ARE DEVELOPMENTAL MATH COURSES BEING OFFERED AT THE APPROPRIATE TIME OF DAY TO OPTIMIZE STUDENT SUCCESS?

by

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ARE PRE-REQUISITE DEVELOPMENTAL MATH COURSES BEING OFFERED AT THE APPROPRIATE TIME OF DAY TO OPTIMIZE STUDENT SUCCESS?

Ralph John Cox

This research paper will identify if a relationship exists between success in pre-requisite developmental math courses and the time of day that the course is offered for students enrolled at a rural community and technical college in northwestern Minnesota. The ACCUPLACER Arithmetic test was administered originally during new student orientation and then, again, at the completion of pre-requisite developmental Math Foundations courses. Paired Pre- and Post-Test data was gathered over seven years, from 2002 to 2009, for a total of 268 students (n=268). The data was then evaluated using one-tail two-sample T-tests assuming unequal variances to determine if a significant performance difference existed among those students enrolled in morning Math Foundations courses versus those enrolled in afternoon Math Foundations courses. The results of the research strongly suggest that students who enroll in afternoon Math Foundations courses significantly outperform their counterparts in the morning courses.

Approved by

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Chapter 1: Introduction

This research paper will begin by briefly reviewing some of the issues currently debated regarding college developmental mathematics courses, sometimes also referred to as remedial mathematics courses. Throughout this discussion, I will not try to identify the root causes of college mathematics under-preparedness, nor will I seek to cast blame on any legislative action, funding policies, or mathematics curriculums. Rather, this study will identify if a relationship exists between success in pre-requisite developmental math courses and the time of day that a course is offered for students enrolled at a rural community and technical college in Minnesota. In short, do students who take a mathematics class in the morning demonstrate a propensity for a greater level of improvement than students who take the same class in the afternoon?

Statement of the Problem

Each year, 50 percent to 60 percent of all incoming students at Northland Community and Technical College (NCTC) are assessed and placed into MATH 0080, Math Foundations, the lowest level developmental math course offered at the college. Math Foundations is a three-credit course designed specifically to teach, or re-teach, basic arithmetic content and skills that are pre-requisites for success not only in future math courses, but also in future program or degree specific courses that require a certain level of math skill proficiency.

NCTC is required to follow the open enrollment policy, including the assessment, and placement guidelines, set forth by the Chancellor's office of the Minnesota State College and University System (MnSCU). As such, NCTC has developed a series of developmental mathematics courses to assist those incoming students who are under-prepared in mathematics for success in college-level courses. Yet, as public and private educational funding sources have been squeezed, educational institutions have been forced to make difficult decisions regarding increases in tuition and cuts to curriculum and student support services. In such times, the call for greater efficiency and accountability in the classroom is increases and the policies governing developmental education are often called into question. Are these developmental courses really necessary? And, if so, are they actually as effective and efficient as they should and could be?

This paper reviews the current offering of developmental mathematics courses at NCTC and their effectiveness in preparing students for success in their future required course work and chosen careers. In particular, the test scores of students, categorized based on the time of day the developmental math courses are scheduled (morning or afternoon), will be analyzed for levels of improvement shown and any possible variations amongst the two groups.

Research Question

Is there a significant performance difference among students enrolled in morning (AM) Math Foundations courses versus those enrolled in afternoon (PM) Math Foundations courses.

Significance of the Research Problem

As the world becomes more technologically advanced, problems become more complex. The need to understand and apply mathematical concepts and critical thinking skills to everyday life becomes increasingly important. By under-preparing our students in mathematics, we handicap not only their problem solving and decision making capabilities, but also their employment opportunities. “Mathematical competence opens doors to productive futures.” (NCTM, 2000, p. 5) Teachers within a variety of liberal arts, vocational and technical program areas are often required to teach fundamental mathematics concepts. This takes away from the time spent on course and program specific tasks and information. As liberal arts, vocational and technical programs utilize more complex technologies, it becomes increasingly important for the pre-requisite mathematics courses to provide students with the mathematics skills and applications necessary to succeed in their chosen careers and beyond. "College students who enroll in developmental courses, on average, have less favorable educational outcomes than students who enter ready for college-level work. Successful completion of developmental coursework, however, reduces the gap and provides a stepping-stone to degree attainment." (Russell, 2008, p. 3)

Assumptions

- All students enrolled in liberal arts, vocational and technical programs need mathematics.
- Some variance in the classroom learning environment is assumed due to changes in the dynamics involving the individual students and their attendance, attitudes, efforts, and abilities.
- Honesty and integrity, within the testing, data collection, and analysis process is assumed.
- Strict confidentiality has been maintained to protect the identity of the students involved.

Limitations

- The research for this paper is limited to MATH 0080, Math Foundations, the lowest prerequisite developmental course required for admissions to programs at Northland Community and Technical College in Thief River Falls, Minnesota.
- Data was collected through an analysis of student Pre-Test and Post-Test performance on the ACCUPLACER Arithmetic Test. Any incomplete data sets were discarded.
- An attempt has been made to limit any variance regarding the teaching style and philosophy of the instructor by utilizing the data collected from courses taught by a single faculty member.
- A Learning Style Inventory was not given to the students in the study, so individual time-of-day preference is an unknown measure.

- Attendance records were not kept, so the effects of absenteeism are unknown.

Definition of Terms

ACCUPLACER: The computerized-adaptive placement testing system that is used in this study for Pre- and Post- testing the mathematics knowledge and skills of developmental students.

AEE : the Alliance for Excellent Education.

AMATYC: the American Mathematics Association of Two-Year Colleges.

CUPM: the Committee on Undergraduate Program Mathematics.

Developmental/ Remedial Education: Courses that teach or re-teach knowledge, skills, and abilities that students should have already learned prior to college. Developmental education and remedial education are considered the same and used interchangeably in this study.

DOE: the U. S. Department of Education.

ECS: the Education Commission of the States.

Liberal Arts: The classical college majors that include traditional academic disciplines such as language, literature, history, philosophy, mathematics and the sciences.

MAA: the Mathematical Association of America.

MnSCU: the Minnesota State College and University System.

NCES: the National Center for Education Statistics.

NCTC: Northland Community and Technical College.

NCTM: the National Council of Teachers of Mathematics.

NSF: the National Science Foundation.

STEM: Science, Technology, Engineering, and Math.

SAT: the College Board's Scholastic Aptitude Test.

Career/Technical/Vocational: Used interchangeably to denote programs that teach knowledge, skills, and abilities needed for specific jobs, crafts, or trades including traditionally non-academic areas such as agriculture, cosmetology, law enforcement, nursing, transportation, and welding.

Summary Statement

Through this research study, the author will determine if a relationship exists between success in pre-requisite developmental math courses and the time of day that a course is offered. The effectiveness of pre-requisite math foundations courses will be evaluated not only by comparing the post test scores of students enrolled in the morning Math Foundations courses versus those of the students enrolled in the afternoon courses, but also by investigating the performance gains shown by each group.

While students enrolled in liberal arts, vocational and technical programs often exhibit different skills, talents, abilities and interests, they all need math. While the need to understand and apply mathematical concepts and critical thinking skills to everyday life becomes increasingly important, this is not to say, however, that all programs require the same mathematical skill level or depth of understanding. Every student should receive the math skill development opportunities that will allow them to succeed within their chosen educational program and beyond.

Chapter 2: Review of the Literature

This chapter will review trends in developmental education and the influence of time-of-day on student achievement. Also reviewed are other considerations that have potential influence on student performance in mathematics courses, specifically with regard to gender, race, and program major.

Developmental Mathematics

"Apathetic students, illiterate graduates, incompetent teaching, impersonal campuses – so roles the drumfire of criticism of higher education." (Chickering & Gamson, 1987, p. 3) Higher educational institutions across the board are being attacked from all sides and criticized as outdated, impersonal, insensitive, and incompetent in preparing our students for the challenges they will face in the world of tomorrow. But what if the student is unprepared or under-prepared for the rigors of college life? If he comes to the institution inadequately prepared, with gaps in his knowledge, skills, and abilities, how then can the institution be expected to adequately prepare him for his future without first filling those gaps?

The open enrollment and access policies governing many public two-year colleges mandate that anyone be allowed to enroll in the institution. This puts additional burden on these institutions by requires them to respond to the diverse needs of the students. The response tends to result in 'gap filling' pre-requisite courses that often fall into the realm of developmental education, sometimes also referred to as remedial education.

While there are several operational definitions of developmental education, for the sake of this research, the definition will be limited to those educational practices designed "to remediate skill deficiencies in areas like math, reading, and writing so as to increase the probability of success in other (or 'regular') college course work involving these skills." (Wilkie, 1994, p. 7) As such, developmental education can come in a variety of forms, from skill-oriented assistance in reading, writing, and math, to specialized counseling and advising services, to remedial courses, to para-professional and peer tutoring programs, to admission to university ‘general’ colleges, all of which are intended to offer additional support for students whose skills and abilities are not at the levels they should be upon entering college. These students often then carry the label ‘at risk’ when determining the probability for successful college completion.

Higher education institutions across the nation have seen a significant increase in the numbers of ‘at risk’ students needing developmental education over the past several years. This “alarming status” of skills “comes as no surprise to faculty and staff at community colleges, whose mission encompasses the task of raising the skill level of students who enter college with pre-college skills.” (Epper & Baker, 2009, p. 3) A 2008 MnSCU report on recent Minnesota public high school graduates enrolled in Minnesota public higher education institutions from 1999 to 2006, indicated that while the percentage of students who took at least one developmental course at state universities within two years of high school graduation showed signs of leveling off, the percentage continued to grow at two-year colleges to the current rate of 50 percent for 2006 high school graduates. Another study in 2003, by the National Center for Education Statistics (NCES), found that students enrolling at public two-year institutions were more than twice as likely to take at least one developmental course as students enrolling at four-year colleges (42 percent to 20 percent, respectively). (Russell, 2008, p.2) A similar study in 2002 by the Education Commission of the States (ECS) found that state by state rates of students enrolled in developmental education at public two-year colleges ranged from ten percent to 72 percent, while individual state rates at public four-year colleges ranged from six percent to 50 percent. These variations occur because enrollment and placement policies vary considerably from state to state, and there is no common national standard for college readiness. (Jenkins and Boswell, 2002)

"The increased developmental education rates may be due to a more thorough identification of under-preparation, along with better enforcement of required enrollment." (Russell, 2008, p. 3) More states are moving to mandatory college readiness testing and the common cut scores among the various state institutions for determining the need for placement into appropriate developmental courses. In Minnesota, MnSCU recently called together representatives from the two-year colleges and four-year universities to review the different assessment tests and placement strategies. As a result, the College Board's ACCUPLACER was chosen as a common student assessment instrument, and a consensus was reached regarding minimum cut scores across the system for the various levels of developmental education.

Recently, however, the additional cost of providing developmental education at public higher education institutions has come under increasing public scrutiny. In turn, the general public has begun to question the necessity and validity of such courses. From students, to parents, to high school counselors, to state and federal legislators, many see the proliferation of developmental courses on college campus across the nation as nothing more than money grabbing on the part of higher education institutions. It has been estimated by the Alliance for Excellent Education (AEE) that developmental education at community colleges for students who have recently completed high school costs taxpayers about $1.4 billion annually. "Community colleges already bear the greatest share of the remediation burden, and trends indicate that their responsibilities in this arena are likely to grow." (AEE, 2006, p.2) With the current economic crunch and the associated rising costs of higher education, several state legislatures "reacted to the seeming waste of 'paying twice' for what should have been taught in high school." (Russell, 2008, p. 2)

Perhaps William Adams of the University of Maryland - College Park sums up the issues associated with placement testing and developmental mathematics best with the following account of a typical student's experience:

> We begin with a familiar story. A student, we call him Tom, arrives at the University, happy to begin his college adventure. Almost immediately he is confronted with the Mathematics Placement Exam, designed to see if he is ready to enroll in a general education mathematics course (or in a credit-bearing course required by his major). The results of the Placement Exam unfortunately indicate that Tom is not prepared for the course he wants, and he must instead take a Developmental Mathematics Course. The results: he faces a delay in completing the needed mathematics course, he must take (for no credit) a course that he feels he has already taken, and to add insult to injury, he must pay an extra fee for the developmental course. Unhappiness, frustration and despair set in, the course is treated as a lowest priority (and often failed because of it), and an angry and frustrated student emerges. (Adams, 2003, p. 1)

But what should higher education institutions do? As Adams continues, "Without such a test, Tom would register for a course he appears to be unprepared for. Data show that the result is frequently failure in the course, which would slow his progress and perhaps lead to his dropping out of the college." (Adams, 2003, p. 1)

In the current educational climate emphasizing accountability and efficiency every step of the way, the question really comes down to how effective are these pre-requisite developmental courses in closing those 'gaps' and preparing the 'at risk' students to be successful in their chosen careers? There are many different existing studies that have asked that very question, that have examined many different aspects of the issue, with many different results, conclusions, and recommendations, several of which have not been very positive. Indeed, “Critics of remedial education cite statistics that remedial students are far less likely to persist in college and earn a degree, arguing that it is a waste of students’ time and money as well as taxpayer costs.” (Russell, 2008, p. 2)

Time-of-Day

One interesting trend that has recently begun to get more critical review, in industry as well as in education, is the time-of-day syndrome. It does not take long at all to find several resources that will help you with your own personal time management system. Indeed, there are several different companies, programs, and websites offering ways to identify your own “work window”, and helping you to “maximize your performance” by helping you to focus on your “peak production” times of the day, those times when your energy levels are at their highest. “Wonder why energy is so crucial to our job performance? Examine the meaning of the word. In the scientific terminology of physics, energy is specifically defined as ‘the capacity for doing work.’ So there’s the connection.” (Pritchett, 1999, p. 10) There are even tests designed to help you determine your ‘energy personality’ and to assist you in targeting specific tasks for specific times of the day based on your energy levels. “The most obvious ‘productivity tactic’ is to play to your strengths and use prime time for tasks that require high levels of concentration and use the fuzzy periods to do less mentally challenging activities.” (May, 2007, p. 3)

Studies related to time are not new to business and industry, as they have long been interested in improving productivity, efficiency, and effectiveness. From the early time-on-task related work of industrial efficiency specialists like Frank and Lillian Gilbreth, to the early work of Henry Ford and the automotive production line, to the more recent onslaught of computerized and internet-based applications, people have always been looking for ways to get things done better, faster, more efficiently, and more effectively.

Education, in turn, has followed the lead of business and industry, looking for ways to teach and learn things better, more efficiently and effectively. All of the different educational theories, pedagogies, and philosophies and the related curriculum changes, all have the same intent, to improve student performance. New information and research regarding brain-based education, learning styles, and the use of active learning strategies, all focus on helping teachers to better understand learning as an individual student phenomena. Each student is unique and, as such, brings to the classroom their own particular set of characteristics, personality traits, skills and abilities, likes and dislikes.

Time as a commodity has also become an issue. As our students' lives have become more and more complex and demanding, we see reduced time for work on subject matter in the classroom due to increased involvement in athletic and extra-curricular activities. Time-on-task studies have shown students are spending less and less time in the classroom studying the traditional academic curriculum subjects like mathematics, science, history and English, and standardized test scores have suffered because of it. Concurrently, there seems to be reduced time for students to do homework because of the demands of after-school practices, part-time jobs, and volunteer activities. With all of these available distractions afforded students today, and let's not forget the pervasive diversions of video games, cable television, cell phones, the internet, it is no wonder they come to our classes un-prepared, un-rested, and un-focused. Unfortunately, other than doing our best to create a caring and nurturing learning environment, we as teachers have very little control over the situation. How then can we best position our classrooms to have the greatest possible impact on improving student performance?

The medical profession has long recognized the role of biological clocks in influencing behaviors at differing times of the day. There is a significant amount of research regarding the role of circadian rhythms on human behavior, those regular changes in mental and physical characteristics, such as sleeping patterns, alertness, and body temperature, that occur over the course of a day. (Schmidt et al, 2007)

Among the forerunners in time-of-day correlation studies in education, Rita and Kenneth Dunn conducted several learning style studies starting in the 1970s. In their school based research, the Dunns were among the first to recognize variations in student responses to differing instructional materials. They were able to identify five key dimensions to student learning styles: environmental, emotional, sociological, physiological, and psychological. In particular, as a result of this research, they were able to identify time-of-day preference as a key physiological dimension as it relates to the individual's internal body clocks, on which learning styles differed. (Banks & Atkinson, 2002) Educators now recognize that the Dunns time-of-day preference research harbors a potentially significant influence on student performance. In fact, several studies make a strong case that for some students, this time-of-day preference is "sufficiently powerful to account for a good or bad test result." (Callan, 1995, p. 2)

It is important to note here, however, that a person's time-of-day preference may not be static over their lifespan. In fact, research indicates that it may change considerably as students get older. One such study found that "28% of K-2 students are morning learners, in comparison to 30% of middle grade students, 40 % of high school students, and 55% of adults." (Dunn, 2000, p. 4) Several other studies indicate that time-of-day preference may also vary across genders, and across cultural or ethnic backgrounds.

Most educational researchers agree that while some students may function best in the morning, others demonstrate their best academic performance later in the day. However, not all researchers agree that time-of-day preference is the underlying cause. One such study, suggests it is not preference that matters so much as the actual time of day. (Allen et al, 2008) The study offers three possible causes for consideration and continued research, each with potentially strong physiological influences on academic performance. Younger adults often show tendencies for higher body temperatures in the afternoons and evenings than in the mornings, and "increased body temperature is associated with improved cognitive performance." Likewise, poor morning productivity may be due the fact "that many college students do not eat breakfast, resulting in lower blood glucose levels." Finally, sleep deprivation may have a significant role in morning performance. (Allen et al, 2008, p. 561)

As teachers, we understand our roles and responsibilities in education. We are in charge of the classroom and responsible for its management. We set the mood, tone, and standards for the classroom. We determine the depth and scope of course content, and control the pace, direction, and emphasis of the demonstrations and discussions. However, teachers also recognize that we are not solely responsible for the learning process. Students have very important roles and responsibilities as well. All that we do in preparation is for not, if the students do not share our readiness, commitment, and preparation. As teachers, we clearly understand that it is much easier to teach when the students are motivated, interested, and attentive.

> Ancient teachers believed that all special techniques of teaching were to no avail if the learner was not prepared to receive a teaching. If their minds and motivation were not fertile, then no amount of teaching would make a difference. Ancient teachers developed thousands of teaching techniques that they combined in highly creative ways, but they never forgot that the individual's own spirit would guide their real learning. (Cajete, 1999, p. 177)

The question is then, how can we ensure the students' biological clocks are in sync with our current course offerings in order to maximize the students' motivation, interest, preparation, and, ultimately their academic performance? Are the various times courses are being offered allowing individual students to maximize their educational performance by engaging them during their peak production times of the day, when their energy levels are at their highest?

Other Considerations

One of the recurrent themes that I encountered during my literary review is the issue of diversity and its role in the developmental process. "No unit of American higher education is expected to serve such a diversity of purposes, to provide such a variety of educational instruments, or to distribute students among so many types of educational programs as the junior college." (Baker & Roueche, 1987, p. 3) "Widely reported studies have shown math serves as a critical filter in determining many educational, vocational, and professional options." Still, community colleges are tasked with embracing an open enrollment policy and yet providing educational opportunities for a student body that presents a variety of different backgrounds, experiences, interests, not to mention skills and abilities. This variety in turn requires colleges to respond to the special needs of the differing populations, particularly in the area of math. "At the community college level, we see many students who can't possibly meet this math requirement, either because they had poor math backgrounds to begin with or because they've been out of school so long they've forgotten what they once knew." (Arem, 2003, p. 6)

One area that has drawn considerable interest is the differences in math test scores, specifically between whites and blacks. "The challenge of raising math skills is further compounded by the fact that students who test into remedial math coursework are disproportionately minority." (Epper & Baker, 2009, p. 3) According to 2007 data provided by the College Board which administers the Scholastic Aptitude Test (SAT), African Americans score significantly lower in math than their Caucasian counterparts. (Geisler, 2008)

Likewise, the difference in math performance between males and females has received significant attention and critique. Women in mathematics have long battled an uphill climb regarding their skills and abilities, from Teen Barbie declaring "Math is hard!", to the president of Harvard asserting his opinion regarding " 'the unfortunate truth' that women probably are not as mentally equipped for work in math and science as men." (Wible, 2008) SAT results have served to foment the argument as they have also shown that females consistently score lower on the math portion of the test than males. (Geisler, 2008) In addition, data collected from children in forty countries around the world by the 2003 Program for International Student Assessment (PISA), also indicates that males consistently outperform females in mathematics. (Wible, 2008)

Some researchers have attributed these discrepancies to hormonal differences between men and women, or genetic differences between races. Recent studies, however, have sought to debunk these age old myths. They point to gender and ethnic stereotyping as having a negative impact on math performance. (Geisler, 2008) Others suggest gender and ethnic bias in the standardized testing process, thereby questioning on the validity of the test results.

Another topic of interest is the role of program major on math performance, in particular regarding perceived differences in those students enrolled in traditional liberal arts majors versus those pursuing vocational and technical majors. In the past, vocational education had as its primary objective the goal of preparing its graduates for entry-level jobs in occupations such as agriculture, automotive services, clerical, construction trades, cosmetology, electronics technology, and welding. These programs were designed to train students who did not plan to go on to a four-year college in basic occupational specific skills. As such, "Academic expectations for 'vocational' students were generally low, and the math, science, and English courses to which they were assigned were typically less rigorous." (DOE, 2003, p. 1) As such, within higher education, vocational and technical (vo-tech) institutions were commonly viewed as the 'safety net' for the higher education system. Those students fell who did not have the knowledge, skills, and abilities necessary to be successful in the traditional academic track offered at two-year community colleges and four-year universities, went to the vo-tech. As such, vocational and technical students were often assumed to be lower-ability students, and the primary ingredients of the developmental pipe line.

The recent consolidation of many two-year institutions into comprehensive community colleges, as well as the growth of many technology centered programs at four-year universities, has provided the opportunity to revisit some of these old notions. Some advocates for technical education suggest that teachers of pre-requisite mathematics courses that support vocational and technical programs need to emphasize applications rather than the more theory-based approach found in most traditional liberal arts curriculum. They insist that a liberal arts bias and a general lack of technical knowledge by developmental mathematics faculty only serves to complicate the learning process for vocational and technical students. Students are then often left under-prepared, disenfranchised, and dissatisfied with the process. (Doversberger, 1970)

Vocational education advocates have long recommended that faculty teaching mathematics courses should have a solid working understanding of the various technical applications. Many suggest imbedding the developmental mathematics skills into the program content in order to provide relevance and motivation for the students. Addressing this problem of providing appropriate pre-requisite developmental courses for these students therefore requires the cooperative efforts and input from both mathematics and technical faculty. (Shuert, 1984)

In 2004, the Committee on Undergraduate Program Mathematics (CUPM) called on mathematics teachers to actively seek out examples, problems, and projects from other disciplines, including the vocational and technical programs, to be used in all mathematics courses. Likewise, in the Principles and Standards for School Mathematics, the National Council of Teachers of Mathematics (NCTM) suggest an integrated approach be used to teach mathematics content, emphasizing data analysis, real world applications, and the use of appropriate technology. (2000) As Ganter and Barker point out:

> Students do not see the connections between mathematics courses and their chosen disciplines; instead they leave mathematics courses with a set of skills that they are unable to apply in non-routine settings and whose importance to their future careers is not appreciated. Indeed, the mathematics many students are taught often is not the most relevant to their chosen fields. (Ganter & Barker, 2004, p.1)

Mathematics faculty need to continue to work with students and faculty outside of mathematics to build partnerships in order to strengthen the content, application and delivery of pre-requisite developmental mathematics courses that serve the needs of students within all programs. "Barriers between departments and lack of communication between faculty restrict the understanding and development of students." (Arney & Small, 1999, p. 97)

Betsy Brand echoes the frustration of many in her argument regarding the need for connections and applications in math education.

> The current national focus on increasing STEM (Science, Technology, Engineering, and Mathematics) education is an example of where we are missing an opportunity to demonstrate to students how disciplinary content areas, such as algebra or physics, can be applied to real world situations and problem-solving. Once you learn that the Pythagorean Theorem helps carpenters and builders make perfect right angles and square corners, it makes a lot of sense to learn it. But if students are never shown how the equation is used in everyday life, it seems meaningless and irrelevant. Most of the policy responses so far to the STEM problem have been to increase the number of math and science teachers and increase the level of their content and disciplinary knowledge. It has not been about changing teaching and instruction to help students make connections between disciplinary knowledge and real applications, nor in using technology and engineering as means of teaching academic content. There has been scant attention paid to integrating science and math curriculum with technical and occupational curriculum, where many natural connections exist. (Brand, 2008, p. 8)

Chapter 3: Methodology

Summary of the Experiment

Northland Community and Technical College administers the ACCUPLACER Arithmetic test to all incoming students as part of the assessment and orientation process. Approximately 35 percent of NCTC's incoming students assess below the predetermined cut score of 50, and are placed into MATH 0080, Math Foundations. During this study, the ACCUPLACER Arithmetic test was re-administered at the end of the Math Foundations course to determine if a significant change in skill level and mastery had been indicated.

This paired Pre- and Post- Test data, gathered from the Fall of 2002 to the Spring of 2009, was evaluated using one-tail two-sample T-tests assuming unequal variances to determine if a significant performance differences existed among those students enrolled in morning (AM) Math Foundations courses versus those enrolled in afternoon (PM) Math Foundations courses.

Course Information

MATH 0080 Math Foundations is the lowest level developmental math course offered at Northland Community and Technical College. The college catalog and website list the following course description:

> This course is designed to help students improve basic math skills in order to apply these skills to a variety of degree and occupational programs and experiences. Topics include fractions, decimals, percents, ratios and proportions, powers and roots, and signed numbers. To successfully complete this course, students much achieve a grade of "C" or higher. This course fulfills the College's requirement but does not count towards graduation. Prerequisites: None. (NCTC, 2009)

The course is designed specifically to teach, or re-teach, basic arithmetic content and skills that are pre-requisites for success not only in future math courses, but also in future program or degree specific courses that require a certain level of skill proficiency. The majority of the activities in the course are, therefore, designed to promote active recall and skill development through application.

Sixty percent to seventy percent of the students enrolled in Math Foundations courses are Caucasian, and enrollment is split about evenly regarding both gender and major. Many of the students enrolled in the course have had several previous negative experiences in math and, therefore, have confidence and self esteem issues involving their abilities in math. Still, by the end of the course, each student enrolled needs to demonstrate skill mastery at the individual level, independent of assistance and/or guidance.

Northland Community and Technical College

Northland Community and Technical College in Thief River Falls is a comprehensive community and technical college located in northwestern Minnesota.

> The history of Northland Community and Technical College 's Thief River Falls campus dates back to 1949, when the Thief River Falls Area Vocation Institute opened. A few years later in 1965, the Thief River Falls State Junior College, also held its first classes. The names of the two colleges changed several times throughout its history. One of the most prominent changes occurred in July of 1995 the two colleges merged to create Northland Community and Technical College. In July of 2003, Northland Community and Technical College in Thief River Falls merged with the East Grand Forks campus of Northwest Technical College, to become a two campus comprehensive college. (NCTC, 2009)

NCTC in Thief River Falls has an enrollment of approximately 2,000 students, of which 54 percent are male, 46 percent female, 1 percent are international students, and 11 percent are students of color.

NCTC is a member of MnSCU, and, as such, it is subject to the assessment and mandatory placement policies as directed. See Appendix A for more information on MnSCU placement policy and procedures.

ACCUPLACER

Northland Community and Technical College administers the ACCUPLACER Arithmetic test to all incoming students as part of the assessment and orientation process. The ACCUPLACER Arithmetic test is a computerized test "designed to provide placement, advisement, and guidance information for students entering two- or four-year institutions of higher education." (ACCUPLACER, 2003, p. 1) The function of the math placement test is to assist college counselors and advisors in determining if a student is prepared for college-level courses or if the student would benefit from a developmental mathematics course. "The Arithmetic test measures students' ability to perform basic arithmetic operations and to solve problems that involve fundamental arithmetic concepts. There are three content areas measured on this test: (a) Whole Numbers and Fractions, (b) Decimals and Percents, and (c) Applications." (ACCUPLACER, 2003, p. 21) The test consists of 17 multiple choice items and the individual student score for the Arithmetic test ranges from 20 to 120 points.

> ACCUPLACER tailors the test to each student using an item-selection algorithm. This algorithm initially administers an item of middle difficulty to each student, randomly selected from one of about five very similar items. If the response were wrong, it branches to a randomly chosen one of three extremely easy items; if the response were

> right, it branches to a randomly chosen one of three extremely difficult items. Items presented stay very easy or very difficult until there is at least one right or wrong answer, whereupon item selection aims for maximum information but is subject to constraints that provide for content balance. (ACCUPLACER, 2003, p. 4)

Each student's ACCUPLACER Arithmetic score is determined using a combination of how many questions they answered correctly, and the difficulty level of the questions that they answered correctly.

Data Collection

Paired Pre- and Post- Test scores using the ACCUPLACER Arithmetic, as well as demographic information regarding each student's gender, race, chosen program major, and age at the time of the test, was gathered and analyzed for use in this experiment.

The data collection was limited to Math Foundations courses taught by the same faculty member in order to limit the influence of differences in teaching style that may occur from one faculty member to another. Initially, the data was collected as a way to provide assessment evidence for North Central Accreditation, however nothing up to this point had been done to organize or analyze the information.

The data was collected from MATH 0080 students over a period of seven years from the Fall of 2002 to the Spring of 2009. The faculty member collected and saved the student pre- and post-test scores rounded to the nearest whole number. Note that early student pre- and post-test scores reports were automatically rounded by the ACCUPLACER software, while later score reports gave scores that were taken out to the nearest tenth by the ACCUPLACER software. In order to keep scores consistent for comparison purposes, all test pre- and post- test scores were rounded accordingly to the nearest whole number.

All of the data was reviewed for completeness of information, and any incomplete data sets were rejected. After careful review, a sample population of 268 complete data sets was included in this experiment, representing 128 students enrolled in morning (AM) classes and 140 students enrolled in afternoon (PM) classes.

Focus of the Research

The focus of the experiment was two-fold, to investigate student math achievement represented by a comparison of the post test scores of those students enrolled in the morning Math Foundations courses versus the post test scores of those students enrolled in the afternoon Math Foundations courses, and to investigate student math improvement based on analyzing the pre- and post- test scores of those same groups of students. Of particular interest was the relation of the time of day to the students' performance. The following hypotheses were considered:

Null Hypothesis 1:

The mean post-test score of those students enrolled in the PM courses will not be significantly different than the mean post-test score of those students enrolled in the AM courses. Ho_1: $P_{1PM} = P_{1AM}$

Alternate Hypothesis 1:

The mean post-test scores of those students enrolled in the PM courses will be significantly greater than the mean post-test scores of those students enrolled in the AM courses. Ha_1: $P_{1PM} > P_{1AM}$

Null Hypothesis 2:

The mean gain (math improvement scores) of those students enrolled in the PM courses will not be significantly different than the mean gain of those students enrolled in the AM courses. Ho_2: $P_{2PM} = P_{2AM}$

Alternate Hypothesis 2:

The mean gain (math improvement scores) of those students enrolled in the PM courses will be significantly greater than the mean gain of those students enrolled in the AM courses.

Ha_2: $P_{2PM} > P_{2AM}$

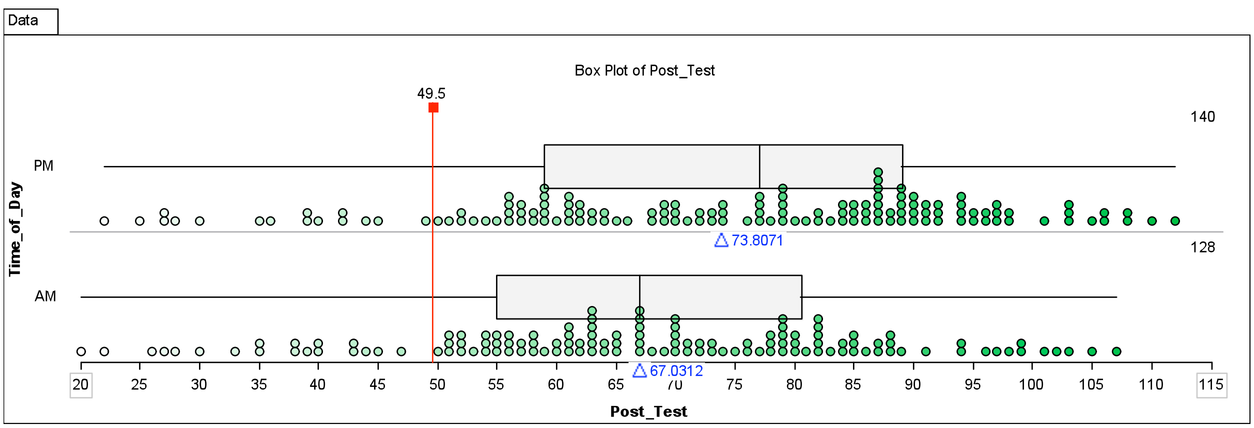
Confidentiality

All student names and identification numbers have been removed from the data collected in order to protect the privacy of those individuals involved. Permission to utilize the information for this research was granted by the college with the stipulation that strict confidentiality would be maintained and student identity protected.

Chapter 4: Data and Results

Post Test Data

Graph 1 represents the Post Test data distribution using both a scatter plot with like scores stacked vertically, and a box and whisker plot. The vertical red line represents the minimum cut score (49.5) for placement into the next higher developmental math course and the blue triangles represent the mean Post Test scores for each of the AM and PM groups. Table 1 displays the Post Test t-test results and related statistical measures for Hypothesis 1.



Graph 1: AM and PM Post Test Comparison

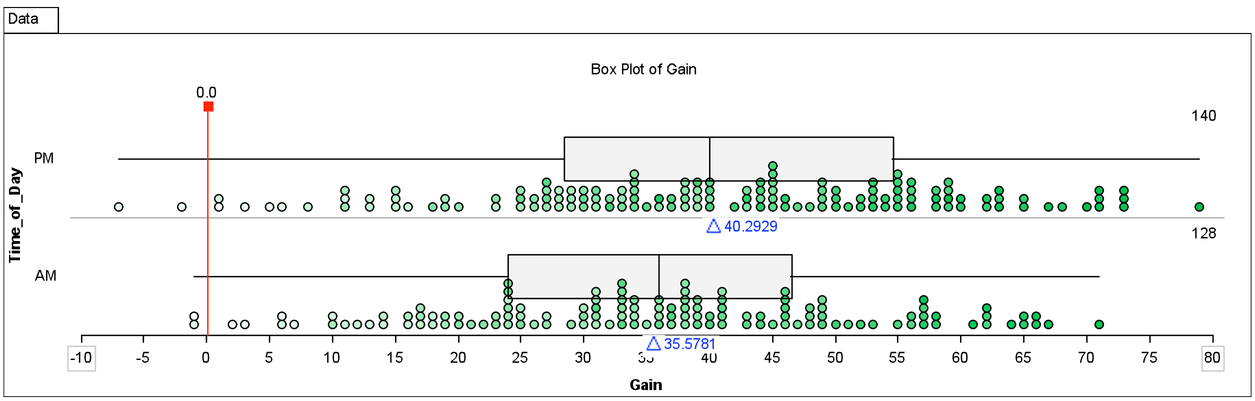
Post Test t-Test: Two-Sample Assuming Unequal Variances

	AM Post Test	*PM Post Test*
Mean	67.03125	73.80714286
Variance	362.3769685	419.9265673
Observations	128	140
Hypothesized Mean Difference	0	
df	266	
t Stat	2.806156797	
P(T<=t) one-tail	0.002692071	
t Critical one-tail	1.650602207	
P(T<=t) two-tail	0.005384141	
t Critical two-tail	1.968922265	

Table 1. Post Test t-Test Results

Gain Data

Graph 2 represents the Gain data distribution again using both a scatter plot with like scores stacked vertically, and a box and whisker plot. The vertical red line represents a gain of zero and the blue triangles represent the mean Gain for each of the AM and PM groups. Table 2 displays the Gain t-test results and related statistical measures for Hypothesis 2.



Graph 2. AM and PM Gain Comparison

Gain t-Test: Two-Sample Assuming Unequal Variances

	AM Gain	*PM Gain*
Mean	35.578125	40.29285714
Variance	268.5765256	330.7121788
Observations	128	140
Hypothesized Mean Difference	0	
df	266	
t Stat	-2.23236926	
P(T<=t) one-tail	0.013211619	
t Critical one-tail	1.650602207	
P(T<=t) two-tail	0.026423238	
t Critical two-tail	1.968922265	

Table 2. Gain t-Test Results

Chapter 5: Conclusions

Discussion of Hypothesis 1

Since the Post Test t-Test indicates a one-tail p-value of 0.00269 which is less than 0.05, the null hypothesis must be rejected and the alternative accepted. This indicates that the post-test scores of students enrolled in the PM courses are significantly greater than the post-test scores of students enrolled in the AM courses.

In fact, in this experiment, those students enrolled in afternoon Math foundations courses scored on average nearly 6 ¾ points higher than their morning counterparts, and the median score of the PM students was 10 points higher than the AM students. Further review of the data reveals that 124 out of 140 of the afternoon students' Post Test scores met or exceeded the minimum cut score for moving on to the next higher course, as compared to 109 out of 128 of the morning students' scores.

Discussion of Hypothesis 2

Similarly as in the first hypothesis, since the Gain t-Test indicates a one-tail p-value of 0.01321, which is also less than 0.05, the null hypothesis must be rejected and the alternative accepted. This indicates that the gains (math improvement scores) of students enrolled in the PM courses are significantly greater than the gains of students enrolled in the AM courses.

Again, in this experiment, those students enrolled in afternoon Math foundations courses gained on average nearly 4¾ points more than their morning counterparts, and the median gain of the PM students was 4 points higher than the AM students. Additionally, a closer look at the data reveals that only four individuals out of the 268 students in the study failed to show improvement, that is two from each group experienced negative gains.

Additional Research Questions

The following questions could be further researched using the data collected in this study:

- Are there performance differences among males and females?
- Are there performance differences among whites and minorities?
- Are there performance differences among liberal arts majors and vocational and technical majors?
- How does the time of day in which a course is enrolled influence performance in each of the above cases?

Summary and Conclusion

The result of the study clearly indicates that students who enroll in afternoon Math Foundations courses significantly outperform their counterparts in the morning courses. However, the causes for these performance discrepancies are not so easily determined.

The math course offerings are set without knowledge of student preference, but efforts are made to offer courses at differing times to accommodate the differing needs of students. Since students self-select their classes, one could argue that they should tend to play to their strengths and preferences, and schedule their math classes for the time of day that would afford them the best opportunity for success. However, other discipline courses and curriculum demands often force students to choose their developmental courses around their required schedule. And then there are outside issues such as transportation, employment, extracurricular activities, and family commitments.

It is also difficult to draw conclusions from the data regarding the differences in math performance because attendance records were not kept for the courses and we do not know the impact of absenteeism on the results. Did morning students tend to miss more class time than the afternoon students? How much influence did students' outside commitments have on their attendance, and, subsequently their performance?

Finally, some consideration must be given to the discussion put forth by Allen's group and others regarding the potential physiological influences on academic performance due. (Allen et al, 2008) Just how much of the performance discrepancies can be attributed to the lower body temperatures, lower blood glucose levels, and sleep deprivation of those students enrolled in the morning classes versus their counterparts in the afternoon?

With the current MnSCU policy calling for mandatory assessment and placement into appropriate level developmental mathematics courses, Northland Community and Technical College will continue to face many challenges regarding its incoming students. Past scheduling of pre-requisite developmental math courses at NCTC has been subject to parameters set by the other required program and discipline course scheduling. Developmental math courses tended to be offered during "open" periods in the schedule, usually at the beginning or ending of the normal school day, that is either early in the morning or late in the afternoon.

The data collected for this study indicates that while the current Math Foundations course and schedule have had some success in raising the achievement levels of students, improvements can and should be made. While it is still very important to recognize that each individual student has his or her own needs and time-of-day preferences, based on the information in this study, more sections of Math Foundations should be offered at NCTC in the afternoon than in the morning in order to maximize student performance.

This shift to more afternoon developmental math class offerings may require the education of both faculty and students as to the reasoning behind the shift. It is important to emphasize that there is still a need for morning developmental math options, as some students do perform better in the morning than in the afternoon. Also, additional responsibilities such as family, work, or extra-curricular activities, often require students to seek out morning developmental courses in order to meet their outside commitments later in the day.

Finally, if NCTC is truly committed to maximizing student potential, then it should be aggressive in reviewing past practices and investigating future opportunities in developmental education. Developmental education is often seen by prospective students, and their parents, as a stumbling block, or at least a deterrent, to continuing their education. There are currently several studies and initiatives with funding available for looking specifically at new and innovative ways to package developmental math courses and integrate technology into the curriculum. It only makes sense to investigate the alternatives and to critically examine the potential impact of changing the current way of doing things.

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APPENDIX A: MnSCU Policy and Procedures for Course Placement

3.3 Assessment for Course Placement

Part 1. Purpose.

The purpose of this policy is to improve student success in college and university courses through student assessment and course placement that addresses reading comprehension, written English, and mathematics knowledge and skills.

Part 2. Course Placement Assessment.

Subpart A. College and University Policy. Each college and university shall develop and implement a course placement policy that addresses how student knowledge and skills shall be assessed for course placement decisions according to Procedure 3.3.1 Course Placement.

Subpart B. System-Endorsed Placement Instrument. The chancellor shall select the system-endorsed placement instrument for assessment of reading comprehension, written English, and mathematics according to Procedure 3.3.1 Course Placement.

Procedure 3.3.1 Assessment for Course Placement

Part 1. Definitions.

Subpart A. College-level courses. A college-level course is a college or university course that meets college-level standards. Credits earned in a college-level course apply toward the requirements of a certificate, diploma, or degree.

Subpart B. Developmental-level course. A developmental-level course is a course designed to prepare a student for entry into college-level courses. Developmental-level course credits do not apply toward a certificate, diploma, or degree.

Part 2. Assessment for Course Placement Committee. The senior vice chancellor of academic and student affairs shall appoint an Assessment for Course Placement Committee (ACPC).

Subpart A. Committee membership. The committee shall include college and university faculty, academic and student affairs staff, and students.

Subpart B. Committee responsibilities. The ACPC shall periodically review national assessment instruments and submit recommendations to the senior vice chancellor on the following: the instrument to be designated as the system-endorsed placement instrument, the minimum scores on the system-endorsed placement instrument for placement into courses at the developmental or college-level, changes to board policy and system procedure related to assessment, and other items as needed to address consistency of assessment and placement practices at system colleges and universities.

Part 3. Placement Instruments.

Subpart A. System-endorsed placement instrument. Effective July 1, 2006, the College Board Accuplacer is designated as the system-endorsed placement instrument. Each college and university shall evaluate students with the system-endorsed placement instrument. A student who meets one of the conditions specified in Part 5. Subpart A. of this procedure may be exempted from completing the Accuplacer for course placements. A student who presents ACT subject area scores may also be exempted from completing the Accuplacer for course placements, and the ACT subject area scores may be used to determine course placements. System colleges and universities shall not require the ACT test for course placements.

Subpart B. Assessment for course placement in a higher level course. A college or university may use additional assessment measures in reading, writing or mathematics for placement into a course above the introductory college-level only if the system-endorsed course placement instrument does not assess for placement into the higher-level course. Additional assessment measures as specified in this subpart shall not be used in place of the system-endorsed course placement instrument. These additional assessment measures shall be administered at no cost to the student.

Subpart C. Assessment of students who are non-native speakers of English. A student who is identified as being a non-native speaker of English shall be evaluated for college readiness in the area of English language proficiency using the ESL version of the system-endorsed placement instrument.

Subpart D. Additional assessment measures. A college or university may require additional assessment measures (e.g., computer literacy, study skills inventories, or occupational-related tests) for purposes other than the objectives (reading, writing, and math) of the system-endorsed placement instrument for advising and placement purposes. These additional assessment measures shall be administered at no cost to the student.

Subpart E. Student fees for system-endorsed placement instruments. A student shall not be charged a fee for the system-endorsed placement instrument. A college or university may charge a fee to a student who requests a retest of the system-endorsed placement instrument.

Subpart F. Common background questions for collection of demographic data. Each college and university shall incorporate a set of system-established student demographic background questions into the assessment process.

Part 4. Placement Instrument Review and Approval. A complete review of the system-endorsed placement instrument shall be conducted at least every five years, and the senior vice chancellor shall approve the system-endorsed assessment instrument that shall be specified in this procedure. Criteria used to justify the recommendation for the system-endorsed instrument shall include instrument validity and reliability indices, cost, ease of test administration, availability of related vendor support services, and other relevant information.

Part 5. Criteria for Student Exemptions. Each college and university shall develop criteria for exempting a student from all or portions of the system-endorsed placement instrument and/or the course placement decisions recommended based on the assessment results. A student enrolling exclusively in non-credit courses shall not be required to complete the Accuplacer.

Subpart A. Exemptions. A student may be exempted from taking all or portions of the system-endorsed placement instrument based on documentation of:

1. assessment scores taken on the system-endorsed placement instrument at any system college or university within three calendar years, inclusive of the current calendar year, with the provision that mathematics scores are valid for only two calendar years, inclusive of the current calendar year, as defined in Subpart A. 2. below;
2. subject area scores equivalent to or above the system-endorsed minimum on standardized college admissions tests (ACT) taken within three calendar years, inclusive of the current calendar year, for reading and writing and two calendar years, inclusive of the current calendar year, for mathematics;
3. assessment scores on an assessment instrument other than the system-endorsed instrument at an institution outside the Minnesota State Colleges and Universities system, providing that placements can be determined by using the placement levels of the alternative instrument;
4. successful prior postsecondary education indicating a high probability of success in the introductory college-level course for which a course placement score is required; or fulfillment of a college-level course in the area for which the course placement score is used.

Subpart B. Course placement decisions. A student may be exempted from course placement decisions that are based on assessment scores according to institutionally-based criteria. A college or university shall specify the type(s) of additional evidence that will be considered to exempt a student from the results of the assessment scores and the processes that will be used to make the decision.

Part 6. Course Placement.

Subpart A. System minimum course placement scores The Assessment for Course Placement Committee (ACPC) shall develop and recommend to the senior vice chancellor a process for establishing system minimum course placement scores on the system-endorsed instrument for use by colleges and universities to place a student appropriately in developmental coursesor introductory college-level writing, mathematics, and reading-intensive courses.

Subpart B. Implementation of system minimum course placement scores. The following course placements based on Accuplacer subtest scores indicate that a student is ready for introductory college-level courses. A student who obtains the minimum score or higher shall be placed in the corresponding college-level course(s).

1. Reading.
   a. College-level Reading: A student who scores 77.50 or higher on the Reading

Comprehension test shall be placed in courses that designate college-level reading skills as a prerequisite.

b. Developmental Reading: A student who scores below 77.50 on the Reading Comprehension test shall be placed in developmental reading courses.

2. Writing
   a. College-level Writing: A student who scores 77.50 or higher on the Reading Comprehension test shall be placed in college-level writing courses. However, if a system college or university chooses to use the Sentence Skills test as an additional placement measure, a student who scores 77.50 or higher on the Reading Comprehension test and 85.50 or higher on the Sentence Skills test shall be placed in college-level writing courses.

   b. Developmental Writing: A student who scores below 77.50 on the Reading Comprehension test shall be placed in developmental writing courses. However, if a system college or university chooses to use the Sentence Skills test as an additional placement measure, a student who scores below 85.50 on the Sentence Skills test shall be placed in developmental writing courses.

3. Mathematics.
   a. College Algebra: Placement into College Algebra shall be based on two test scores. A student must score 75.50 or higher on the Elementary Algebra Test and also must score 49.50 or higher on the College Level Mathematics test. A student attaining the minimum scores shall be placed in College Algebra.

   b. A System College or University may establish lower minimum score(s) for placement into introductory college-level mathematics courses other than College Algebra and for developmental mathematics courses.

Placement	**Minimum Score**	**ACCUPLACER Subtest**
College-level reading	77.50	Reading Comprehension
College-level writing	77.50 and 85.50	Reading Comprehension Sentence Skills (optional additional measure for college-level writing)* * If a college or university opts to use the Sentence Skills subtest as an additional measure,

		the minimum scores must be attained for both subtests.
College Algebra	75.50 and 49.50	Elementary Algebra College Level Mathematics Both scores are required. A student attaining the minimum scores or higher on both subtests shall be placed in College Algebra.

Subpart C. Implementation date of system minimum course placement scores. The minimum course placement scores specified in this procedure apply to a student who plans to begin taking courses the fall semester of 2008 and thereafter.

Subpart D. Course placement scores for advanced courses. Each college and university may set course placement scores higher than the minimum scores established in Procedure 3.3.1 for college-level courses that are beyond the introductory college level.

Part 7. Ongoing Reporting on Course Placement. Each college and university shall ensure that placement data are entered into the Integrated Statewide Record System (ISRS)according to the standards of the Office of the Chancellor, including the following:

placement test results

course placement, and

student responses to system-approved and required demographic questions asked at the time of assessment.

Approval Date: 9/12/06

Effective Date: 1/14/08

Date & Subject of Revisions:

1/14/08, System minimum course placement scores added, obsolete language deleted and clarifying language added.

There is no additional HISTORY for procedure 3.3.1 at this time. (MnSCU, 2008)

APPENDIX B: NCTC Math Placement Scores and Recommendations

Arithmetic (ARTH)	**0 – 49 (ARTH)** Will need to register for:		**MATH0080 Math Foundations**
	50 – 120 (ARTH) No *Math Foundations required*		
	Accuplacer administers Algebra		
	50- 120 (ARTH)	Eligible to register for:	MATH1001 Technical Mathematics MATH1003 Math Applic for Nurses
Elementary Algebra (EA)	**50 – 89 (ARTH) <u>and</u> 0 – 39 (EA)**	Will need:	**MATH0090 Introductory Algebra**
	90 – 120 (ARTH) <u>or</u> 40 – 59 (EA)	Will need:	**MATH0094 Pre-College Algebra**
	50 – 120 (ARTH) <u>and</u> 60 – 84 (EA)	Will need:	**MATH0098 Intermediate Algebra**
		Eligible to register for:	CHEM2205 Survey Of Chemistry CHEM1105 Forensic Science
College Level Math (CLM)	**85 – 120 (EA) or** **78 (EA) and 50 - 120 (CLM)**	Eligible to register for:	MATH1102 Contemporary Math MATH1106 Trigonometry MATH1110 College Algebra MATH1113 Pre-Calculus MATH2203 Statistics BUSN2203 Business Statistics CHEM1020 Introduction to Chemistry CHEM1121 General Chemistry I PHYS1010 Physics

APPENDIX C: Interpretation of ACCUPLACER Arithmetic Test Scores

The **Total Right Score** for the ACCUPLACER multiple-choice tests ranges from 20 to 120 points and is calculated using a formula. This score should be used in computing summary statistics, in correlating test performance with other information in a student's records, and in other statistical treatments of the test data.

Interpretation of Test Scores
ACCUPLACER Tests are designed to assist institutions in placing students into appropriate courses. Given that institutions differ greatly with respect to composition of the student body, faculty, and course content, it is not possible to stipulate specific test cut scores that should be used for placement decisions. Instead, each institution should establish their own cut scores to facilitate placement decisions based on factors and data unique to their institution. To help institutions establish these cut scores, the College Board has developed "proficiency statements" that describe the knowledge and skills associated with specific ACCUPLACER Total Right scores. These statements were derived by convening a panel of experts in each subject area to review items anchored at specific points along the Total Right score scale and to describe the knowledge and skills that are required to answer these items correctly. The Proficiency Statements for each test are provided below. These statements offer useful information for understanding students' skill levels. Wherever possible, actual placement decisions should include other variables that may contribute to an accurate assessment of a student's ability, such as high school grades, background information, etc.

Proficiency Statements for Arithmetic
Total Right Score of about 31

Students at this level have minimal arithmetic skills and can:

- perform simple operations with whole numbers and decimals (addition, subtraction, and multiplication)
- calculate an average, given integer values
- solve simple word problems
- identify data represented by simple graphs

Total Right Score of about 57

Students at this level have basic arithmetic skills and can:

- perform the basic arithmetic operations of addition, subtraction, multiplication, and division using whole numbers, fractions, decimals, and mixed numbers
- make conversions among fractions, decimals, and percents

Total right score of about 90

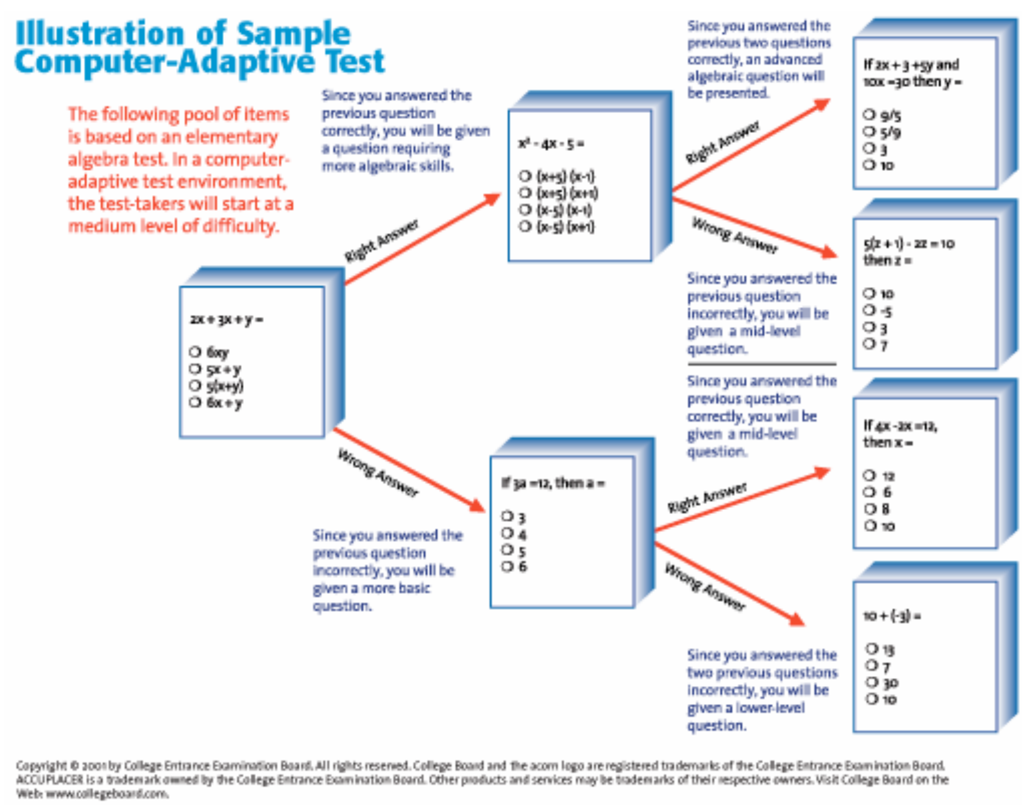
Students at this level have adequate arithmetic skills and can:

- estimate products and squares of decimals and square roots of whole numbers and decimals
- solve simple percent problems of the form p% of q = ? and ?% of q = r
- divide whole numbers by decimals and fractions
- solve simple word problems involving fractions, ratio, percent increase and decrease, and area

Total right score of about 112

Students at this level have substantial arithmetic skills and can:

- find equivalent forms of fractions
- estimate computations involving fractions
- solve simple percent problems of the form p% of ? = r
- solve word problems involving the manipulation of units of measurement
- solve complex word problems involving percent, average, and proportional reasoning
- find the square root of decimal numbers
- solve simple number sentences involving a variable



Excerpts from ACCUPLACER Technical Manual (ACCUPLACER 2003)

APPENDIX D: Data

Test Year	Semester	Time of Day	Birth Year	Race	Gender	Program	Pre-Test	Post Test	Gain	Age
102	F	AM	83	W	F	L	22	58	36	19
102	F	AM	82	I	M	L	31	70	39	20
102	F	AM	83	W	F	T	25	55	30	19
102	F	AM	83	B	M	T	24	40	16	19
102	F	AM	84	W	F	T	39	73	34	18
102	F	AM	84	W	M	L	24	80	56	18
102	F	AM	82	B	M	L	26	43	17	20
102	F	AM	81	W	M	L	27	61	34	21
102	F	AM	84	W	F	L	36	82	46	18
102	F	AM	83	W	M	T	31	65	34	19
102	F	AM	84	W	F	L	33	56	23	18
102	F	AM	83	W	M	L	40	61	21	19
102	F	AM	82	W	M	L	31	88	57	20
102	F	AM	80	W	M	T	31	30	-1	22
102	F	AM	69	W	M	L	27	72	45	33
102	F	PM	83	W	M	L	32	40	8	19
102	F	PM	59	W	F	L	33	85	52	43
102	F	PM	83	W	M	T	32	103	71	19
102	F	PM	83	W	M	L	37	108	71	19
102	F	PM	83	W	M	T	29	77	48	19
102	F	PM	84	W	M	T	30	77	47	18
102	F	PM	83	I	M	T	25	28	3	19
102	F	PM	84	W	F	T	23	52	29	18
102	F	PM	84	W	F	T	36	94	58	18
102	F	PM	79	W	F	T	27	83	56	23
102	F	PM	84	W	F	T	37	87	50	18
103	F	AM	85	W	F	L	26	64	38	18
103	F	AM	85	W	F	L	24	62	38	18
103	F	AM	83	I	F	T	42	62	20	20
103	F	AM	84	W	F	L	37	89	52	19
103	F	AM	84	B	M	L	31	57	26	19
103	F	AM	84	B	M	L	27	33	6	19
103	F	AM	82	W	F	T	27	39	12	21
103	F	AM	84	W	M	T	21	28	7	19
103	F	AM	85	W	M	L	29	80	51	18
103	F	AM	82	W	F	L	35	99	64	21
103	F	AM	85	B	M	L	29	43	14	18
103	F	AM	85	B	M	L	43	80	37	18
103	F	AM	84	B	M	L	27	45	18	19

103	F	AM	84	W	F	T	29	84	55	19
103	F	AM	83	B	F	T	46	70	24	20
103	F	AM	85	W	M	L	33	91	58	18
103	F	AM	85	W	M	L	34	65	31	18
103	F	AM	81	B	M	L	20	44	24	22
103	F	AM	72	W	F	T	29	86	57	31
103	F	AM	75	W	F	T	37	99	62	28
103	F	AM	84	W	M	L	29	94	65	19
103	F	AM	84	W	M	T	45	102	57	19
103	F	AM	72	W	F	T	33	60	27	31
103	F	AM	79	W	F	T	38	82	44	24
103	F	AM	83	H	F	T	35	76	41	20
103	F	AM	84	W	M	L	46	79	33	19
103	F	AM	84	W	F	L	37	70	33	19
103	F	AM	83	W	F	L	42	78	36	20
103	F	AM	84	B	M	T	37	56	19	19
103	F	AM	84	W	F	L	31	97	66	19
103	F	AM	56	W	F	T	20	61	41	47
103	F	AM	78	W	F	L	45	82	37	25
103	F	AM	84	W	M	L	35	52	17	19
103	F	AM	83	W	M	L	46	79	33	20
103	F	AM	84	W	M	L	32	56	24	19
103	F	AM	84	B	M	L	21	27	6	19
103	F	AM	84	W	F	T	26	64	38	19
103	F	AM	56	W	F	T	20	51	31	47
103	F	AM	85	W	M	L	20	82	62	18
103	F	AM	82	B	M	L	29	40	11	21
103	M	PM	53	W	F	T	46	64	18	50
103	M	PM	84	W	F	L	41	86	45	19
103	M	PM	59	W	M	T	46	85	39	44
103	M	PM	82	W	F	T	59	95	36	21
103	M	PM	84	B	F	L	21	59	38	19
104	S	AM	83	W	F	L	35	51	16	21
104	S	AM	83	B	M	L	24	67	43	21
104	S	AM	57	W	M	T	38	81	43	47
104	S	AM	68	W	F	T	27	58	31	36
104	S	AM	84	H	F	T	31	87	56	20
104	S	AM	83	B	M	L	20	38	18	21
104	S	AM	84	B	M	T	21	20	-1	20
104	S	AM	84	W	M	T	25	50	25	20
104	S	AM	82	W	M	L	36	107	71	22
104	S	AM	85	I	F	T	24	63	39	19

104	S	AM	77	W	F	T	40	101	61	27
104	S	AM	74	W	F	T	20	51	31	30
104	F	AM	86	W	F	L	30	63	33	18
104	F	AM	81	I	M	T	50	74	24	23
104	F	AM	81	B	M	L	22	35	13	23
104	F	AM	85	W	F	L	34	53	19	19
104	F	AM	86	B	M	L	20	47	27	18
104	F	AM	86	W	M	L	37	103	66	18
104	F	AM	85	W	M	T	34	54	20	19
104	F	AM	86	W	F	L	22	71	49	18
104	F	AM	85	W	M	L	37	94	57	19
104	F	AM	85	W	F	T	34	83	49	19
104	F	AM	86	W	F	L	37	54	17	18
104	F	AM	84	W	F	L	31	96	65	20
104	F	AM	86	W	M	L	39	85	46	18
104	F	AM	85	H	F	L	32	69	37	19
104	F	AM	85	W	F	L	28	77	49	19
104	F	AM	85	W	F	L	32	78	46	19
104	F	AM	85	W	F	L	42	67	25	19
104	F	AM	86	W	M	T	37	61	24	18
104	F	AM	84	W	M	T	25	73	48	20
104	F	AM	85	W	F	L	34	58	24	19
104	M	PM	62	W	F	T	44	84	40	42
104	M	PM	82	W	F	T	36	90	54	22
104	M	PM	83	W	F	T	36	51	15	21
104	M	PM	80	I	F	T	34	60	26	24
104	M	PM	85	W	M	L	36	103	67	19
104	M	PM	86	W	F	L	44	74	30	18
104	M	PM	59	W	F	T	32	62	30	45
104	M	PM	72	W	F	L	29	74	45	32
104	M	PM	84	W	F	T	51	95	44	20
104	F	PM	79	W	M	T	27	63	36	25
104	F	PM	85	I	M	L	39	69	30	19
104	F	PM	84	W	F	L	37	91	54	20
104	F	PM	82	B	M	L	20	25	5	22
104	F	PM	84	W	M	T	41	94	53	20
104	F	PM	85	W	F	L	33	106	73	19
104	F	PM	85	B	M	L	23	56	33	19
104	F	PM	86	W	F	T	38	58	20	18
104	F	PM	85	B	M	L	21	59	38	19
104	F	PM	82	W	F	T	39	94	55	22
104	F	PM	85	W	M	L	34	27	-7	19
104	F	PM	72	W	F	T	40	71	31	32

104	F	PM	86	W	F	T	36	92	56	18
104	F	PM	84	B	M	L	35	69	34	20
104	F	PM	86	W	M	L	40	63	23	18
105	S	AM	82	W	M	L	31	60	29	23
105	S	AM	84	H	M	T	20	22	2	21
105	S	AM	86	W	F	L	27	75	48	19
105	S	AM	84	W	M	T	25	63	38	21
105	S	AM	84	W	F	T	39	85	46	21
105	S	AM	67	B	M	L	23	55	32	38
105	S	AM	81	W	F	T	30	55	25	24
105	S	AM	80	B	M	L	24	38	14	25
105	S	AM	85	W	M	T	27	63	36	20
105	S	AM	85	W	F	L	51	82	31	20
105	S	PM	82	W	M	T	20	59	39	23
105	S	PM	84	B	M	L	27	72	45	21
105	S	PM	84	B	M	L	35	36	1	21
105	S	PM	84	W	M	T	22	61	39	21
105	S	PM	86	W	M	T	33	65	32	19
105	S	PM	85	W	M	T	31	58	27	20
105	S	PM	83	B	F	T	30	103	73	22
105	S	PM	86	W	M	T	32	70	38	19
105	S	PM	85	B	M	L	24	35	11	20
105	S	PM	86	W	F	T	37	89	52	19
105	S	PM	85	W	F	T	27	55	28	20
105	S	PM	74	I	M	T	29	27	-2	31
105	S	PM	85	W	F	T	29	73	44	20
105	S	PM	86	W	F	T	42	79	37	19
105	S	PM	72	W	F	T	21	49	28	33
106	S	AM	86	B	M	L	42	52	10	20
106	S	AM	85	W	M	L	38	105	67	21
106	S	AM	85	W	F	T	34	67	33	21
106	S	AM	87	W	M	L	40	98	58	19
106	S	AM	84	B	M	L	42	65	23	22
106	S	AM	86	W	M	L	24	70	46	20
106	S	AM	85	W	M	T	22	70	48	21
106	S	AM	86	W	M	L	25	35	10	20
106	S	AM	78	I	F	L	25	72	47	28
106	S	AM	86	W	M	L	37	67	30	20
106	S	AM	86	W	F	L	38	88	50	20
106	S	AM	86	W	F	L	41	63	22	20
106	S	AM	86	B	M	L	29	67	38	20
106	S	AM	79	I	M	T	28	67	39	27
106	S	AM	81	W	F	L	35	88	53	25

106	S	PM	81	W	F	L	24	64	40	25
106	S	PM	87	W	M	T	41	87	46	19
106	S	PM	81	W	M	T	34	96	62	25
106	S	PM	76	W	F	T	42	79	37	30
106	S	PM	66	W	M	T	53	112	59	40
106	S	PM	85	W	M	T	27	56	29	21
106	S	PM	84	W	F	T	38	72	34	22
106	S	PM	85	B	M	L	29	54	25	21
106	S	PM	86	W	M	T	38	101	63	20
106	S	PM	86	B	M	L	21	70	49	20
106	S	PM	86	W	M	L	26	97	71	20
106	S	PM	84	W	F	T	45	56	11	22
106	S	PM	87	W	M	T	40	110	70	19
106	S	PM	87	H	M	L	40	59	19	19
106	S	PM	87	B	F	L	43	78	35	19
106	S	PM	86	W	M	T	42	82	40	20
106	S	PM	83	H	F	L	30	89	59	23
106	S	PM	85	H	F	T	34	61	27	21
107	S	AM	87	B	F	T	22	52	30	20
107	S	AM	72	W	F	L	41	85	44	35
107	S	AM	87	W	M	L	40	79	39	20
107	S	AM	84	B	M	L	37	78	41	23
107	S	AM	87	B	M	L	39	79	40	20
107	S	AM	87	B	M	L	28	63	35	20
107	S	AM	86	B	M	L	25	87	62	21
107	S	AM	88	B	F	L	23	26	3	19
107	S	AM	76	B	F	L	23	59	36	31
107	S	AM	88	B	M	L	30	68	38	19
107	S	AM	81	W	F	T	44	84	40	26
107	S	AM	88	H	M	L	38	79	41	19
107	S	AM	81	W	F	T	24	57	33	26
107	S	AM	87	W	F	L	22	71	49	20
107	S	AM	88	W	M	L	35	76	41	19
107	S	AM	83	B	M	L	20	54	34	24
107	S	PM	71	W	F	T	40	90	50	36
107	S	PM	87	W	F	T	32	87	55	20
107	S	PM	88	W	M	T	28	90	62	19
107	S	PM	88	W	F	T	35	68	33	19
107	S	PM	79	W	M	T	46	92	46	28
107	S	PM	87	W	F	T	36	70	34	20
107	S	PM	85	W	M	L	29	97	68	22
107	S	PM	88	W	F	T	33	106	73	19
107	S	PM	79	W	F	T	25	53	28	28

107	S	PM	83	I	M	T	24	69	45	24
107	S	PM	81	B	M	T	45	87	42	26
107	S	PM	86	B	M	L	26	89	63	21
108	F	PM	86	B	M	L	36	62	26	22
108	F	PM	90	B	M	L	31	84	53	18
108	F	PM	88	I	M	T	31	50	19	20
108	F	PM	90	W	F	L	34	94	60	18
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108	F	PM	87	W	F	L	29	108	79	21
108	F	PM	90	W	F	T	34	79	45	18
108	F	PM	90	W	M	T	47	81	34	18
108	F	PM	87	W	F	T	21	59	38	21
108	F	PM	90	H	M	L	27	76	49	18
108	F	PM	90	W	M	T	23	56	33	18
108	F	PM	88	B	M	L	21	44	23	20
108	F	PM	87	B	M	L	25	68	43	21
108	F	PM	89	W	M	T	53	80	27	19
108	F	PM	88	W	M	T	27	61	34	20
108	F	PM	88	A	F	L	40	98	58	20
108	F	PM	89	W	F	T	28	57	29	19
108	F	PM	90	W	F	L	36	89	53	18
108	F	PM	89	B	M	L	23	39	16	19
109	S	PM	85	W	F	L	29	42	13	24
109	S	PM	88	W	M	L	26	91	65	21
109	S	PM	82	B	F	T	35	88	53	27
109	S	PM	88	W	F	L	26	57	31	21
109	S	PM	73	W	M	T	32	87	55	36
109	S	PM	86	H	M	L	27	82	55	23
109	S	PM	88	W	F	L	22	61	39	21
109	S	PM	87	B	M	L	31	62	31	22
109	S	PM	89	B	M	L	41	52	11	20
109	S	PM	71	W	F	T	36	87	51	38
109	S	PM	87	W	F	T	23	66	43	22
109	S	PM	89	B	M	L	38	98	60	20
109	S	PM	89	W	M	T	42	86	44	20
109	S	PM	87	W	F	T	24	30	6	22
109	S	PM	81	B	F	T	36	91	55	28
109	S	PM	89	B	M	L	46	73	27	20
109	S	PM	90	B	M	L	21	22	1	19
109	S	PM	79	W	M	L	49	92	43	30
109	S	PM	84	W	F	T	41	97	56	25
109	S	PM	90	B	M	T	30	45	15	19
109	S	PM	87	W	F	T	26	39	13	22

109	S	PM	89	W	F	T	49	74	25	20
109	S	PM	62	B	F	T	32	57	25	47
109	S	PM	89	B	M	L	39	79	40	20
109	S	PM	88	B	M	L	32	77	45	21
109	S	PM	85	W	F	T	42	105	63	24
109	S	PM	89	B	M	L	41	85	44	20
109	S	PM	90	B	M	L	27	42	15	19
109	S	PM	89	W	F	L	40	90	50	20
109	S	PM	89	W	M	T	31	96	65	20
109	S	PM	85	W	F	T	33	89	56	24
109	S	PM	82	H	M	T	28	86	58	27
109	S	PM	79	W	F	T	30	79	49	30
109	S	PM	89	W	M	L	55	87	32	20
109	S	PM	79	B	F	T	28	77	49	30
109	S	PM	90	B	M	L	29	88	59	19