7	6.9%
C	9	8.8%
Total Successful	18	17.6%
D	9	8.8%
F	50	49.0%
W	25	24.5%
Total Unsuccessful	84	82.4%
Total	102	100.0%

Note. CR = credit, S = satisfactory, I = incomplete, NG = no grade, W = withdraw. $N = 102$.

As illustrated in Table 1, group S contains a sample of size 10,481. One can see the frequency distribution for each individual grade given, and more importantly, that 57.3% of the students were successful. Comparatively, in Table 2, group T has a grade frequency distribution that illustrates a sample size of 102 and only 17.6 % of the students were successful.

Based on the sample data in the frequency distribution, a histogram for the final grades of those students in groups S and T helps visualize the grade distribution in the two samples (Appendix C, Figure 1). More importantly, one can see that the sample proportion of those who were successful from group S is significantly greater than that of those who were successful from group T (Appendix C Figure 3).

Next it was determined whether or not the difference in these sample proportions warrants the same inference for the underlying populations. Was this difference in the

sample proportions significant enough to rule out sampling error and to make generalizations to an underlying population?

Here, inferences were drawn about the population of students' success rate in MAT 0024 by analyzing the two samples of students who enrolled and completed MAT 0024.

The claim for the formal hypotheses test in this case is that the population proportion p_1 for group S is greater than the population proportion p_2 for group T. The notation, sample values, hypotheses, and computations for the formal hypotheses test can be found in Appendix D. Here, a p -value of .0001 is obtained (Appendix D). Thus, the claim is supported and one can conclude that there is evidence to suggest with 95% confidence that the population proportion for group S is greater than the population proportion for group T.

Analysis of Those Finishing Intermediate Algebra (MAT 1033)

Table 3 shows the final grade distribution for those students who tested into MAT 1033 and took that recommended course. Group U has experienced the greatest success with 71.6% ($n = 2,531$) of the group receiving a passing grade of A, B, or C.

Table 3.		
Final Grade Distribution for Students Who Tested Into and Took MAT 1033 (Group U)		
Grade	N	%
A	871	24.7%
B	860	24.3%
C	800	22.6%
Total Successful	2531	71.6%
D	186	5.3%
F	491	13.9%
NG	1	0.0%
W	305	8.6%
X	1	0.0%
XC	18	0.5%
Total Unsuccessful	1002	28.4%
Total	3,533	100.0%

Note. CR = credit, S = satisfactory, I = incomplete, NG = no grade, W = withdraw. $N = 3,533$.

Table 4 shows the final grade distribution for the students who were originally placed in MAT 0024, were unsuccessful, and then went on to take MAT 1033 as a result of a retest. 40.6% ($n = 99$) of these students received a passing grade of A, B, or C.

Table 4.		
Final Grade Distribution for MAT 1033 Students Who Tested Into and Were Unsuccessful in MAT 0024 (Group V)		
Grade	N	%
A	11	4.5%
B	23	9.4%
C	65	26.6%
Total Successful	99	40.6%
D	21	8.6%
F	64	26.2%
NG	1	0.4%
W	55	22.5%
X	1	0.4%
XC	3	1.2%
Total Unsuccessful	145	59.4%
Total	244	100.0%

Note. CR = credit, S = satisfactory, I = incomplete, NG = no grade, W = withdraw. $N = 244$.

As illustrated in Table 3, group U contains a sample of size 3,533, and the frequency distribution for each individual grade assigned is presented. Most importantly, 71.6% of the students were successful. Comparatively, in group V (Table 4), the grade frequency distribution illustrates a sample of size 244 with only 40.6% of the students successful.

From the sample data in the frequency distribution, a histogram for the final grades of those students in groups U and V assists in understanding the grade distribution in the two samples (Appendix C, Figure 2). More importantly, one can see that the sample proportion of those who were successful from group U is again significantly greater than that of those who were successful from group V (Appendix C, Figure 4).

Next, it was determined whether or not the difference in these sample proportions warrants the same inference for the underlying populations. How significant was this difference?

Here, an effort was made to draw inferences about the population of students' success rate in MAT 1033 by analyzing the two samples of students who enrolled and completed MAT 1033.

The claim for our formal hypotheses test in this case is that the population proportion p_1 for group U is greater than the population proportion p_2 for group V. The notation, sample values, hypotheses, and computations for the formal hypotheses test can be found in Appendix E. Again, a p -value of .0001 is obtained (Appendix E). Thus, the claim is supported and one can conclude that there is evidence to suggest with 95% confidence that the population proportion for group U is greater than the population proportion for group V.

Analysis of Those Retaking the Placement Test

From the sample data illustrated in Tables 1, 2, 3, and 4 within the previous analyses, a total of $10,481 + 102 + 3,533 + 244 = 14,360$ students took the placement test and went on to take one of the courses of interest during the study's timeframe. However, it can be seen in Tables 2 and 4 that only $102 + 244 = 346$ students retook the placement test. So, approximately $\frac{346}{14360} = .024$, or 2.4% of the students who took the placement test then retook it. So, the retake policy does not affect the majority of students. However,

an attempt must be made to assure that the college testing policy does not help these 2.4% of the students to perform academically worse as a result of the retake.

The next thing focused on was how many in that 2.4 % actually performed better versus worse as a result of the retake. As illustrated in Tables 2 and 4, the sample exhibits a total of 346 students who retook the placement test and enrolled in the courses under study. Of these 346 students, only 117 were successful in the latter course and 229 were unsuccessful (Table 2, Table 4). So, $\frac{117}{346} \approx .338$ or 33.8% of the students retesting actually performed better as a result of the retake with successive replacement. Thus, approximately 66.2% of the students who retook the test actually performed worse as a result of the retest since they placed into a more difficult course for which they did not seem to have the skills. So, out of all the students who took the placement test and enrolled during the study's timeframe, only 33.8% of 2.4% – or approximately 0.8% (i.e. less than 1%) – of the students who took the placement test and enrolled did better as a result of the retake. Perhaps these students would perform equally well if they were allowed to retake the test multiple times *before* initial enrollment.

Since these numbers are based on sample data, a formal hypothesis test was needed to see if most students (i.e. more than half) in the population that retested performed worse as a result of the retest. The claim for this formal hypotheses test is that most students who retake the placement test do not perform better as a result of the retake. The notation, sample values, hypotheses, and computations for the formal hypotheses test can be found in Appendix F. Again, a p -value of .0001 was obtained

(Appendix F). Therefore, there is very strong evidence to suggest with 95% confidence that most students who retested actually performed academically worse after the retest.

5. Conclusions, Recommendations, and Implications

Conclusions

From an administrative perspective, the study suggests that in multiple sections of developmental mathematics courses at Broward Community College (BCC), students are being taught only to fail, and then they have to go back and start the cycle again by retaking the CPT. Thus, a better mathematics placement testing/retesting system would help lessen this waste of resources for BCC and our students. For both Beginning Algebra and Intermediate Algebra, the differences in the corresponding sample proportions in each pair of groups for each course under study are very great. As a matter of fact, since the p -value in both cases was insignificant ($p = .0001$), it can be further suggested with 99.99% confidence that BCC students who retested did academically worse than those who did not retest for both Beginning Algebra and Intermediate Algebra.

Furthermore, the proportion of students who performed academically better as a result of the retake was very insignificant; perhaps those students would still perform better if they took the retake *before* initial enrollment. Although the total number of students who retested was relatively small, students should not be encouraged to do something that generally has a negative impact on their academic success.

Finally, the samples' random nature and the method of data collection minimize the affect of other variables on the study. The incidence of other variables such as illness or family problems should occur at the same rate in both samples for each pair of samples studied. Collecting the two samples in each pair was done in such a way that the only observed difference between the two samples was whether the students retook the placement test or not. As a result, the study suggests that retaking the placement test was the variable that caused such drastic differences in the proportions.

Recommendations

Since the evidence suggests that students who retest perform significantly worse in the latter placed course than those who do not retest, and most students who do retest do not perform better as a result of the retest, the following recommendations are offered.

Recommendation 1

A new mathematics placement test policy should be written that permits students to retest every 30 days (up to three times) prior to starting their mathematics coursework at BCC. Placement will be based on the average of these scores.

Rationale for Recommendation 1. Permitting students to retest before enrolling in coursework gives students the benefit of retesting in the event that for whatever reason they had a poor experience during their initial test(s). Existing research and literature indicates that many factors influence a student's placement score (Hills et al., 1990).

Also, students who choose to self-remediate before enrollment can also retest before they enroll.

Retesting before enrollment may still help the extremely small group of students (less than 1%) who actually performed better as a result of retesting after enrollment in their first course.

The literature also indicates that using the average of the placement test and retest scores is fairly common (Hills et al., 1990). This method will not only discourage retests (since retesting and averaging the scores will not bring the score up as much as if only the highest score were used), but will also better place students in a course where they will be academically sound. This, in turn, should increase retention because students who get placed lower (rather than higher) will get more remediation and have a more sound academic foundation.

Recommendation 2

The second change to the mathematics placement test policy would mandate that after a student enrolls in his or her first mathematics course at BCC, he or she can not retest. For this particular policy, students who have not taken any math courses at BCC within the last 12 months will be considered as if they are taking their first course at BCC.

Rationale for Recommendation 2. This research suggests that allowing retakes is actually causing most students who retake the placement test after enrolling, by implication do not complete the first course, and then enroll in the latter course to do

significantly worse than those who never retook the test. This research also suggests that of those students who do retake the placement test and enroll, most do not perform better – and only very few of them benefit. So, allowing retakes after enrolling in a first course would not be beneficial to the students.

Additionally, allowing retakes after initial enrollment would be contradictory to having prerequisite requirements. Particularly in a discipline such as mathematics, students should progress based on course performance and prerequisite completion, not placement test scores.

Recommendation 3

The mathematics placement test policy should be revised so that any student who has not taken a placement test or enrolled in a math course for at least 12 months will be permitted to retest every 30 days (up to three times) prior to taking another mathematics course at BCC. Placement will be based on the average of these scores.

Rationale for Recommendation 3. This recommendation addresses those students who take one or more math courses, take some time off from school, and choose to reenroll at some later time. Contrary to Sworder's (1990) study, for mathematics placement purposes these students would be classified as students who never enrolled. This procedure should encourage some students to study, e.g., to find tutoring or some other method, to develop the necessary prerequisite knowledge before taking the retest.

Using a one-year time limit may allow students who remediate through other means (i.e. courses at other institutions, private tutors, etc.) to retest sooner rather than later. The college should be considerate of students who choose this option.

Lastly, this recommendation permits placement scores to be valid for 12 months. As seen in the literature review, many similar institutions, such as Northern Virginia Community College (2006b), adhere to this standard. This time constraint seems more appropriate for BCC because it will enable students to be more properly placed than if their scores were older.

Implications

The inferences made in this research project are based on sample data and would apply to a population with similar attributes. Since the sample was chosen from students at BCC, implications from this research can be strictly applied to the underlying population of all BCC students during any significant timeframe. Based on the statistical theory, generalizations from the sample to the population would also take into consideration sampling errors and fluctuations in any given random sample.

Other institutions who have similar academic dilemmas based on retesting may want to consider some of this study's conclusions and recommendations. The suggestions may be considered for use, but the reader must be certain that his or her institutional hypotheses are very similar to those that were occurring at BCC, as suggested from the sample data.

Although the population in this study consists of enrolled students at BCC, under certain assumptions when the demographics (i.e. age, race, ethnicity, etc.) and testing practices are similar to BCC's, the population may be considered to be all students enrolling in similar courses at various comparable institutions over any significant duration. Thus, many institutions may consider such suggestions for tweaking their placement processes in order to increase retention.

BCC may want to experiment with some other modifications that may help the placement process. These modifications can be explored on an experimental basis while additional studies are conducted using the new ideas.

One experiment may be to modify the placement test cutoff scores. In the literature, Hills et al. (1990) emphasize that this process may be quite challenging, involves much analysis, uses several methodologies, and greatly impacts the placement test's overall reliability. The literature review illustrates one such study conducted by Bashford (1998).

Another experiment may be to offer remedial seminars or workshops to help students prepare for a retake, then base retake policies on matriculation in such seminars or workshops. The outcome of Sworder's (1990) study in the literature review that claimed that scores being valid for a long time do not cause students to forget the material was based on the premise that allowing scores to be valid for a longer period of time would accommodate those students who wish to self-remediate (Sworder, 1990).

This study examines just a few of the many unanswered questions among placement testing policies at colleges and universities. Many other studies can be done to

help better place students and increase retention, such as including other variables that may affect placement test scores that were not examined in this study: age, gender, race, ethnicity, socioeconomic status, military status, incidence of family problems, or any other related variable. Thus, much further research needs to be done in order to better understand the placement process and create more effective placement strategies – with the ultimate goal of helping our students achieve the academic success that brings them to us in the first place.

Appendix A
Placement Test Competencies for the Courses Under Study

0012 – Pre-Algebra

1. Whole Numbers: Operations and Applications
2. Integers: Operations and Applications
3. Fractions and Mixed Numbers: Operations and Applications
4. Decimal Numbers: Operations and Applications
5. Linear Equations in One Variable
6. Ratios, Rates, and Proportions
7. Percents
8. Geometric Calculations
9. Measurements and Unit Analysis
10. Square Roots (OPTIONAL)
11. Charts and Graphs

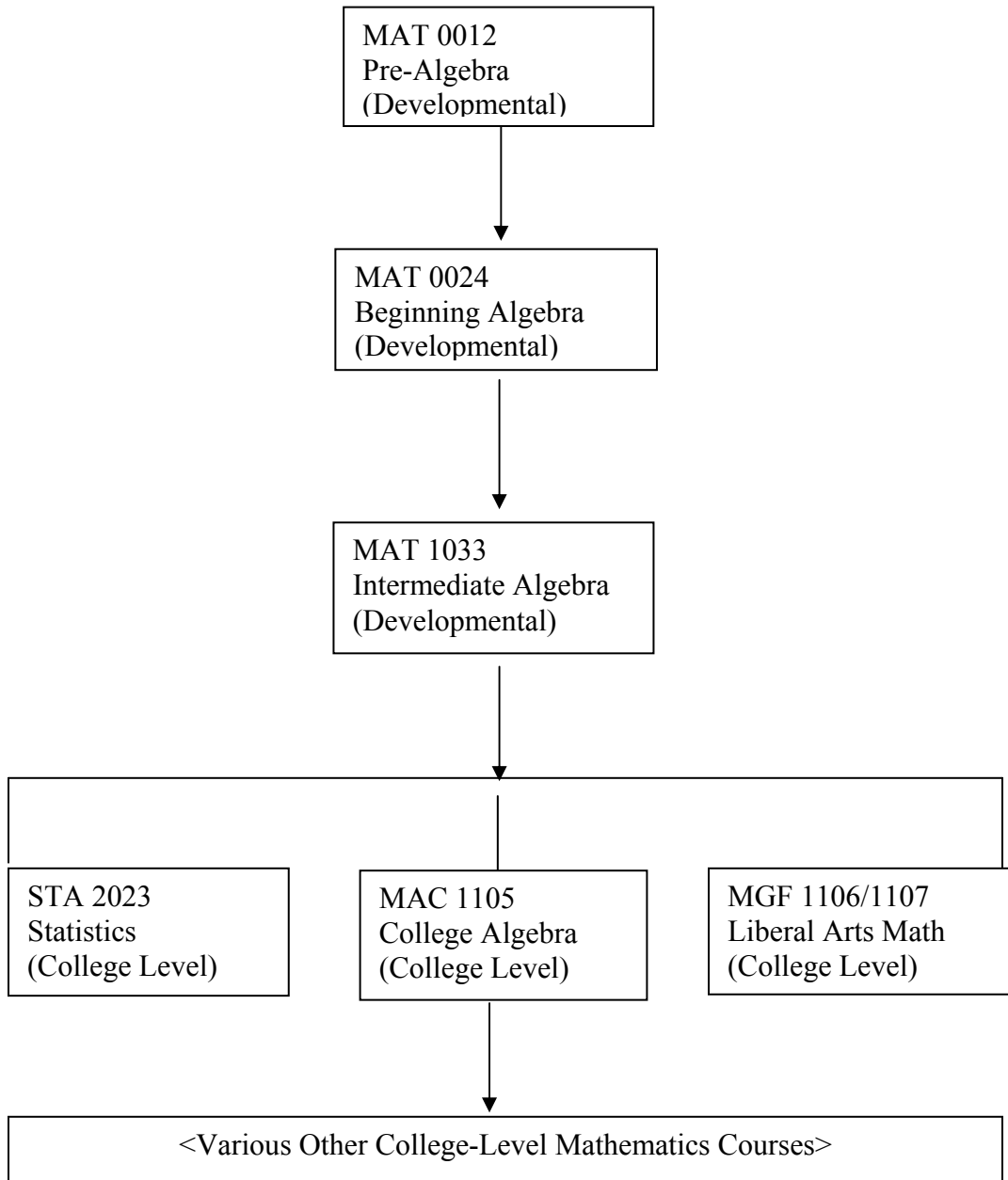
0024- Beginning Algebra

1. Optional Review of Selected Topics in Pre-Algebra
2. Sets and Linear Equations/Inequalities in One Variable
3. Polynomials
4. Factoring Polynomials and Solving Quadratic Equations
5. Integer Exponents
6. Rational Expressions and Equations
7. Radical Expressions
8. Introduction to Graphing

1033 – Intermediate Algebra

1. Factoring Polynomials
2. Algebraic Fractions and Equations
3. Selected Linear Equations and Inequalities
4. Rational Exponents, Radicals, and Complex Numbers
5. Quadratic Equations in One Variable
6. Linear Equations and Inequalities in Two Variables
7. Introduction to Functions

Appendix B
Sequence of Courses at Broward Community College



Appendix C
Grade Dispersions and Success Rates

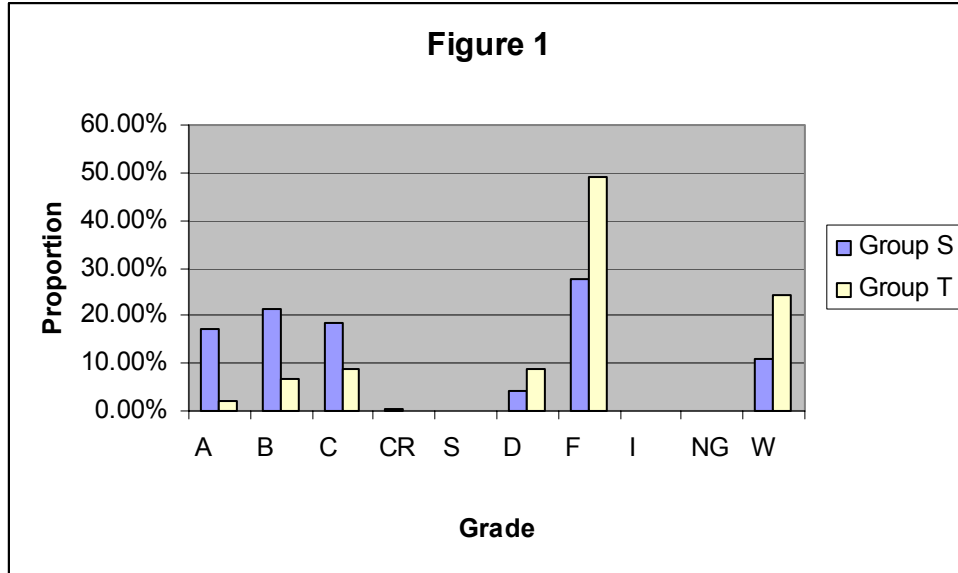


Figure 1. Grade dispersions for groups S and T.

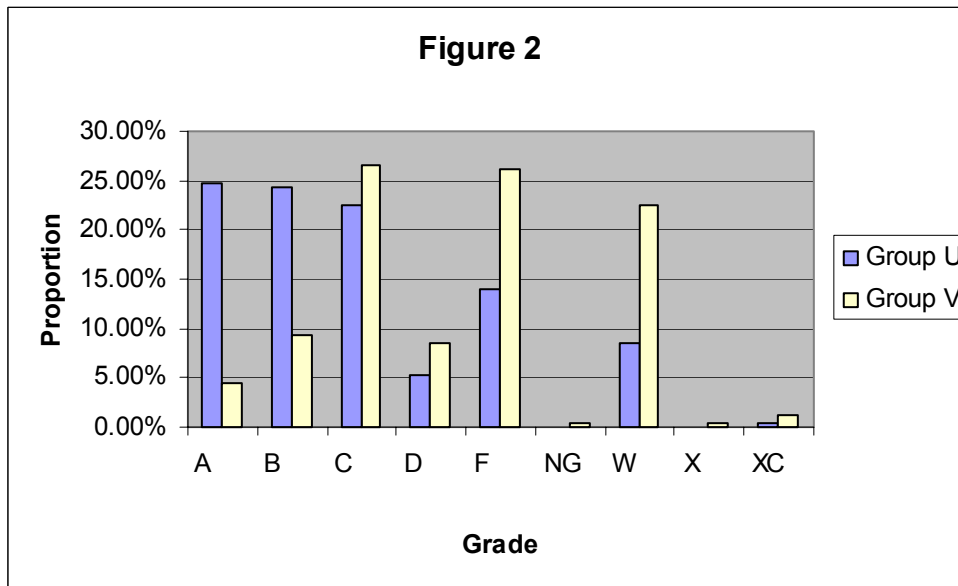


Figure 2. Grade dispersions for groups U and V.

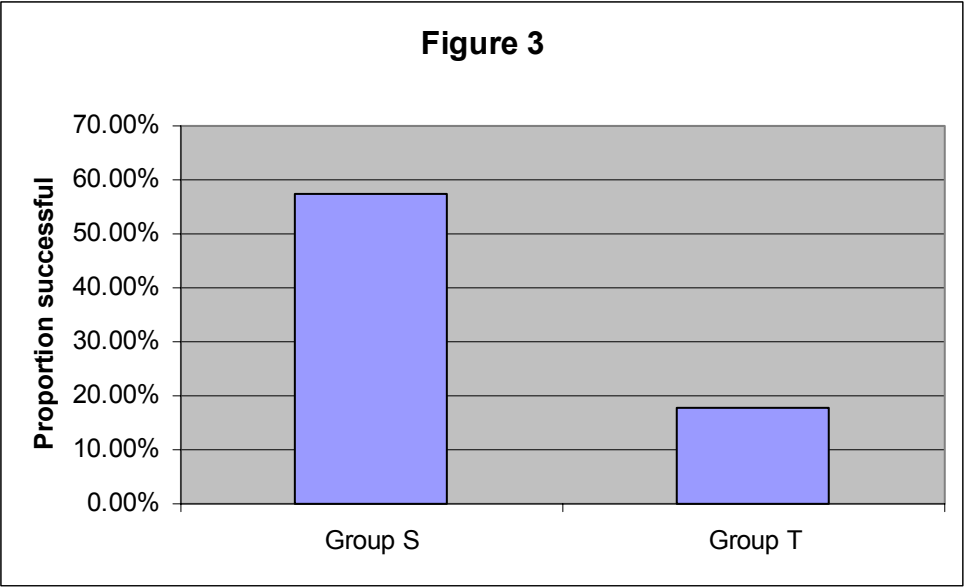


Figure 3. Overall success rates for groups S and T.

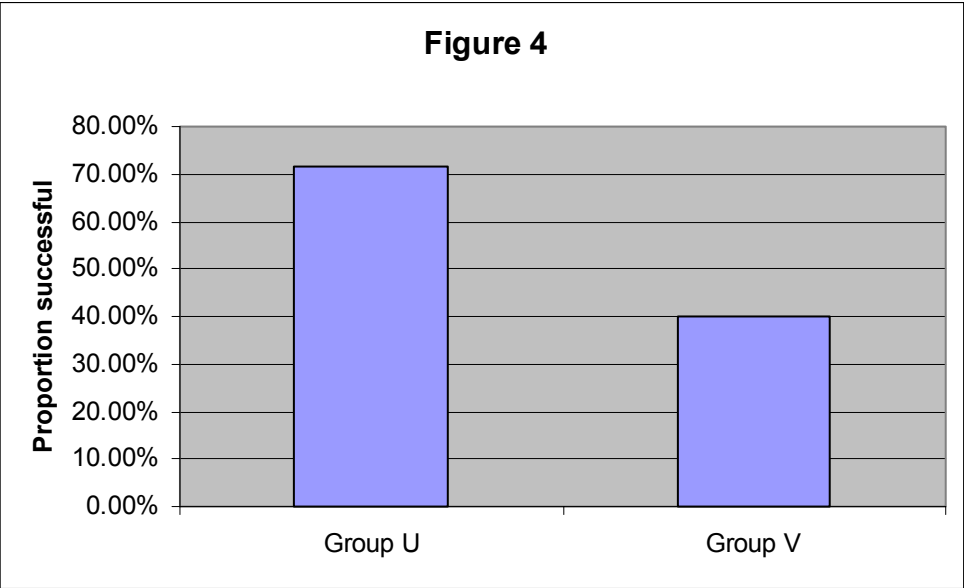


Figure 4. Overall success rates for groups U and V.

Appendix D
Notation and Analysis for Hypothesis Test of the Proportion for Those Finishing
Beginning Algebra (MAT 0024)

Notation

p_1 = Population proportion of those who succeeded in group S

p_2 = Population proportion of those who succeeded in group T

n_1 = Sample size for group S

n_2 = Sample size for group T

x_1 = Number of successes in group S

x_2 = Number of successes in group T

$\hat{p}_1 = \frac{x_1}{n_1}$ (The sample proportion of successes in group S)

$\hat{p}_2 = \frac{x_2}{n_2}$ (The sample proportion of successes in group T)

$\hat{q}_1 = 1 - \hat{p}_1$ (The sample proportion of failures in group S)

$\hat{q}_2 = 1 - \hat{p}_2$ (The sample proportion of failures in group T)

$\bar{p} = \frac{x_1 + x_2}{n_1 + n_2}$ (The pooled sample proportion of successes for both groups S and T)

$\bar{q} = 1 - \bar{p}$ (The pooled sample proportion of failures for both groups S and T)

Sample Values

$n_1 = 10,481$

$n_2 = 102$

$$x_1 = 6006$$

$$x_2 = 18$$

$$\hat{p}_1 = .573$$

$$\hat{p}_2 = .176$$

$$\bar{p} = \frac{6006+18}{10481+102} \approx .57$$

$$\bar{q} = 1 - \bar{p} = .43$$

Claim and Hypotheses

Claim

The population proportion p_1 for group S is greater than the population proportion p_2 for group T.

Hypotheses

$H_0: p_1 = p_2$, or equivalently $p_1 - p_2 = 0$ (Null Hypothesis)

$H_1: p_1 > p_2$ (Alternative Hypothesis)

Note: This is a one-tailed (i.e. right tailed) hypothesis test for the proportion and a 95% confidence level (i.e. $\alpha = .05$) was used.

Hypothesis Test and p-Value

Next, the value of the test statistic will be found:

$$z = \frac{(\hat{p}_1 - \hat{p}_2) - (p_1 - p_2)}{\sqrt{\frac{\bar{p}\bar{q}}{n_1} + \frac{\bar{p}\bar{q}}{n_2}}} = \frac{(.573 - .176) - 0}{\sqrt{\frac{.25}{10481} + \frac{.25}{102}}} \approx \frac{.397}{.050} \approx 7.94 \quad (\text{Test Statistic})$$

Thus, a p -value of .0001 was obtained. Since $.0001 < \alpha = .05$, the null hypothesis will be rejected. Therefore there is very strong evidence to suggest with 95% confidence that the population proportion for group S is greater than the population proportion for group T.

Appendix E
Notation and Analysis for Hypothesis Test of the Proportion for Those Finishing
Intermediate Algebra (MAT 1033)

Notation

p_1 = Population proportion of those who succeeded in group U

p_2 = Population proportion of those who succeeded in group V

n_1 = Sample size for group U

n_2 = Sample size for group V

x_1 = Number of successes in group U

x_2 = Number of successes in group V

$\hat{p}_1 = \frac{x_1}{n_1}$ (The sample proportion of successes in group U)

$\hat{p}_2 = \frac{x_2}{n_2}$ (The sample proportion of successes in group V)

$\hat{q}_1 = 1 - \hat{p}_1$ (The sample proportion of failures in group U)

$\hat{q}_2 = 1 - \hat{p}_2$ (The sample proportion of failures in group V)

$\bar{p} = \frac{x_1 + x_2}{n_1 + n_2}$ (The pooled sample proportion of successes for both groups U and V)

$\bar{q} = 1 - \bar{p}$ (The pooled sample proportion of failures for both groups U and V)

Sample Values

$n_1 = 3,533$

$n_2 = 244$

$$x_1 = 2531$$

$$x_2 = 99$$

$$\hat{p}_1 = .716$$

$$\hat{p}_2 = .406$$

$$\bar{p} = \frac{2531 + 99}{3533 + 244} \approx .70$$

$$\bar{q} = 1 - \bar{p} = .30$$

Claim and Hypotheses

Claim

The population proportion p_1 for group U is greater than the population proportion p_2 for group V.

Hypotheses

$H_0: p_1 = p_2$, or equivalently $p_1 - p_2 = 0$ (Null Hypothesis)

$H_1: p_1 > p_2$ (Alternative Hypothesis)

Note: This is a one-tailed (i.e. right tailed) hypothesis test for the proportion and a 95% confidence level was used (i.e. $\alpha = .05$).

Hypothesis Test and p-Value

Next, the value of the test statistic will be found:

$$z = \frac{(\hat{p}_1 - \hat{p}_2) - (p_1 - p_2)}{\sqrt{\frac{\bar{p}\bar{q}}{n_1} + \frac{\bar{p}\bar{q}}{n_2}}} = \frac{(.716 - .406) - 0}{\sqrt{\frac{.21}{3533} + \frac{.21}{244}}} \approx \frac{.310}{.030} \approx 10.33 \quad (\text{Test Statistic})$$

Thus, a p -value of .0001 is obtained. Since $.0001 < \alpha = .05$, the null hypothesis is rejected. Therefore there is very strong evidence to suggest with 95% confidence that the population proportion for group U is greater than the population proportion for group V.

Appendix F
Notation and Analysis for Hypothesis Test of the Proportion for All Those
Retaking the Placement Test

Notation

p = Population proportion of those who did perform better as a result of the retake

n = Sample size

x = Number of people in the sample who benefited from the retake

$\hat{p} = \frac{x}{n}$ (The sample proportion of those who did benefit from the retake)

$\hat{q} = 1 - \hat{p}$ (The sample proportion of those who did not perform better as a result of the retake)

Sample Values

$n = 346$

$x = 117$

$\hat{p} = .338$

$\hat{q} = .662$

Claim and Hypotheses

Claim

Most students who retake the placement test do not perform better as a result of the retake
(i.e. $p < .5$).

Hypotheses

$H_0: p = .5$ (Null Hypothesis)

$H_1: p < .5$ (Alternative Hypothesis)

Note: This is a one-tailed (i.e. left tailed) hypothesis test for the proportion and a 95% confidence level was used (i.e. $\alpha = .05$).

Hypothesis Test and p-Value

Now, the value of the test statistic will be found:

$$z = \frac{\hat{p} - p}{\sqrt{\frac{pq}{n}}} = \frac{(.338 - .5)}{\sqrt{\frac{(.5)(.5)}{346}}} \approx \frac{-.162}{.027} \approx -6 \quad (\text{Test Statistic})$$

Thus, a p-value of .0001 is obtained. Since $.0001 < \alpha = .05$, the null hypothesis will be rejected. Therefore there is very strong evidence to suggest with 95% confidence that most students who retest actually are performing worse after the retest.

REFERENCES

REFERENCES

- Agras, N. M. (2002). Florida Two-Year College Mathematical Association (FTYCMA). *Developmental mathematics: A plan for florida's community colleges*. Retrieved from <http://www.ftycma.org/html/DM1104.pdf>
- American College Testing Program. (2007). The ACT Test. Retrieved July 25, 2007, from www.act.org
- American Mathematical Association of Two Year Colleges (AMATYC). (2002, November). *Initial placement of two-year college students into the mathematics curriculum*. Retrieved July 19, 2006 from <http://www.amatyc.org/documents/Guidelines-Position/Placement.htm>
- American Mathematical Association of Two Year Colleges. (1997, Sept.). Placement/Assessment Committee to make presentations. *AMATYC Placement and Assessment Committee (PAC) Newsletter*, 3(1). Retrieved from <http://placement.amatyc.org/pacnews0997.pdf>
- Amrstrong, W. B. (1994). *Math placement validation study: A summary of the criterion-related validity evidence and multiple measures data for the Dan Diego Community College District*. San Diego: San Diego Community College office of Research and Planning.
- Bashford, J. (1998). *Placement decisions for first-time-in-college students using the computerized placement test* (Report No. IC-NO-98-12C). Miami: Miami-Dade Community College Office of Institutional Research.
- Blue Mountain Community College. Retrieved July 25, 2006, from http://www.bmcc.cc.or.us/admissions.admissions.admissions_adv_test.html
- Broward Community College. Retrieved July 25, 2006, from <http://www.broward.edu>
- College Board. Retrieved July 25, 2006, from <http://www.collegeboard.com>
- Florida Two-Year College Mathematics Association (FTYCMA). (2007). Retrieved July 25, 2007, from <http://www.ftcma.org>

- Gordon, S. P. (2005). The need to rethink placement in mathematics. *AMATYC Placement and Assessment Committee (PAC) Newsletter*. Retrieved from <http://placement.amatyc.org/keynote2005.html>
- Hills, J. R., Hirsch, T. M., & Subhiyah, R. G. (1990). *Issues in college placement*. Washington DC: Eric Clearinghouse on Tests, Measurement, and Evaluation.
- Kapi'Olani Community College. Retrieved July 25, 2006, from <http://kapiolani.hawaii.edu/object/placementtesting.html>
- Latterell, C. M., & Regal, R. R. (2003). Are placement tests for incoming undergraduate mathematics students worth the expense of administration? *Primus*, 13, 152-163.
- Mesa San Diego Community College. Retrieved July 25, 2006, from <http://www.sdmesa.sdccd.cc.ca.us/testing-center>
- Miami Dade Community College. Retrieved July 25, 2006, from http://www.mdc.edu/testing_information/cpt_clast/01-936.pdf
- Naugatuck Valley Community College. Retrieved July 25, 2006, from <http://www.nvctc.comment.edu/admissions/placement.shtml>
- North Seattle Community College. Retrieved July 25, 2006, from <http://www.northseattle.edu/enroll/testing/place.htm>
- Northern Virginia Community College. Retrieved July 25, 2006(a), from <http://www.nvcc.edu/annandale/lrc/testing/mathplacment.pdf>
- Northern Virginia Community College. Retrieved July 26, 2006(b), from <http://www.nvcc.edu/assessment/doc/rp/bsamannual20012002.rtf>
- Palm Beach Community College. Retrieved July 25, 2006, from <http://www.pbcc.edu>
- Pearlman, D. J. (1977). *Alternative programs in mathematics in the community college*. Tucson, AZ: University of Arizona Graduate Seminar Papers. (Eric Document Reproduction Service No. ED142253)
- Risser, J., & Davis, E. (1965). *Study of variables associated with final grades in mathematics courses* (Report No. PSTR-6). Pasadena, CA: Pasadena City College. (Eric Document Reproduction Service No. ED011760)

- Rodgers, K. V., & Wilding, W. G. (1998). Studying the placement of students in the entry-level college mathematics courses. *Primus*, 8, 203-207.
- Santa Fe Community College. *The Assessment Center: CPT – Computerized Placement Test*. Retrieved July 25, 2006, from <http://admin.sfcc.edu/~acres/assess/cpt.htm>
- Sawyer, R., & Welch, C. (1990). *Changes in PEP test scores for students who have tested more than once* (Report No. ACT-RR-90-1). Iowa City, IA: American College Testing Program Research Series. (Eric Document Reproduction Service No. ED336426)
- Shelton State Community College. Retrieved July 25, 2006, from <http://www.sheltonstate.edu/content.aspx?pageid=352>
- Shoreline Community College. *Testing QA: Assessment*. Retrieved July 25, 2006, from <http://www.shorline.edu/testingcenterpage10.htm>
- Sinclair Community College. *Student Services: Accuplacer FAQs*. Retrieved July 25, 2006, from <http://www.sinclair.edu/stservices/enrl/testing/accfaq/index.cfm?#11>
- Sworder, S. (1990). *An analysis of the relationship between student success and delayed entry into the mathematics curriculum following completion of the matriculation process at Saddleback College* (Report No. 143). Mission Viejo, CA: Saddleback Community College office of Strategic Planning. (Eric Document Reproduction Service No. ED318514)

CURRICULUM VITAE

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