THE EFFECTS OF BEHAVIORIST AND CONSTRUCTIVIST INSTRUCTION ON STUDENT PERFORMANCE IN COLLEGE-LEVEL REMEDIAL MATHEMATICS

A Dissertation

by

MURRAY WILLIAM COX

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

August 2011

Major Subject: Curriculum and Instruction

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ABSTRACT

The Effects of Behaviorist and Constructivist Instruction on Student Performance in College-level Remedial Mathematics. (August 2011)

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The number of American students with insufficient post-secondary mathematical abilities is increasing, and the related rate of student attrition increases alongside the upsurge in college developmental programs. As a consequence, the demand for quality remedial mathematics classes is also growing. Institutions that place learners into remedial classes must also fund these same programs, and are increasingly faced with disgruntled students, the appearance of having lower standards, and a demoralized faculty. The legal implications concerning placement and access have gone as far as litigation over student rights. The threat of performance based funding means that educational institutions are in need of demonstrably effective mathematical remediation techniques.

This study examines the effect of pedagogical style for college-level remedial mathematics students and the effect of the chosen assessment method in determining student success. Specifically, this study explains student achievement for college students exposed to a pedagogical style from either the constructivist or behaviorist foundation as measured with short-answer, rote-knowledge questions and with long-answer, deductive-reasoning questions. Furthermore, consideration of student self-efficacy is investigated in order to account for any variation in instructional method. Ultimately, this study describes the effects of both instruction type and assessment method on the success of college-level remedial mathematics students.

The findings in this study reveal quality teaching is of paramount importance in educating the remedial college student. Students from both methods, with instruction being performed with high fidelity, demonstrated statistically significant improvement over the semester. Moreover, the findings in this study further reveal that remedial students with strong reasons to succeed (combined with the quality teaching method) find success in the developmental mathematics classroom regardless of assessment method. In fact, though students tend to score higher on short-answer questions than extended-answer questions, the amount of improvement after a semester of quality teaching is nearly equal in question types under both instructional methods.

DEDICATION

For my father, possessor of great intelligence, supreme creativity, and an original imagination, who inspires thinking, diligence, and hard work.

“But the power of instruction is seldom of much efficacy, except in those happy dispositions where it is almost superfluous.”

– From Edward Gibbon, *The Decline and Fall of the Roman Empire*

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NOMENCLATURE

DI	Direct instruction
PI	Personalized instruction
SAT	Scholastic Assessment Test
SIR II®	Student Instructional Report II
SWAU	Southwestern Adventist University
D_E	Mean score on direct-instruction extended-answer questions
D_S	Mean score on direct-instruction short-answer questions
P_E	Mean score on personalized-instruction extended-answer questions
P_S	Mean score on personalized-instruction short-answer questions

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1. INTRODUCTION AND RATIONALE

Introduction

American students are not succeeding in mathematics at levels comparable to students in other international leading countries. As a result, the demand for quality remedial mathematics classes is growing in community colleges and four-year colleges across the U.S. (National Mathematics Advisory Panel, 2008). For example, as many as 80% of students in New York were required to take at least one remedial course, and 87% of incoming freshmen were failing at least one of three basic skills exams (Wright, 1998). Similarly, California campuses have enrolled as many as 90% of freshmen into remedial education (Hoyt & Sorensen, 2001).

The prominence of college remediation has become a serious issue for numerous people and institutions. Both students and colleges are spending increasing amounts of time and money on remediation. Colleges, especially, are scrambling to find a way to help newly arriving students succeed in their mathematics courses in order to maintain student numbers. Students are prone to leave college if they are not able, or not even allowed to attempt, to complete a non-remedial college-level mathematics course. The legal implications concerning placement and access have even, in some cases, prompted litigation over this debate (Armstrong, 2001).

This dissertation follows the style of *American Educational Research Journal*.

When students are asked to resolve a supposed gap in academic ability befor they can enroll in courses for college credit, then the proposed fix should be a probable cure and not just the provision of a holding area until students make a different life decision. Indeed, Weissman, Bulakowski, and Jumisko (1997) warn, "The performance-based funding initiative sweeping the United States means that . . . colleges must be prepared to prove that the programs and policies they have established improve students' chances to succeed and achieve their academic goals" (p. 79). Proving the effectiveness of a college-level remedial course necessitates information concerning quality teaching-and-learning experiences. In order for a college to be prepared to demonstrate the effectiveness of a program and implement a working policy, the institution must be aware of what works and what does not. Yet proven methods for college-level remedial mathematics students are rare and implementing a system that leads to student success is often a hit-and-miss process.

Purpose

The aim of this study is twofold: first to determine the effect pedagogical style has on the results of an end-of-course exam for college-level remedial mathematics students and, second, to ascertain the effect of two assessment methods in making this determination. Specifically, this study explains student achievement for college students exposed to a pedagogical style from either the constructivist or behaviorist foundation. Both instructional styles are discussed within mathematics education literature.

Instructional style in general is considered an appropriate approach to guiding the remedial student. Venville, Sheffield, Rennie and Wallace (2008) stated that the classroom context affects learning. Roth (2000) also pointed out that mathematics scores were indeed sensitive to instructional type. Various other researchers have concluded that pedagogy affects the success rates of college students in remedial classes (Baxter & Smith, 1998; Waycaster, 2001).

However, current research does not point to instruction focused on the student alone nor does it indicate instruction should be entirely focused on the teacher (National Mathematics Advisory Panel, 2008). This investigation of classroom pedagogy was conducted by accounting for a number of components found in any classroom – the teacher (teaching method), the student (self-efficacy), and how learning is measured (the assessment method) – while holding other variables constant.

These three variables (teaching method, student sense of self-efficacy, and assessment method) were either manipulated or accounted for while investigating the teaching-learning experience; interaction between variables was also considered. Each variable was important in its own way. First, teaching methods vary with instructor, and the method in which instruction should be delivered must be informed by educator judgment, quality research, and experience. Second, student sense of ability is critical to accurately measuring the success of any teaching method because educational efforts are hampered when students sabotage research efforts through lack of interest or effort due to self-efficacy issues. Finally, assessment is important because different metrics can produce different conclusions. In fact, a 2008 report by the U.S. Department of

Education concluded, “More research is needed on test item design features and how they influence the measurement of the knowledge, skills, and abilities that students use when solving mathematics problems on achievement tests” (National Mathematics Advisory Panel, 2008, p. 61).

For that reason, in addition to noting pedagogical influence, this study describes how assessment methods affect students’ ability to demonstrate their knowledge within different pedagogical contexts. Interaction between pedagogy and assessment method was investigated to account for one instructional method appearing more beneficial under a particular assessment.

Alongside pedagogical effects and analysis of assessment, this study also considered the perceptions of the students immersed in the instructional methods. Student perception of their ability to succeed is important in determining pedagogical effects because students must be involved and interested in class in order to make accurate inferences; student efficacy perceptions can account for possible variation in instructional method. These perceptions were measured using a battery of questions found in the Student Instructional Report II ® (SIR II ®, 2009) questionnaire. Ultimately, this study describes the effects of both instructional types and assessment methods on the success of college-level remedial mathematics students.

Background

Research at the college level is particularly important in light of the suggestion that the current methods in which mathematics is taught and learned in the U.S. are not working and must change (National Mathematics Advisory Panel, 2008). The implication is that many students who arrive at college do so with a poor mathematics foundation and possibly the realization that they are on their last chance. Failing out of college infers the student will not be able to go on to higher level education. Effective developmental classes are, thus, vital to overall collegiate success (Hodges, 1998).

The reason for students being admitted to college with less than an adequate foundation is a matter of debate. The cause may be as straightforward as a mismatch in what is taught in secondary school and what is measured by placement exams (Latterell, 2007). Another view offered by Dettori and Ott (2006) is that previous achievement does not necessarily match current ability. Alternatively, Ruiz (1999) claimed that more and more low achievers are starting to attend college. Perin and Charron (2003) backed up this latter view with the claim that modern incoming students are simply not prepared for college-level academics. However, none of these explanations address how to teach remedial students on the doorstep of colleges across the country. They merely address possible causes without providing guidance as to how to effectively teach these students.

Solutions to the college remediation crisis are found in enhanced remediation courses and the improvement of instruction (Strong American Schools, 2008). Details on how to enhance and improve instruction, though, have yet to be defined accurately. Young (2002) stated (without specifics) that the retention of a remedial student came from a pedagogy that generates student perseverance. Numerous other researchers have also pointed to pedagogy as the answer to providing success for remedial students.

Implementing a specific teaching method is an important decision for reaching a particular crowd. Improving instruction with any pedagogy in the college classroom is becoming increasingly complex as well as critically important. An engaging and interactive pedagogy is demanded by the generation of college freshmen entering higher education after the year 2000 (Latterell, 2007). Mighton (2008) claimed that changing teaching style to account for new research in cognition may develop more expert learners. Venville et al. (2008) in particular found that success came from small groups and team activities.

Instructional suggestions such as the ones mentioned above fall under the auspices of various teaching theories. Two mainstream theories of instructional practice are behaviorist and constructivist theories. Proponents of direct instruction, an instructional method from behaviorist theory, point out that developmental students often need to be told exactly what to do before they can build up confidence and ability, i.e., dependent learning with a focus on procedure (Weinstein, 2004). Conversely, proponents of personalized instruction, an instructional method from constructivist theory, tend to de-emphasize basic skills in favor of student exploration and discovery. Joyce, Weil, and Calhoun (2004) described the general context of personalized instruction as a student-oriented classroom with the teacher having a working relationship with each student.

Problem Statement

Remediation does not always provide an adequate segue for many students tracked into remedial classes, and little has been written about efficient or effective ways to approach the modern college-level student deficient in mathematical skills. The resulting study builds upon past research to provide detail and clarify our knowledge of effective pedagogy for teaching remedial students. This study could lead to insights into a better understanding of the type of relationship between pedagogy, assessment, and the college-level remedial students' beliefs in their abilities.

Today there are a very small number of quality studies concerning college-level remedial programs and scant information concerning the effectiveness of remediation programs (Bahr, 2008). Just thirty years ago most educators were not even talking about developmental education unless the discussion was about eliminating it or making sure it was in the domain of the community college. The discussion was definitely not at the national level seen today, and there were no policy or legislation to support the concept (Boylan & Bonham, 2007).

It has been suggested that additional research is needed in at least four areas in order to improve mathematical knowledge in students: 1) effective instructional methods and designs, 2) methods of learning, 3) improving the effectiveness of teachers' efforts, and 4) improved assessment of mathematical knowledge via assessment features (National Mathematics Advisory Panel, 2008). Similar conclusions were reached by Jones and Southern (2003) who found that there needed to be significantly more research in the area of mathematics instruction, especially in the area of efficiency and effectiveness rather than focusing on ideology. This researcher agrees with Taylor (2008) who noted that further research was needed to determine best practices in college-level developmental mathematics courses.

The “best practices” for remedial students has been alluded to by a handful of researchers with broad overarching generalizations but there have been few studies that explore these claims. Maxwell, Hagedorn, Cypers, Lester, and Moon (2004) stated that if students are not passing remedial mathematics classes, then colleges should address the learning process. Another study suggested that the lack of success in remedial mathematics implies that the curriculum should be more closely examined (Haeck, Yeld, Conradie, Robertson, & Shall, 1997). A third view offered by Telese and Kulm (1995) was that the chosen assessment method should be considered as it can disguise certain student’s true abilities.

This research will provide insight into the learning processes of college-level remedial mathematics students by examining specificities of teaching, learning, and assessment. This study addresses the teacher, the student, assessment method, and considers the interaction between them. Currently little empirical research exists that measures the effects of instructional methods for college-level remedial mathematics students differentiated by self-efficacy level, and none exists which investigated the effects on decisions made by consulting two different assessment metrics.

Significance

This study will add to the mathematics education literature base by simultaneously analyzing pedagogy and assessment methods of goal driven students. Instructional methods will be compared under two different metrics. The value of contemporaneously comparing instructional methods and assessment techniques lies in the ability to decipher the value of a given method under more than one metric because one metric may imply different results from an alternative metric.

Just as the Taylor study (2008) drew comparisons from the results of students exposed to standard lecture and those who were involved in a web-based, computer-assisted curriculum, this study will compare the results of students exposed to two different classroom instructional teaching philosophies. However, the present study extends the evaluation by narrowing the comparison found within two classrooms with dissimilar and distinct teacher-student interactions. Narrowing the focus is further accomplished by accounting for student self-efficacy and by including more than one metric. This research extends the findings of previous studies that recommended further investigation into elucidating methods effective with remedial students. Finally this study will present conclusions useful for future research of other pedagogical comparisons.

Questions and Hypothesis

The overarching research focus of this study was inquiry into the achievement of college-level remedial mathematics students that participate in different types of instruction and whether these methods differentially impact their understanding as measured through two different types of assessment. The null hypothesis of this study was that there would be no difference in test scores regardless of the teaching method employed. The research questions that were addressed and that provided motivation for the study design were as follows:

1. Do developmental algebra students experience differential achievement rates, on a customized end-of-course exam, based on direct-instruction versus personalized-instruction?
2. Does personalized instruction or direct instruction differentially impact student performance on rote knowledge (multiple –choice items) as compared to synthesis and analysis questions as measured by extended response?
    a. How does personalized instruction affect student performance on (1) short-answer (rote-knowledge) questions and (2) extended-answer (deductive reasoning) questions?
    b. How does direct instruction affect student performance on short-answer (rote-knowledge) questions and extended-answer (deductive reasoning) questions?
3. Does the perception (of instruction) of students in direct instruction (based on the SIR II® categories) differ from the perceptions of students in personalized instruction?
4. Does the self-efficacy of students in direct-instruction (based on SIR II® categories) differ from the self-efficacy of students in personalized-instruction?

As implied from the previous questions, the independent variable, instructional method, was either direct instruction or personalized instruction. The instructional methods were kept distinct in terms of class pacing, class dialogue, guidance provided, and instructional delivery. The treatment was instructional method and it was measured through two approaches.

Dependent variables included exam score difference, perception, and self-efficacy. The dependent variable, exam score difference, was acquired from a comprehensive exam in the form of a pre-test and a post-test. The other dependent variables, perception, and self-efficacy were gleaned from the SIR II® questionnaire. The outcome of this research can help college administrations, department heads, and teachers address remedial students more effectively.

Objectives and Outcomes

The specific objective of this research was to study the effect that defined teaching methods have on college-level remedial mathematics students. Implementing particular instructional philosophies with identifiable procedures moved this purpose forward. In other words, various teaching methods were employed and each method was verifiable with an explicit checklist of behaviors or actions that were representative of the specific teaching method in use. The aim of this research was guided by keeping all other variables constant, and results were then analyzed to define the effect of individual teaching methods.

The results from this study will hopefully guide educators in looking at: (1) effects of different teaching methods, (2) effects of different assessment methods, and (3) student self-efficacy levels using different teaching methods. These outcomes were tied directly to the research questions and hypothesis of this study while simultaneously contributing to previous research calling for more insight into the pedagogy of college-level remedial mathematics students.

Applying Instructional Methods

Within both direct instruction and personalized instruction lecture format is integral. Wood, Joyce, Petocz, and Rodd (2007) claimed that lecturers need to be aware of different modes of presenting material, that a good lecture will inspire students to learn, and that lecture should connect different representations in mathematics. For instance, though both direct instruction and personalized instruction can be delivered via lecture, lecturing within a personalized approach is generally much shorter than in the traditional classrooms (Weinstein, 2004). Using a shorter lecture technique was part of reaching the modern student with a shorter attention span (Latterell, 2007). A quality lecture can be accomplished with a focus on either the student or a focus on teacher knowledge and preparation. The art of lecture lends itself nicely to student emphasis as well as to a teacher-focused information source.

Limitations

A potential weakness of this study is that the data were collected from a university with fewer than 1000 students. Though the student body is quite diverse, they are part of a small, private, parochial university that may limit the scope of these results, i.e., limiting the ability to generalize findings outside small parochial colleges. As a consequence, the sample sizes drawn might not be large enough to produce statistically significant results. Though the sample sizes could be seen as a design flaw, the limitations of the present study involving sample size will be partly nullified with the addition of interviews and other qualitative research techniques. In addition, participant sampling was completely random, and lack of class overlap contributed greatly to keeping the results indicative of the treatment.

A confounding variable would be the teacher effect. The use of different teachers could influence the data in unintended and or unexpected ways because there is the potential for teacher bias error. Having two different teachers demonstrating two different instructional models creates the prospect of introducing a teacher effect due to individual experiences, charisma, and classroom management style among other qualities. However, student perception of their teacher's instructional methods will be measured and compared from the SIR II® in order to account for any disparity in preference. Alternatively, two teachers are actually desired because they can then teach to their strength without having to be an actor in a teaching method that they do not truly believe in.

Delimitations

This study is delimited by the researcher in several ways. First, though the sample used can be considered a convenience sample as it was taken from the university at which the researcher teaches, the size is indicative of a typical small college, i.e., university population is in line with generalizing to smaller institutions. Choosing a smaller university with an open enrollment was decided, in part, due to its similarity to the typical smaller college. This milieu contains the type of students most in need, with regards to remedial mathematics, and, hence, here is where to start investigating the problem.

Second, the sample was selected from a private institution. Many of the attending students also attended small private high schools before enrolling at the university involved in the study. Those students who are enrolled in public educational settings may bear different characteristics and, therefore, will not be represented by this sample population.

Assumptions

Assumed in this research is the idea that student perceptions of the instruction they received as well as the classroom environment are valid and valuable measures of how well the applied teaching method worked. As such, special attention was placed on student survey responses. In general, it is assumed that student effort played a key role in the determination of efficient teaching methods. It is also assumed that the chosen pedagogy affected the students' ultimate grade.

Definition of Key Terms - Remedial

The word "remedial" is an expression that is encompassed by a larger category. The term "developmental education" refers to a wide range of courses and services that are put in place to provide successful completion of college-level academics partly in an effort to retain at-risk or remedial students. Remedial courses are a subset of developmental education, are non-credit bearing courses, and are made up of content considered to be pre-college. Students who partake in remedial courses are by definition, remedial students (Boylan & Bonham, 2007).

Definition of Key Terms – Behaviorist and Constructivist

Behaviorism and constructivism are theories that inform instructional methods such as direct instruction and personalized instruction, respectively. The concept behind behaviorism is that people react to their environment due to external conditions, these reactions become conditioned, and the behavior is then learned. The behaviorist model of education emphasizes teachers teaching content to students using particular methods (Joyce et al., 2004). Since direct instruction focuses on the content to be learned and a "direct" delivery system for learning that content, direct instruction is behaviorist in nature. In contrast, constructivism suggests that learning is the social construction of knowledge. Constructivists emphasize that students are taught by and with the teacher and each other *how* to learn new content (Joyce et al.), and, hence, personalized instruction is constructivist since it emphasizes the give and take of questioning content, assimilation of content, and how students learn (Campbell, Robinson, Neelands, Hewston, & Mazzoli, 2007).

Definition of Key Terms – Direct Instruction and Personalized Instruction

Direct instruction is a teaching method well described by its very title. Direct instruction, a behavioral approach, emphasizes teacher behavior and initial instructional motivation (Kinder & Carnine, 1991). Thus, the focus of direct instruction is on the teacher and the teacher's actions.

Personalized instruction focuses on understanding students, who they are, and what their needs are. Personalized instruction, a broad term, encompasses a variety of activities including a lecture format. Personalized instruction includes activities such as getting to know students on a personal basis, understanding students on their level, being a friend of students, knowing student names, and creating a self-paced atmosphere. Personalized instruction, however, is all of these and more. Personalized instruction also considers learning styles, student needs and talents, individual interests, and each student's academic background (Jenkins & Keefe, 2001).

Organization of the Dissertation

This dissertation is divided into five sections. Each section is titled and has corresponding subtitles describing the content. This first section has introduced the general problem and issues under investigation, the approaches previously applied to these issues, and the unique approach proposed for this study. Section 1 also introduced the big picture of this research with brief descriptions of concepts taken into account. Additionally, the conceptual basis of the study was established with supporting research for the study focus.

Section 2 contains literature and research related to the broad topics including specifics about teaching philosophies, pedagogy, assessment, and student self-efficacy. Methodologies, instrumentation, and participant demographics are presented in Section 3 including the research design, selection of the sample, data collection tasks, and data analysis procedures. Results obtained from these methodologies are detailed in Section 4. The final section, Section 5, is a summary and discussion of the study with interpretations and recommendations. Section 5 also provides implications for practice and further research as well as the relationship of the results to theory.

2. REVIEW OF LITERATURE

Introduction

This section contains literature and research related to the broad topics including specifics about teaching philosophies, pedagogy, assessment, and student self-efficacy. Beginning with a description of the criteria and foundation for relevant literature, this section contains a theoretical perspective, definitions, and a review of literature addressing the growing number of students arriving at colleges with less than adequate mathematical ability and the problems that ensue. There is also a review of the literature on possible pedagogical solutions and the variables that predict the success of students in remedial mathematics courses. Next, the literature concerning lecture as a delivery system is reviewed. Finally, studies on assessment and its effect on predicting success are reviewed.

The purpose of this review is to provide an understanding of previous research concerning college-level remediation as well as providing a rationale for investigating student attitudes on personal ability and to take assessment methods into account when evaluating student performance. Broadly speaking, the items selected for review address three main characteristics: Mathematics remediation, pedagogy, and assessment. First, literature is reviewed concerning remediation with facts and figures about the repercussions of increasing numbers of college level remedial students in mathematics. The second area includes a discussion of teaching and learning. Finally, the discussion concludes with a look at the assessments of students with self-efficacy.

Literature Criteria

The literature review contained in this section is aimed at identifying, assimilating, summarizing, and synthesizing all studies germane to pedagogy, self-efficacy, and assessment for college-level remedial mathematics students. The following databases were mainly used: Wilson Select, ERIC, PsycINFO (CSA), and Academic Search Complete (EBSCO).

The researcher included texts and only full articles in the literature review. The terms used in searching the literature were: *Remedial, developmental, college, university, mathematics, algebra, self-efficacy,* and *assessment*. The boundaries chosen were studies published in highly respected peer reviewed journals, conducted since 1990, concerning remedial mathematics students, with a focus on college students.

Purpose and Theoretical Perspective

The purpose of this study was to determine the most effective approach to teaching and assessing college-level remedial mathematics students. The theoretical framework of this study was built on the epistemological theory that self-efficacy affects student performance and attainment. Several researchers have pointed out that students' confidence about their abilities in math class (self-efficacy) was a significant predictor of how well they were going to perform (Carmichael & Taylor, 2005; House, 2001; Malpass, 1999; Singh, Granville, & Dika, 2002; Wadsworth, Husman, Duggan, & Pennington, 2007). Self-efficacy was significantly related to effort, that is to say that students with higher self-efficacy put forth more effort than students who were not confident in their abilities (Skaalvik and Skaalvik, 2005; Wadsworth et al., 2007). Students' belief in their ability to succeed (self-efficacy) motivated desirable learning behaviors (Carmichael & Taylor, 2005) and it strongly influenced their motivational attitudes (Middleton & Spanias, 1999). Belcheir (2002) stated that ". . . ultimately nothing an instructor can say or do will make a difference if the student is unmotivated to implement it" (p. 2).

Self-efficacious students will ultimately put forth more effort, be more motivated, and, therefore, will provide a truer picture of teaching method effects (Hall, 2002). Hence, in order to account for effort bias, this study took into consideration the students' perceptions of their ability, and, therefore, their effort level. In this manner the true effect of the teaching strategies, as measured via the different assessment techniques, was determined (Tapia & Marsh, 2004).

Pedagogically speaking, the dominant theoretical perspective in the mathematics education research community is that of constructivism. According to this perspective, students are the ones that make meaning, and the teacher is a simple guide in the co-construction of meaning and knowledge (White-Clark, DiCarlo, & Gilchriest, 2008). This theory rattles against the concept of the student being an empty container waiting to be filled (Weinstein, 2004).

A competing perspective found in the literature is that of behaviorism along with the view that learning is an individual act as opposed to a social act. This behavioral model has its foundation in the works of B. F. Skinner with principles of conditioning like those espoused by Pavlov (Joyce et al., 2004). According to this perspective, human beings self-correct in response to stimuli such as information concerning their success or failure (Kinder & Carnine, 1991).

Remedial Mathematics

Young (2002) stated that developmental and/or remedial mathematics education was defined as mathematics courses for students in college who do not have the pre-requisite skills needed to perform at the level required. Kozeracki and Brooks (2006) stated that the U.S. Department of Education defined developmental education as "courses in reading, writing, or mathematics for college students lacking those skills necessary to perform college-level work at the level required by the institution" (p. 2). Another description of remedial, given by Perin and Charron (2003), provided a similar definition; they defined remediation as instructional activities intended to bring academic abilities to a postsecondary level. In broader terms, then, developmental education was an all-encompassing approach to providing students with an improved ability to learn. This is a more holistic concept than merely providing extra classes for students deemed underprepared (Illich, Hagan, & McCallister, 2004).

The terms remedial and developmental were, indeed, often used synonymously. In actuality, a number of terms referred to the same category of student. Young (2002) stated that students who were considered remedial were also assigned the term underprepared. These students might be part of an educational program termed developmental, remedial, or even preparatory with all of these terms being used synonymously (Kozeracki & Brooks, 2006).

Another term sometimes heard in similar discussions was that of the at-risk student. Though these students were often found in the same classes as the remedial student, their classification was somewhat different. Students referred to as at-risk were students guaranteed to fail if no intervention were to take place (Young, 2002). Thus, remedial students and at-risk students were both not performing at the college-level; whereas some remedial students might go on to find success, at-risk students would not succeed unless proper guidance was interjected on their behalf.

Beyond using the words to label students is the question of their definition. There are actually slightly varied meanings behind these words. The differences do not lie in the actual word being used; rather, the difference is in who is using the word. Each college maintains its own standards; therefore, developmental education is defined by each institution (Kozeracki & Brooks, 2006). A student was termed remedial by the particular test that he/she took, and there was no consensus on a single metric. Finding the appropriate policies for the optimal placement of students continues to elude those who have tried (Rodgers & Wilding, 1998).

Remedial students are deemed as such only by the institutional standards of the college they attend and standards vary from state to state. There is a lack of consistent definition across institutions (Saxon & Boylan, 2001). In essence, remedial students take remedial course work; this work is part of the student's identity. Remedial coursework is part of developmental education and is considered to be academic work that prepares a student for the rigors of college. Mathematics classes such as introduction to algebra and intermediate algebra are part of the college developmental education program (Illich et al., 2004).

Prevalence of the Modern Remedial Student

Issues such as remediation and the role of the high school have been around for more than a century. Contrary to the popular viewpoint today, one of the first school-reform commissions in the U.S., the Committee of Ten in 1893, stated that the purpose of high school was *not* to prepare students for college. This perspective remained to be predominantly true until more modern times (Strong American Schools, 2008).

For most of U.S. history, a college education was reserved for a privileged few. However, recent studies have indicated ninety-four percent of high school students claimed they wanted to attend college after graduation. This situation has left policymakers battling an incomprehensible connection between aspiration and achievement (National Leadership Council for Liberal Education, 2008). One researcher (Strong American Schools, 2008) concluded that increased numbers of students desiring to attend higher education implies that college student populations are no longer occupied by the honored top few high school graduates. This same researcher stated that many campuses are inundated with remedial students and, ironically, the modern student is required to have a much larger skill set with a more rigorous foundation of knowledge than previous generations.

Subsequently, numerous college freshmen have arrived unprepared for their academic venture (Perin & Charron, 2003). This group of remedial students was not in the freshman minority on several campuses; actually at certain institutions they made up the vast majority of incoming students. Some college campuses in California are witnessing up to 90% of their freshmen in need of remedial education (Hoyt & Sorensen, 2001). Remedial courses are now the norm at many higher-level institutions. One study found ninety-five percent of the U.S. community colleges offer remedial education (Young, 2002). Furthermore, of the students enrolled in mathematics classes in college, greater than one-third were in classes described as developmental (Johnson, 2007).

Not all of the students filling these classes were necessarily bottom tier students either. Eighty percent of remedial students were found to have had a high school grade point average of 3.0 or higher (Strong American Schools, 2008). Students who had high grade point averages in high school and were taking college preparatory classes were still being found not able to keep pace at the college-level (Strong American Schools). In other words, remedial students were doing what was expected of them in high school, taking college preparatory classes and even maintaining a high enough grade point average, only to find that their chosen colleges judged them unworthy of direct entry (Hoyt & Sorensen, 2001).

One study (ACT Inc., 2005) found that today's high school graduates were simply finding themselves underprepared for college-level work. More students than ever before have been entering colleges with fewer algebra skills and were being required to take remedial mathematics classes as a result (Latterell, 2007). Consequently, the necessity for remediation programs has greatly increased since 2000 (Illich et al., 2004).

Consequences and Costs

In the past, the majority of high school graduates did not pursue higher education. Many found work in sales and in factories as their destination from high school. In fact, before the 1980's, not even half of high school graduates sought higher education. It is a much more modern phenomenon to witness the preponderance of high school students making decisions to attend college. Presently, an undeniable majority of high school graduates are indeed attending higher education (Strong American Schools, 2008).

Despite student interest in going to college, Illich et al. (2004) stated that high remediation numbers were important to keep under control because students enrolled in remedial courses have been found to have much lower pass rates and were destined to drop out when they could not complete these remedial courses. One study found the numbers of community college students that transfer to four-year institutions was, in fact, quite low; in California less than 5% of students made this transfer (Maxwell et al., 2004). The main reason for low transfer rates from community colleges has been found to be the inability to pass remedial mathematics courses (Maxwell et al.).

The National Leadership Council for Liberal Education & America's Promise (2008) claimed the inability to progress to four-year institutions meant that students were stopped in their quest for higher education. Furthermore, when students did not continue their education they put themselves at possible future risk. This risk included a significantly lower standard of living due to lower wages earned in a modern society where education after high school was an imperative for nearly everyone.

From a larger perspective, the displeasure with developmental expenses has been found to be spreading quickly (Wright, 1998). There are extensive feelings of discontent with having to spend increasing amounts of time and money on remediation (Wright). Bahr (2008) stated that taxpayers were actually paying two times for the same education: high school first, then college. Those opposed to remediation further argued that federal financial aid should not be used for remedial purposes (Saxson & Boylan, 2001).

The direct monetary cost of remedial programs was estimated between one and two billion dollars per year, and the indirect costs were estimated to be approximately $17 billion per year (Bahr, 2008). During the 2004-2005 school year, the entire cost for remediation was found to be between $2025 and $2531 per student in a public four-year institution (Strong American Schools, 2008). The total amount of money paid for tuition and fees in remediation was found to be between $708 million and $886 million (Strong American Schools).

The cost of college remediation, however, is measured in more than dollars. Remediation is said to lower academic standards and diminish colleges' credentials as well as demoralize faculty. Currently, remediation is in crisis due to its sheer size and purpose, and college-level remediation has been described as the most important problem in education that currently faces the United States (Bahr, 2008).

Juxtaposed Positions

How to best work with a costly over-abundance of remedial students is said to be in the instruction (Hambleton, Foster, & Richardson, 1998). However, the most appropriate type of instruction for remedial mathematics students is found to be a continuing matter of debate in the field (Jones, & Southern, 2003). There exist supporters for a pedagogical style from the constructivist foundation and at the same time there are those who endorse a pedagogical style from the behaviorist foundation (Weinstein, 2004). Both styles are simultaneously promoted by advocates and resisted by opponents in educational literature.

The majority of research points to constructivist instruction for remedial mathematics though there is a schism in mathematics education over whether learning is an individual act or a social act (Weinstein, 2004). Dettori and Ott (2006) indicated that a social, personalized approach to teaching and learning helps remedial students in mathematics find success. On the other hand, Kinder and Carnine (1991) pointed out that direct instruction aimed at individuals has been found to produce greater academic gains when compared to any of the other forms of instruction it has been compared with.

Some researchers (proponents of constructivism) maintained that students found experiences in mathematics more meaningful and, therefore, more motivating when they were able to construct the knowledge themselves (Jones & Southern, 2003). Mathews (1996) pointed out that such educational luminaries as Piaget, Dewey, and Montessori felt that people learn best when they do something and then thought about what they did. Mathews found that mathematics classes consisted of two features: the teacher's component and the students' component. He further stated that if the focus of the class was on the students' issues, then the teachers' aspects would take care of themselves.

Traditional teaching must give way to personalized pedagogical ideas such as activities, talking less to students and listening more to them, and reflection (Mathews).

Conversely, proponents of direct instruction (behaviorist theory) have pointed out that developmental students often need to be told exactly what to do before they can build up confidence and ability, i.e., dependent learning with a focus on procedure (Weinstein, 2004). Stunkel (1999) stated that authentic learning was the result of an individual effort that cannot be a shared experience. Wadsworth et al. (2007) stated that the most important factors predicting grade achievement (self-efficacy, motivation, concentration, information processing, self-testing) were all affected by direct instruction. Hashemzadeh and Wilson (2007) found there was no correlation between lecture and passive learning/disengagement that had been widely assumed; these researchers claimed that student's valued direct instruction in the form of lecturing skills when compared to alternative methods. In other words, direct instruction was inferred to be superior to social discovery.

Opponents of personalized instruction pointed out that direct instruction, in the form of a quality lecture, was inspiring and motivated students to learn (Wood et al., 2007). Learning from those more astute and/or educated was plainly an important skill to cultivate. Furthermore, it was claimed that knowledge was best learned as an individual effort with an educated teacher as the leader (Stunkel, 1999). No interactive model can match a quality presentation that amasses information, brings to light the most pertinent concepts, advises applications, covers the important findings and interpretations, and presents an example of a caring, learned, inquisitive teacher (Stunkel).

Opponents of direct instruction, however, maintained that presenting information and having students repeat it was a passive activity that worked well on standardized tests, but was mostly ineffective for higher-order thinking (Mathews, 1996). Traditional instruction was teacher-led and did not promote problem solving or mathematical reasoning (Jones & Southern, 2003). Direct instruction was said to be effectual in teaching simple skills but not in teaching complex skills, especially to difficult-to-teach students (Jones & Southern). Long-term thinking and versatile problem solving were not served well with lecturing and listening (Mathews).

Possible Solutions

Mathews (1996) stated that mathematics teachers had to learn how to teach in a pedagogical fashion that worked for students that were likely different from themselves. A college student's success in a course was partly dependent on the effectiveness of the instruction and partly on the informed instructor assisting students in developing strategies for retaining information and expanding their knowledge base (Thiel, Peterman, & Brown, 2008). The effectiveness of instruction in turn was dependent upon how the teacher decided to structure the classroom as either socially oriented or centered on the individual, i.e. the context of the classroom affected the way curriculum was set up which was said to affect how students were going to learn (Venville et al., 2008).

Appropriately enough, Young (2002) claimed one of the first places to consider when working with remedial students was the classroom and the method of teaching and learning to be used. The chosen instructional method was said to be one that generated a great amount of student determination. To this end, teachers needed to be aware of effective teaching strategies and how to put these ideas to work (Wadsworth et al., 2007).

Remedial mathematics students think about mathematics in a very different manner than the typical mathematics instructors does (Weinstein, 2004). Mathematics teachers realized that the students in their classes were not younger versions of themselves nor did remedial students think in similar ways as their instructors who had completed more mathematics courses (Latterell, 2007). Mathematics was difficult to comprehend for many students (Latterell) and the discovery process had to be fun for students in order for them to persist in their attempts. Students should be allowed to play at math and discover in their learning process (Mighton, 2008). Simply put, where mathematics is concerned, remedial students carry a different mindset than their teachers.

The success of the college student was based on many different factors such as ability, previous subject knowledge, instructional effectiveness, and self-efficacy (Thiel et al., 2008). Pedagogies that produced interest enhanced persistence, and each student had different interests; therefore, the contemporary college student needed a customized pedagogy (Latterell, 2007). Waycaster (2001) and Baxter and Smith (1998) stated that different pedagogies affected the success rates of remedial students. Roth (2000) supported this point and added that math scores were sensitive to instructional type. Latterell (2007) also identified that the newest college freshmen, the “Millennial” (p. 67) generation, demanded a certain (but unnamed) type of engaging and interactive pedagogy.

Pedagogical Approaches

There are a few different theoretical frameworks concerning the most appropriate teaching methods for remedial students. One approach was to address all students from an epistemological standpoint. This view maintained that student beliefs were the primary point of concern to overcome in order to promote learning (Koller & Baumert, 2001). Another stance was that of reflective thinking whereby students were encouraged to think about their own questions (Hammerman & Goldberg, 2003). Students were not treated as receptacles of information as much as they were treated as creators of knowledge. A third mode of dealing with the remedial population focused on specific learning approaches as the preferred technique. Learning approaches were centered on situations in which the students learned best (Hammerman & Goldberg). Each framework, which placed emphasis in a different area, is individually addressed.

Epistemological Beliefs

First time students to college found that they were asked to be more responsible for their own learning (Wadsworth et al., 2007). These students were better equipped to make a smooth transition to accountability when they possessed behaviors and beliefs that made possible the attainment of new knowledge. Hall and Ponton (2005) stated that an educator's primary role should be to do whatever was needed to increase students' perceptions of their own ability.

Epistemology focuses on these student perceptions and some researchers (Hall & Ponton, 2005) found that when students believed in themselves, they also performed at an accelerated level, i.e. a student's perception of his/her own ability, or self-efficacy, played an important role in mathematical success. Alexander and Buehl (2005) confirmed that epistemological beliefs are related to learning outcomes. In a similar manner, students with negative attitudes were found to be more prone to failure (Hammerman & Goldberg, 2003). Furthermore, self-efficacy was affected when students were embarrassed or ashamed; remedial classes were seen as a stigma to those students enrolled in such classes (Hall & Ponton, 2005). Taylor (2008) confirmed that negative attitudes and anxiety affected mathematical achievement. Previous events, negative and positive, affected students' accomplishments in education, and it has been determined that remedial students' previous experiences, attitudes, and emotions all played a role in their academic performance (Ironsmith Marva, Harju, & Eppler, 2003).

To take into account these important self-efficacy concepts, the ethic of care can be employed in the design of remedial curriculum and classrooms in an attempt to deal with student anxiety. The context of the classroom affected the way curriculum was set up, which in turn affected how students learned (Venville et al., 2008). Creating an atmosphere that did not belittle the student and letting the students know the class was going to be operated fairly was part of the process that affected student epistemology and eventually allowed each student an opportunity to gain knowledge (Hall & Ponton, 2005).

Reflective Thinking

Reflective thinking involves being more engaged in the question and answer process. In this framework students should be encouraged to answer their own questions (Hammerman & Goldberg, 2003). Teachers promoted more reflective thinking with a change in their own perspective of the class. Teachers habitually ranked their students, sometimes subconsciously, in groups based upon achievement (Dettori & Ott, 2006). The problem, however, was students' achievements and abilities were not necessarily related to each other (Dettori & Ott). If teachers changed their thinking about student ability and changed their thinking about how they needed to assess student ability, then they could get rid of artificial hierarchies in the classroom (Mighton, 2008).

Learning Approaches

Another theoretical perspective was to design pedagogy in a manner that considered the learning ability of the students and conveyed information in an original and thought provoking way (White-Clark et al., 2008). Students often had difficulty learning in remedial mathematics classrooms because they had to overcome previous misconceptions and needed to see information presented to them in new and different ways (Hammerman & Goldberg, 2003). These developmental students often needed creative and non-traditional teaching methods. At the same time, previous faulty misconceptions needed to be replaced with new and corrected perceptions (Hammerman & Goldberg).

Affecting how students learn started from the bottom up before the syllabus was written and before the grading of papers began (Anthony, 2000). The milieu of the classroom was designed first because classroom context affected curriculum design that in turn affected how students learned (Venville et al., 2008). School context including such features as the organization of the school, the structure of the classroom, the teacher's qualifications, the timetable utilized, and the assessment method applied also affected curriculum design and teaching approaches (Venville et al.).

The Direct and Personalized Classroom

Both direct instruction and personalized instruction fall under wider umbrellas. Direct instruction was considered behavioral and connected to the learning approach taken with students (Jones & Southern, 2003). Personalized instruction was considered to be constructivist, which was more of an epistemological viewpoint (Hambleton, Foster, & Richardson, 1998). Both of these larger concepts envelop the instructional methods. In simple terms the line separating the two can be stated as direct instruction emphasized the content to be taught while personalized instruction emphasized inquiry and how to learn (Joyce et al., 2004).

Direct Instruction

Direct instruction (behaviorist) consists of many components such as reinforcement, mastery, regular assessment, assessing directly, using task analysis to break bigger tasks into smaller ones, and introducing prerequisite skills. These components are all part of the theory behind the effectiveness of direct instruction. Studies have found that direct instruction is known to produce greater academic gains than other forms of instruction (Kinder & Carnine, 1991). Stunkel (1999) declared there was no equivalent to a well- thought out, well-designed lecture from a competent, knowledgeable, caring, questioning teacher with the ability to bring out relevant information and convey it to students. The focus of the labor involved to fit that description is performed by a teacher using direct instruction.

Jones and Southern (2003) defined direct instruction as follows:

> The term direct instruction has been used broadly to refer to behaviorally based instructional activities that are directly related to increasing achievement in basic academic skills. Accordingly, instructional procedures are considered to be “direct” if the explicit purpose of instructional activities is to increase academic achievement and if instruction emphasizes teacher behaviors and variables related to classroom structure, such as small-group instruction, teacher direction of learning, academic focus, high rates of accurate responding, controlled practice, use of higher cognitive-level questions, group responding, independent practice, and feedback to student responses. (p. 4)

Direct instruction differed from other behavioral models in that it put stronger emphasis on the words of the teacher which were the preliminary motivation (Kinder & Carnine, 1991). Direct teaching emphasized the teacher’s introductions and examples while focusing on how the teacher presented new material (Kinder & Carnine). The focus is now on the teacher’s knowledge instead of the student’s classroom efforts.

Direct instruction is most often associated with lecture, and lecture is currently the most popular teaching method for college-level mathematics. Proponents of direct instruction (lecture, more specifically) claimed that this method of delivery promoted authentic learning. It has been said that authentic learning was the result of individual labor and concentration that cannot be a shared experience; authentic learning was the outcome of quality lecturing (Stunkel, 1999).

Direct instruction required considerable preparation before any interaction occurred between teacher and student. Jones and Southern (2003) outlined the parts of a direct instruction lesson beginning with an investigation of the depth and the order of the concepts to be learned. Next, an analysis of the important skills and concepts to be learned took place. Finally, an identification of the connection between these skills and concepts was qualified. Direct instruction included mastery learning, reinforcement, regular assessing, direct assessing, breaking larger tasks into smaller tasks, and teaching foundational skills (Kinder & Carnine, 1991). The self-belief and skill of a developmental student often came only after he/she was told exactly what to do (Weinstein, 2004). This behavioral model promoted learning in the manner of repeated and remembered actions, similar to habits (Joyce et al., 2004). In spite of the prominence of constructivist ideas, Jones and Southern (2003) stated that instructional models from the behaviorist family of instruction that used explicit direction from the teacher produced superior results when compared to any other models of instruction.

Personalized Instruction

Personalized instruction, a broad term that encompasses a variety of activities, focuses on understanding students, who they are, and what their needs are (Joyce et al., 2004). Jenkins and Keefe (2001) found that personalized instruction took on meanings and activities including getting to know students on a personal basis, understanding students on their level, being a friend of students, knowing students' names, and creating a self-paced atmosphere. This definition infers more than one way to personalize instruction because such teaching considers learning styles, student needs and talents, individual interests, and each student's academic background.

The experience and demographics of the modern college campus have changed dramatically; diversity is at an all time high (Kitzrow, 2003). The diversity of today's student body was claimed to require personalized instruction (Jenkins & Keefe, 2001). The modern college student arrived on campus overwhelmed and carried more psychological problems than past incoming classes (Kitzrow). Researchers (Thiel et al., 2008) found anxiety, unrest, and general indifference among students in the classroom. College students were found having trouble passing courses due to previous high school experiences that induced a fear of mathematics (Thiel et al.). Students were also having difficulty concentrating for long periods of time. The modern student has a shorter attention span than previous generations (Latterell, 2007). The contemporary classroom contained many of these students that were generationally much different from previous classes (Latterell) and were found to be in need of a personal approach to education (Jenkins & Keefe).

Personalized pedagogy is not a new concept; as mentioned before, it is constructivist in nature (Joyce et al., 2004). According to constructivist theory, students constructed knowledge through activities because knowledge cannot be transmitted solely by the teacher. Jones and Southern (2003) discovered that personalized instruction was not isolating a teacher and a student for a one-on-one lesson. When put into practice, a personalized pedagogy was social not individualized, and understanding was produced by the class as a whole and yet achieved by the individual (Campbell et al., 2007).

Jenkins and Keefe (2001) considered personalized education as consisting of 6 elements: “A dual teacher role of coach and adviser, the diagnosis of relevant student learning characteristics, a school culture of collegiality, an interactive learning environment, flexible scheduling and pacing, authentic assessment” (p. 72). One short description of personalized instruction stated that it was simply responsive to the ways that each student best achieved (Department for Children, n.d.). Jenkins and Keefe (2001) claimed that personalized instruction best served today’s diverse crowd of students, and Latterell (2007) concurred when she stated that the contemporary college student needed customized pedagogical strategies.

Signs of the personal approach in the classroom were found in the use of manipulatives, technology, and group work. These activities and others were abundantly described in the literature. White-Clark et al. (2008), stated “Cooperative learning, hands-on activities, discovery learning, differentiated instruction, technology, distributed practice, critical thinking, and manipulatives are elements that embrace the constructivist educational philosophy" (p. 42). Burns (2004) also supported the personal approach in the utilization of manipulatives.

Personalized instruction was most commonly associated with at-risk students in small classes though this was not its sole application (Jenkins & Keefe, 2001). The personalized approach can be employed simply to encourage and inspire any classroom. Personalized instruction consisted of lessons intended to motivate rather than deliver the main content (Hambleton et al., 1998). Personalized instruction worked well with a teacher that understood modern cognitive science (Jenkins & Keefe, 2001).

Though there were a variety of approaches to the application of personalized instruction, there were prominent attributes common to each approach. Personalized instruction was often characterized by features such as having the students proceed through the material at their own pace (Hambleton et al., 1998). Mastery of material was the goal with students determining the tempo of new information. Thus, in the personalized approach students pushed the curriculum. The rationale for this type of timing was that teachers wanted students to pursue a depth of knowledge as opposed to breadth of information (Burns, 2004). The personalized approach ensured the pace of instruction set by the student through a curriculum established by the educator beforehand (Jenkins & Keefe, 2001).

Pitfalls of Lecture and "Traditional" Methods

It should be noted that both direct instruction and personalized instruction are vulnerable to the lecture shortcomings that critics have expounded upon. Some researchers (Jones & Southern, 2003) have stated that people do not learn by being idle or watching others. Just mimicking another person's actions was not an indication of critical thinking. Presenting material and having students repeat it might work well on standardized tests, but it does not promote long-term thinking, higher-order thinking, or versatile problem solving (Mathews, 1996). Furthermore, Latterell (2007) indicated that modern students had a difficult time listening to lectures because they had shorter attention spans than previous generations had exhibited.

Though the exact definition of traditional instruction is subtle, traditional instruction was characteristically associated with teacher-led instruction that was informative (Jones & Southern, 2003). Defining traditional or modern teaching approaches was a bit elusive. Traditional instruction was said to encompass the typical mathematical presentation (Baxter & Smith, 1998), and, yet, as Jones and Southern (2003) pointed out, there was no true typical instructional method because classroom practices covered a wide variety of content, organization, and delivery. Though there was no precise definition of traditional teaching methods, traditional models were commonly considered to be behavioral (Jones & Southern).

Opposition to traditional methods was well documented. Some saw traditional instruction as overemphasizing computational skills while allowing problem solving skills too little time in the presentation of concepts (Jones & Southern, 2003). Critics of the traditional method claimed traditional formats continued to flourish because teachers tended to teach the way they were taught (White-Clark et al., 2008). Furthermore, it has been claimed that too many teachers were just delivering rote lectures centering on the teacher supplying information to uninterested students (White-Clark et al.).

Many remedial mathematics students were said to be the product of traditional mathematics teaching. These same traditional methods failed remedial students in the past (Hammerman & Goldberg, 2003); therefore, these methods were part of the necessity for remediation. Sezer (2010) stated that mostly passive learning occurred with lecture and the student tended to forget the material. Mathews (1996) found that helping the beginning mathematics student was not accomplished with the standard method of teaching. Mathews claimed that several different sources have shown that lecturing and listening were the least effective way to learn mathematics. Mathews further stated that traditional teaching was not worth preserving if it was ineffective in promoting learning.

Applying Instruction Methods

Proponents of lecture style delivery pointed out that lecture was not necessarily the caricature of a sage old professor mumbling while bored pupils scribbled down figures (Stunkel, 1999). In fact, Wynegar and Fenster (2009) found that lecture produced the highest GPA and the lowest failing rate when compared to three other pedagogical methods. Lecturing works well when it fits the style of the speaker (Stunkel).

Students have favored ways of learning as revealed in various studies. One survey revealed that the majority (89%) of college students preferred lecture to small group learning and other methods (Latterell, 2007). Students most commonly attributed the majority of their learning in mathematics to lectures and tutorial sessions (Wood et al., 2007).

One study found, when comparing learning activities, 98% of students rated lecture most highly (Wood et al., 2007). Undergraduate students were found to prefer lectures that were well paced, contained many examples, and included more interaction (Latterell, 2007). Without reference to instructional theory, studies have indicated that college students preferred lecture as the method of delivery in their learning experience (Latterell).

Quality teaching in any form was found to be very effective. When several teaching/learning variables were taken into account, the magnitude of effects was small when compared to the teacher effect, i.e. quality teaching is the single most important influence on student achievement (Rowe, 2003). In a meta-study of over 500,000 studies, Hattie (2003) discovered that though there were many things done in education that have positive effects, the single most powerful influence was that of excellence in teaching, regardless of particular pedagogy. In fact, 4 of the top 5 strongest single effects on student achievement were controlled by the teacher (Hattie, 2003). Furthermore, of the many variables that accounted for variance in student achievement, the second highest source of variance was that of the teacher (30%) and what they did. All other lesser sources were smaller than 10% (Hattie, 2003).

Assessment

Teaching method and assessment method were closely linked (Chansarkar, 1995). The instructional style of a classroom informed and dictated how students were to learn; similarly, the assessment method also influenced student performance (Hailikari, Nevgi, & Lindblom-Ylanne, 2007). How the teacher assessed determined what the student learned; in fact, the chosen assessment method can direct students to learn superficially or more deeply (Smith & Wood, 2000). Simply put, questions that teachers put before students demonstrated to the students how they were expected to spend their study time (Smith & Wood).

Smith and Wood (2000) stated that regardless of the chosen pedagogy, any instructional method contained certain assumptions about the learner. Muro and Terry (2007) stated that because students revealed their abilities in different manners, examinations should include both short-answer and long-answer type questions. Telese and Kulm (1995) similarly affirmed that a larger number of students demonstrated their cognitive abilities with the right type of test question. Questions that included both rote knowledge and deductive reasoning were found to reach more students (Muro & Terry).

Assessment method, however, delimited what *can* be known about a student's depth of understanding (Hailikari et al., 2007). For instance, knowing facts was a different kind of knowledge than knowing procedure, i.e., knowing how to do something. Therefore, different methods of assessment should be used in order to account for different types of knowledge (Hailikari et al.). The type of knowledge, from simply remembering to the more intense process of creating, as seen in Bloom's taxonomy was revealed by the type of assessment used (Hailikari et al.).

Thus, assessment needs to be designed placing fewer developmental students at risk. These students were at risk merely because they do not do well on specific types of assessments (Telese & Kulm, 1995). Determining a student's abilities can be better accomplished by measuring in more than one manner as different types of assessments have revealed different aspects of students' knowledge (Hailikari et al., 2007). In point of fact, it was found students actually preferred a mixture of assessment types (Chansarkar, 1995). Assessment that matched a student's learning style revealed more knowledge than another type of assessment (Telese & Kulm).

Many writers have called for further research on methods of assessment. Hailikari et al. (2007) found that more research was needed to find the type of assessment that best predicted comprehension. In fact, it was advantageous to use more than one assessment method when assessing knowledge (Hailikari et al.). Smith and Wood (2000) also called for further research in the area of evaluating the effects of changing assessment on student learning. Additionally, it has been declared that more research was needed not only on varied assessment but also on types of settings that provided the most accurate picture of the developmental student (Telese & Kulm, 1995).

Conclusion

This section reviewed the literature concerning epistemology, terminology, the recent prevalence of the remedial student, the consequences and costs associated with remediation, pedagogical solutions appropriate for remedial mathematics, the application of the behaviorist and constructivist pedagogies, and, finally, the assessment of the remedial student. How and when remedial mathematics came to the forefront of educational discussions was touched on and why remedial mathematics is an important issue today was also investigated. In addition, this section attempted to illustrate that the solution to college-level remediation issues is found in the context of the college classroom, effective pedagogy, and appropriate assessment.

Conclusions drawn from the literature review shows that traditional college teaching methods have focused on relaying information to students who were then expected to absorb the information. However, this review of the literature revealed the call for more research on the most appropriate pedagogy for the modern college-level remedial mathematics student. Interactive discovery-type pedagogies as well as pedagogies involving step-by-step instruction were both shown to be endorsed in the literature. Research conducted in the last few decades has shed light on the fact that modern students are a different breed than students 30, 20, or even 10 years ago, and the most appropriate teaching/learning style is still a matter of discussion.

The research in the literature indicated that practitioners of constructivist theory demand a personalized instructor. Comprehending each student's weakness, strength, and desire is the supposed gateway to helping the underprepared student. In order for remedial intervention to be effective, the teacher must locate the student's personal difficulties and create a personalized intervention (Dettori & Ott, 2006). Personalized learning and teaching includes being responsive to each student's learning style

(Department for Children, n.d.). In fact, some researchers contend that the teacher should only be a guide in the learning process; he/she should relinquish power, allow students to become engaged, and allow them to take responsibility for their own learning (White-Clark et al., 2008). A personalized intervention implies that the teacher has knowledge of exactly what each student needs before acting on each student's behalf. Therefore, effective remedial teaching involves close inspection of each student's attempts to learn (Dettori & Ott, 2006).

People with strong convictions from behaviorist theory, however, state that close contact measuring the daily ongoing attainment of the student is not practical with hundreds of students (Wood et al., 2007). Furthermore, it is believed that teachers must organize thought for the student. Remedial students should be given direct instruction on problem representation and problem solution, i.e., these students need prompts along the way during the solving process (Gagnon & Maccini, 2001). One study recommended the emphasis of direct instruction in the classroom after finding the largest gain in student achievement to be the product of direct instruction (Haas, 2005). Additionally, the principles of direct instruction are beneficial for teaching basic as well as higher-order skills (Kinder & Carnine, 1991). Models of teaching from the behaviorist theory, such as direct instruction, produce higher-quality results when compared to other models of teaching (Jones & Southern, 2003).

Finally, the way students are assessed was found to be important in the way that students are labeled in the first place. Remedial is a term that is relative to the test taken and the institution using the term. Colleges with open enrollment typically serve a very diverse population that is often rife with high-risk and underprepared students (Hodges, 1998). The assessment of these students is important to their successful future, and assessing the student in more than one way provides a bigger picture of the student's true abilities.

Solutions to the college remediation crisis must be sought in enhanced remediation courses and the improvement of instruction (Strong American Schools, 2008). Maxwell et al. (2004) stated that colleges have an obligation to address the learning process if students are not passing remedial mathematics. Moreover, further research is needed to determine what exactly is considered best practices in college-level developmental mathematics courses (Taylor, 2008).

The forthcoming section describes the methodology employed in this study. The design of the experiment and the use of the SIR II® to distinguish the self-efficacy levels of students are presented. Additionally, a description of the pre-test/post test employed is given and the research questions investigated are provided. Lastly, an explanation of the classroom context and the background of the professors are also described.

3. METHODOLOGY

Introduction

The purpose of this study was to compare and evaluate two classroom instructional approaches for college-level remedial mathematics students. This experimentally designed study consisted of participants from Southwestern Adventist University's (SWAU) Introduction to Algebra class, Math 011. Students deemed not ready (per SAT scores) for college-level mathematics are required to take this course. The intent of the study was to ascertain the more effective of two teaching and learning approaches as measured by two different methods of assessment for the college-level remedial mathematics student.

In one instructional approach, the students were taught with key concepts gleaned from a direct instruction philosophy. The second class was taught using opposing concepts typical of a personalized instructional approach. One assessment method was to use short-answer questions; the other assessment method was to employ extended-answer questions. Beyond the different pedagogical and assessment methods, student motivation and perception were also measured as explanatory variables.

The context of this study is based on the need to effectively teach an increasing number of students relegated to developmental mathematics in the current post-secondary system of education. The rationale was to investigate the most appropriate pedagogical method for the modern college-level remedial mathematics student since this topic is currently disputed and open for further investigation. The research questions investigated in this study all point towards finding a better way of instructing and assessing college-level remedial mathematics students. This section describes the pedagogical methods employed, assessment procedures, participants, instrumentation, research questions, and the research design used in this study.

Overview of Methodology

The design of this study is an alternative-treatment design with pretest (Shadish, Cook, & Campbell, 2002). Remedial students were randomly placed into two classes and taught with two different instructional methods. Assessment of each student's abilities was then measured with two different sets of questions. This design produces four groups: instructional method A with assessment type 1, instructional method A with assessment type 2, instructional method B with assessment type 1, and instructional method B with assessment type 2. In addition, the resulting scores were analyzed while taking into account each student's self-efficacy level.

The two instructional methods employed were theories with different foundational beliefs. Each class was taught with key concepts gleaned from these theories that were in direct opposition to the corresponding concepts of the opposing class. To ensure the fidelity of the methods, the participating professors were conditioned in their particular methodology. Additionally, they were prepared and trained in a pilot study. Furthermore, during the semester of the actual data collection, the teachers were observed during various class periods followed by feedback and advice occurring immediately after each observation.

The rationale for this design was to be able to observe variances in measurement as well as differences resulting from teaching styles that were conceptually distinct while also being able to account for student participation levels. The independent variable was instructional method, and the dependent variables investigated were students' score differences between pre-test and post-test, student perception, and self-efficacy. The significance of differences was subject to a two-sample *t*-test, Mann-Whitney *U*-test, or Wilcoxon signed-rank test, as conditions warrant. It is of interest to note that this design is not suitable as a 2-by-2 factorial because assessment method is not considered a treatment.

There are several relevant factors that have bearing on the consequences of this particular methodology. The subjects were all placed into remedial mathematics via scores from the Scholastic Assessment Test (SAT). The data were collected by means of an end-of-course exam and from the SIR II® questionnaire which was administered at various times during the study. Class observations took place with minimal disturbances in the classroom. Evaluation of the subjects' results was accomplished employing a rubric and by comparing their questionnaire results to those from 116 other similar institutions (Student Instructional Report II®, 2009).

Following each presentation of descriptive data from the information collected on pre/post tests and the SIR II® questionnaires was an analysis of differences and patterns. Additionally, qualitative data were derived from answers provided during interviews with both professors and a number of participating students. The open-ended statements presented to the interviewees are found in Appendix C. The results of these questions are presented in the final portion of section 4.

Other procedures for data analysis included checking test assumptions, factor analysis, and various descriptive statistics to elicit relationships between instructional methods and exam scores for different groups of students. The intent of these choices was to help determine the relative benefits of teaching methods, as measured through different instructional practices, for the college-level remedial mathematics students.

Research Perspective

The scope of this study is limited to the modern post-secondary student attempting to pass a remedial mathematics class. The latest generation of college freshmen demands a certain type of engaging pedagogy (Latterell, 2007, p. 67). Furthermore, the number of contemporary college students consigned to remedial mathematics has increased (Perrin & Charron, 2003), and the specificities that deal with their ultimate collegiate success need to be explored in greater depth (Jones & Southern, 2003; Taylor, 2008).

A second purpose for conducting this study within the boundaries of college and remediation is that a great number of students are stopped in their pursuit of further education at this juncture. If students can be successfully remediated, then they are more likely to remain in college (Young, 2002). Furthermore Bahr (2008) pointed out that those who pass remedial mathematics were successful in their other college classes. In fact, Illich et al. (2004) found that failing remedial mathematics in college was highly correlated with failing out of college all together.

The central premise of this study is that a greater number of remedial students will find success and will be able to demonstrate learning with a suitable combination of pedagogy and assessment. Waycaster (2001), Roth (2000), and Baxter and Smith (1998) stated that different pedagogies affected the success rates of remedial students. On the assessment side, Muro and Terry (2007) stated that examinations should include short- and extended-answer questions because students make known their abilities in different manners. A greater number of students will be able to demonstrate their knowledge when they are presented with the appropriate type of test question (Telese & Kulm, 1995).

Research Questions

There were four questions that framed this study. Each question addressed student achievement with respect to pedagogy or assessment method. Student self-efficacy and perception were also investigated as explanatory variables within the students' experience. The students' responses were important in determining the implementation of instruction they experienced.

Questions:

1. Do developmental algebra students experience differential achievement rates, on a customized end-of-course exam, based on direct-instruction versus personalized-instruction?

2. Does direct instruction or personalized instruction differentially impact student performance on rote knowledge (multiple-choice items) as compared to synthesis and analysis questions as measured by extended response?
    a. How does personalized instruction affect student performance on (1) short-answer (rote-knowledge) questions and (2) extended-answer (deductive reasoning) questions?
    b. Does direct instruction affect student performance on short-answer (rote-knowledge) questions and extended-answer (deductive reasoning) questions?
3. Does the perception (of instruction) of students in direct instruction (based on the SIR II® categories) differ from the perceptions of students in personalized instruction?
4. Does the self-efficacy of students in direct-instruction (based on SIR II® categories) differ from the self-efficacy of students in personalized-instruction?

Milieu of Classes

The two classes in this study were set apart in the categories of pacing, dialogue, guidance, and instructional delivery. These four areas distinctly separated direct instruction from personalized instruction. Each class adhered to specific behaviors within these categories, and each class did not encroach on the other class's behaviors listed within these same categories.

The direct instruction class was paced by the instructor according to specific clock times and by the weekly/monthly schedules. The class dialogue was instructor led, academically focused, and directed towards questioning basic skills. Guidance emerged in the form of immediate correctional responses to instructor queries. Instructional delivery followed a regimen of model, prompt, acknowledge/correct. This class additionally followed a daily schedule in order to adhere to specific class pedagogy and content.

The personalized instruction classroom was paced according to students' questions and curiosity. The class dialogue was organized by the instructor who, attuned to students, generated partly practical and personal as well as academic dialogue and directed the class towards content discovery. Instructor guidance materialized as coaching, motivation, and encouragement. Instructional delivery occurred in the form of small group activities, discussions, manipulatives, projects, and interactive student presentations.

Setting

This study occurred in a small (student body typically less than 1000) liberal arts Christian university in central Texas. The school was founded in 1893 and is affiliated with the Seventh-day Adventist Church. This accredited university is located in a small town south of a large metropolitan city. The Spring 2009 enrollment was 817. The university offers 4 undergraduate degrees including 37 undergraduate majors, 26 minors, and master's degrees in business and education. The student to faculty ratio is 12:1 and the student body represents 35 states and 30 countries. Financial assistance is received by 91% of the student body with a tuition of approximately $15 000 per year (2 semesters).

This school was chosen mainly for its diverse student population and its typically large remedial mathematics enrollment. Other factors considered were the philosophy espoused by faculty and staff of the school. According to the university's website, the ideals of the school include, "The University broadens the student's intellect, strengthens the spiritual dimension, contributes to social growth, fosters attitudes and practices of healthful living, develops a wholesome respect for the dignity of labor, and instills a sense of selfless service."

Participants

The students who participated in this study were fulfilling a university mathematics requirement. One admission requirement includes a 500 or higher SAT score. Students whose SAT scores were below 500 are required to enroll in the remedial mathematics course, Math 011, *Introduction to Algebra*. At this point students have three semesters to successfully pass Math 011 and Math 012 (intermediate algebra) before they are allowed to enroll in college-level mathematics. Any student who does not successfully pass these courses within three semesters must dis-enroll from the university until they have demonstrated mathematical readiness.

On day one of the study, the direct-instruction class consisted of 27 students and the personalized-instruction class began with an enrollment of 29 students. By mid-semester five students had dropped leaving 26 students in the direct-instruction classroom and 25 students in the personalized-instruction classroom. In addition to the students lost to attrition, five students incompletely filled out the SIR II® data questionnaires. The data they did provide was tallied in relevant questions.

The students placed in Math 011 were divided into two groups using a random number generator. This division created Math 011 section 1 (26 students) and Math 011 section 2 (25 students). The two sections were taught at the same time of day and in similar classrooms.

The instructors of these two sections were both experienced teachers with personal philosophies closely aligned with the prescribed instructional methodologies described above. The instructor of the direct instruction class, Instructor A, has a background in applied mathematics and believes strongly in understanding the basics. The instructor of the personalized instruction class, Instructor B, has been a principal and is a strong student advocate. Both instructors were trained (see training component in Appendix D) in their prescribed instructional method, and both instructors were observed by the researcher to determine their diligence in maintaining fidelity to their method (see fidelity check sheets in Appendix E).

Instructor A received an M.S. in electrical engineering and a B.S. in computer science from the University of Texas at Dallas. Prior to this experiment he taught university level mathematics for two years, and for six years he ran a learning center for pre-k through 12th grade students in the areas of mathematics and reading. Before teaching he had 10 years experience providing work-related training and mentoring for new hires and contractors and new product release training for clients. When asked about his teaching philosophy, Instructor A replied, “I want to facilitate the acquisition of fundamental skills and foster problem-solving strategies. My goal is for students to learn the objectives of the course contents in small pieces and acquire enough knowledge to eventually connect the pieces together to see bigger pictures” (Personal communication, July 21, 2009).

Instructor B received his Ed.D. from Brigham Young University in Curriculum Development and Foundations. He has taught 39 years, 6 years strictly as a teacher, 25 years as a teaching principal, and 8 years as a full-time principal. Instructor B has taught Algebra I, Algebra II, Geometry, and Physics in his teaching duties. Instructor B has taught high school level math for the majority of his career though he has also taught Masters level classes in education and remedial mathematics at the university level as well. Instructor B’s philosophy of teaching “…would go something like this: I look at every student as a unique individual [that is] at a different spot in their educational development [than any of the] others in the classroom. My job is to find out the right buttons I can push in each individual case that will make them successful” (Personal communication, May 15, 2009).

The university demographics and the sample demographics are displayed in Table 1.

Table 1

University and Sample Demographics

	Male University *n*=434	Female University *n* =634	Male Sample *n* =22	Female Sample *n* =29
Nonresident alien	90 (21%)	100 (16%)	1 (5%)	2 (7%)
African American, Non-Hispanic	44 (10%)	82 (13%)	2 (9%)	4 (14%)
American Indian/Alaska Native	5 (1%)	4 (1%)	0 (0%)	0 (0%)
Asian/Pacific Islander	25 (6%)	26 (4%)	0 (0%)	1 (3%)
Hispanic	112 (26%)	146 (23%)	10 (45%)	11 (38%)
White, Non-Hispanic	141 (32%)	249 (39%)	2 (9%)	3 (10%)
Race and ethnicity unknown	17 (4%)	27 (4%)	7 (32%)	8 (28%)
TOTAL	434	634	22	29

The largest representative portion of the sample consisted of 10 Hispanic males, or about 45%, and 11 Hispanic females, or 38%. Participants in the age range of 18 to 19 comprised 77% of the sample; 91% of the sample were freshmen, and 6% of the sample felt that they could learn better in a language other than English. Every student from the Fall 2009 semester with no previous college-level mathematics classes and SAT scores less than 500 participated in this study; however, the ethnic distributions appeared to be different than would be expected had the sample been drawn randomly from the entire school population. In particular, three percentages stood out. School demographics show the campus to have been 24% Hispanic and 37% White with 4% listing their ethnicity as unknown. In contrast, the sample was 41% Hispanic, 10% White, and 29% listed their ethnicity as unknown. These three sets of demographic data are displayed in Figure 1.

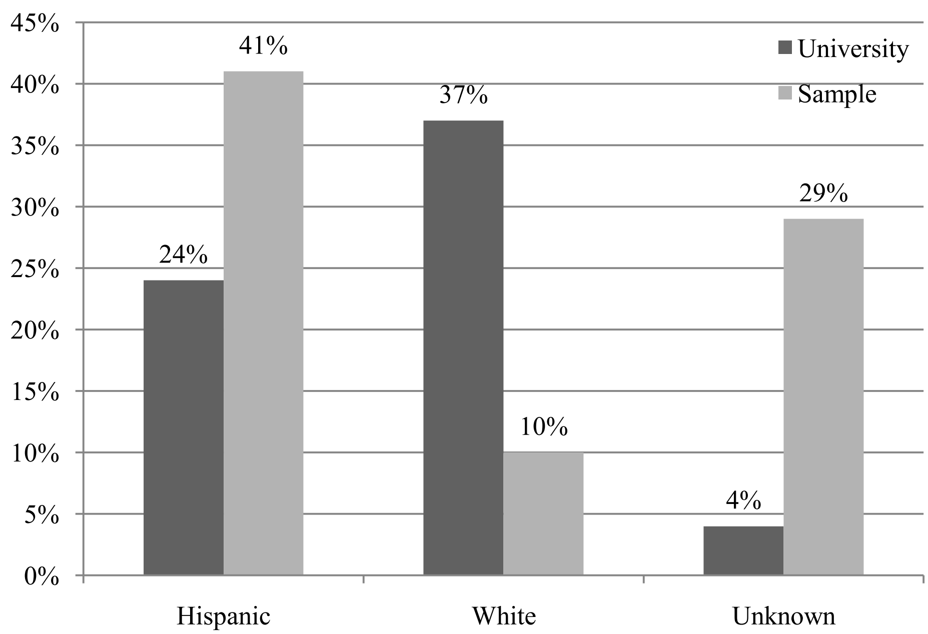

Figure 1. **University versus sample ethnicity percentages.**

Research Variables

Based on the research questions for this study, several variables were identified. The primary independent variable in this study was instructional method. Instructional method, direct instruction or personalized instruction, is a categorical variable, within these instructional methods 4 categories were defined and manipulated: Pacing, dialogue/prompting, guidance, and instructional delivery.

The dependent variables investigated were students' score differences between pre-test and post-test, student perception, and student self-efficacy. Test difference is a continuous variable while student perception and self-efficacy are measured on a Likert type scale from 1 to 5. The overall score difference was measured, as were the differences in short-answer questions and extended-answer questions.

A confounding variable would be the teacher effect. The use of different teachers could influence the data in an unintended manner. However, student perception of their teacher was measured and compared from the SIR II® in order to account for any disparity in preference.

Pilot Study

A pilot study was carried out for logistical purposes and to evaluate the instruments used. An assignment method that placed students into their designated classes was tested and revised, classroom dynamics were investigated, the SIR II® was assigned to these two classes, and the customized end-of-course exam design was piloted. This small-scale version of the study aided in modifying data collection plans regarding content and procedures.

The professors who participated in the pilot test provided constructive suggestions that helped improve the question format and the grading rubric. The assignment of students to sections was altered from the pilot study. The new method used a random number generator to assign students automatically during the initial registration process. Classrooms were assigned according to the style of instruction that each professor used.

The pilot study was also used as an opportunity to observe the teaching style of the potential instructors and to provide continued feedback reinforcing the training. Two professors were decided upon that exemplified the characteristics of the instructional methods being studied. The pilot study period was used to query each teacher about their personal teaching philosophies and to adjust specific classroom activities accordingly. Logistical concerns such as the assignment of classrooms, informing students of their classroom locations, and setting testing dates were additionally investigated and refined. Attendance and classroom switching alerted the researcher to the possibility of student attrition; thus, the assignment-of-students-to-a-classroom procedure was modified to help minimize this issue. Students who registered for Math 011 were now informed on their computer printout concerning classroom location, and the classrooms were in separate buildings. The class attendance policy also played a stronger role because allowing students to switch classes, or to choose their class, would compromise the study design by nullifying the random assignment.

Instrumentation

The customized end-of-course exam administered in this study was derived from the exam that has been used for Math 011 for the previous 4 semesters (See appendix A). Some of the questions were modified in wording, and some questions were added in order to ensure that there were short-answer and extended-answer questions covering similar material for comparison. This exam covered material taught throughout the semester. All questions were from the first five chapters of the textbook required for Math 011. Topics include: fundamental concepts, functions, first-degree equations and inequalities, linear equations, and systems of linear equations.

The SIR II® measures student opinions within various categories. It was designed to provide information on new teaching methods. In effect, the SIR II® allows students to "grade" their instructor. The questionnaire assesses a teacher's contribution toward learning as described by the student. The student plays a critical role in the learning process defined by factors such as effort applied and study time (Educational Testing Service, n.d.). Students rank instructional method on a scale of 5 points based on how effective the instruction was to their learning process. Categories include Course organization and planning (such as the instructor's use of class time); Communication (such as the instructor's ability and enthusiasm); Faculty/student interaction (such as the instructor's ability to listen); Assignments, exams, and grading (such as the helpfulness of the assignments); Supplementary instructional methods (such as labs, projects, and journals); Course outcomes (such as the students interest and involvement levels); and Student effort and involvement (such as whether the student felt challenged or self-efficacious).

The SIR II® was pilot tested in a variety of colleges to investigate reliability and validity. Three types of reliability (Coefficient Alpha analysis, item level reliability analysis, test-retest reliability) were investigated, and each produced positive results. A Coefficient Alpha analysis was done by Centra (1998) for the categories being used in this study with Alpha's that ranged from .67 to .89. Items within each scale were shown consistent in measuring a single dimension. Item reliability examined reliability with different sized groups: for 10 students reliability was .59, for 15 students reliability was .78, and for 20 students reliability measured .89. The sample Centra (1998) gathered his data from came from pretesting that was done in 10 different two- and four-year colleges (Educational Testing Service, n.d.).

Construct validity demonstrated that the SIR II ® measured what it was intended to measure. In fact, it is possible for teachers to use the results of the instrument to improve their practice. There was also a positive average correlation (.39) between SIR II® ratings and student achievement (Educational Testing Service, n.d.).

Data Collection

This study had dual phases: a) collecting data from the customized end-of-course exam and b) collecting data from the SIR II® at different periods during the semester. This data was analyzed by considering overall performance differences and by considering differences relative to assessment method.

The data were collected with a customized end-of-course exam administered at the beginning and the end of the course. The end-of-course exam was a hard copy exam. The test was given during class time in a test like atmosphere, was distributed by the teacher during class time, and picked up by the teacher after the exam period was over. The researcher obtained the exams from the instructors in order to glean the required information. The final exam was jointly developed by the two participating professors and the researcher to accommodate the expected learning outcomes while remaining faithful the research topic being studied. This exam was graded by the researcher according to a rubric (Appendix B).

The SIR II® data was collected three times during the semester. In this manner the students' perceptions (SIR II® question numbers 2, 3, 4, 6, 8, 9, and 11) and self-efficacy levels (SIR II® question numbers 29 – 33) were determined and compared as the instructional time increased. The SIR II® was administered to the participant groups as a hard copy during class time.

Unit of Analysis

The unit about which statements were made was the individual student. The difference from pre-test to post-test for each student was recorded. In this study the unit of analysis was the individual student's score difference after the student was exposed to a particular instructional method.

The research questions in this study pertained to the student and his/her experience under direct instruction or personalized instruction. The research questions could be answered by analyzing the pre/post difference of each student and by analyzing the perceptions and the self-efficacy of the student after he/she was exposed to their prescribed instructional method. The individual student's experience and exam scores kept the focus of this study within the boundaries of college-level remedial mathematics.

Research Design

The design of this study was an alternative-treatment design with pretest (Shadish et al., 2002). There were two treatments and four groups to consider so symbolically the design appears as in Table 2.

Table 2

Four Group Study Design

	Assessment Method 1	Assessment Method 2
Instruction Method A	R O X_{A1} O	R O X_{A2} O
Instruction Method B	R O X_{B1} O	R O X_{B2} O

There were two instructional methods, A and B, and there were two assessment methods, 1 and 2. This design is not suitable as a 2-by-2 factorial because assessment method is not considered a treatment.

Data was collected from a customized end-of-course exam administered twice, once at the beginning of the semester and once at the end of the semester. This pre/post design allowed for a difference to be measured for each student after experiencing a prescribed method. The exam differences from the direct instruction class were compared to the exam differences in the personalized instruction class.

The comparison of instructional methods took into account the possibility that assessment method could play a role in determining exam differences. This possibility of interaction meant assessment must be analyzed alongside pedagogy. Short-answer questions and extended-answer questions were compared in the same pre/post design. Therefore, besides the overall comparison of direct instruction and personalized instruction, this design involved 4 groups for comparison: direct instruction/ short-answer, direct instruction/extended-answer, personalized instruction/short-answer, and personalized instruction/extended-answer.

Data Collection and Analyses

In this 16-week semester student perception and self-efficacy data were collected during week 4, week 9, and week 14. Differences between selected groups were analyzed with the aid of descriptive statistics such as histograms, frequency distributions, scatter plots, and other relevant visual aids.

The pre-test data were collected during week 1 and the post-test data collection happened in week 14. All data were analyzed using SPSS. Data for each student included a pre-test score, a post-test score, an instructional method evaluation score, and a self-efficacy score.

The pre-test and post-test scores were used to calculate a difference score for each student exposed to direct instruction and for each student exposed to personalized instruction. Difference scores were analyzed by considering main effects and interaction with assessment method. Groups compared included direct-instruction and personalized-instruction, as well as short-answer and extended-answer. *T*-tests were used to determine whether the groups were statistically different when comparing the means of groups with normally distributed data. Mann-Whitney U tests and/or the Wilcoxon Signed-rank test was performed on data that was non-normal.

Confidence intervals were used in reporting any differences found in instructional method or assessment method. For detected interaction, an examination of the effects of instructional method for each assessment method was done before any interpretation. Effect size was also calculated and reported for differences found in instructional and assessment method.

There were 9 hypotheses; hypotheses 1,4, and 5 were analyzed with a paired samples *t*-test, at an alpha of .05, which tested whether the means of the two variables were statistically significantly different from zero. The paired samples *t*-test is appropriate for data that are repeated measures, independent of the other pairs, and that come from a normal distribution. Hypothesis 2 was analyzed using the non-parametric Wilcoxon Signed-Ranks test because the data were exhibiting non-normal behavior. Similarly, hypothesis 9 was analyzed using the non-parametric Mann-Whitney U test.

An independent sample *t*-test was used in testing hypotheses 3, 6, 7, and 8. This test is appropriate when the groups are independent of each other and there are different numbers of data points in the two comparison groups. The independent *t*-test employed in this study compared the sample means of the experimental and the control group, at an alpha of .05, to determine if they were statistically significantly different. Assumptions of the independent sample *t*-test are normal distributions, with approximately equal variances. All hypotheses in this study were non-directional.

Normality of distribution is presented visually with histograms and Q-Q plots and was measured quantitatively with skewness and kurtosis values. Skewness measures the center of the distribution; positive values indicate a tail to the right while negative values indicate a tail to the left. The magnitude of the ratio of skewness to its standard error should be less than 2. In other words, if skewness is within 2 standard errors (plus or minus) then skewness is not statistically significantly infringed. Similarly, kurtosis is a measure of how bell shaped, or flattened, the curve appears. Positive values indicate more data in the middle while negative values indicate more data to the sides of the distribution. The ratio of Kurtosis to its standard value should also be less than 2; values larger than 2 indicate asymmetry (Webstat, n.d.).

Equality of variance was determined with Levene's test which has the null hypothesis that variances are equal; the null is rejected when $p<.05$. Effect size was measured with Cohen's *d*. Cohen's *d* is the difference between the two means divided by their pooled standard deviation (King & Minium, 2008).

Descriptive statistics for self-efficacy were reported in order to explain or differentiate any statistically significant differences. Box-plots, tables, and frequency distributions were also given to provide visual representations when appropriate.

Bias and Error

A potential area for error could be teacher bias. Having two different teachers demonstrating two different instructional models had the potential of introducing a teacher effect due to experience, charisma, and classroom management, among others.

However, the advantage of using two teachers for two different teaching methods was that each teacher was able to teach in a manner that he was accustomed to and believed in. In fact, each teacher was chosen to model the particular instructional method prescribed for the very reason that it closely matched pre-existing personal teaching philosophy.

An alternative design could have been to have one teacher teach two different methods. However, this would have introduced a teacher-preference bias in that teachers typically already believe in or prefer one method over another. The use of a solitary teacher would put that teacher in the position of having to play dual roles. The students would then pick up on the motivation, or lack thereof, revealed by the teacher's personal preference. The use of two teachers and two classrooms provided control over two distinct environments.

Summary

This section first situated the study within the framework of college-level remedial mathematics and constructivist and behaviorist instruction. The basis for new instructional methods and varied assessment methods was further presented. After addressing the positions of direct and personalized instruction, the researcher explained the importance of considering self-efficacy levels within this study.

The methodology discussion in this section centered on a detailed account of the research design, the analysis, the instrumentation, a pedagogical description, and the research perspective. The research design described was an alternative-treatment design with pretest. This design involved the use of a customized end-of-course exam that consisted of short-answer and extended-answer questions. The dependent variable was the difference between the pre-test and the post-test. The independent variable, teaching method, consisted of methods set apart in the categories of pacing, dialogue, guidance, and instructional delivery. Another dependent variable was student self-efficacy as described in the SIR II® evaluation. The instruments used were discussed in detail and the SIR II®'s validity and reliability were noted.

The research questions in this study were stated and focused on finding the more effective teaching method while controlling for assessment methods and student self-efficacy. The participants were described along with the setting of the experiment, and the results of a pilot study were explained. The data collection method was detailed and the possibility of bias and error was pointed out. Section 4 will discuss the results of the analysis described here.

4. RESULTS

Introduction

The major focus of this section is to present the results related to differential achievement, self-efficacy levels, and assessment by means of different metrics. In order to help organize the section the research questions are reproduced here:

1. Do developmental algebra students experience differential achievement rates, on a customized end-of-course exam, based on direct-instruction versus personalized-instruction?
2. Does personalized-instruction or direct-instruction differentially impact student performance on rote knowledge (multiple-choice items) as compared to synthesis and analysis questions as measured by extended response?
    a. How does personalized-instruction affect student performance on (1) short-answer (rote-knowledge) questions and (2) extended-answer (deductive reasoning) questions?
    b. Does direct-instruction affect student performance on short-answer (rote-knowledge) questions and extended-answer (deductive reasoning) questions?
3. Does the perception (of instruction) of students in direct-instruction (based on the SIR II® categories) differ from the perceptions of students in personalized instruction?

4. Does the self-efficacy of students in direct-instruction (based on SIR II® categories) differ from the self-efficacy of students in personalized-instruction?

Quantitative Analysis

The quantitative analyses are answered in the order presented above. Questions are addressed in the following format: A brief statement on the relevancy of the question, the research question followed by relevant hypotheses and related analytic method(s), then followed by the appropriate analysis, pertinent graphs or tables, and the results of the analysis with brief summaries.

The purpose of question 1 is to describe the achievement of students experiencing differential instructional and then to determine if the achievement is different between classrooms. Accordingly, the first question has three hypotheses.

Question 1: Do developmental algebra students experience differential achievement rates, on a customized end-of-course exam, based on direct-instruction versus personalized-instruction?

Hypothesis 1

There is a difference between the pre and post-test scores on the customized exam by the remedial-mathematics student group in the direct-instruction class.

The analysis of the data for hypothesis 1 began with an examination of the distribution of the direct-instruction pre-test data because it is important to make an informed decision about the normality of the data to match appropriate parametric or non-parametric analytic methods. Initial visual confirmation of normality is presented in Figure 2, a Q-Q plot of the pre-test scores. Additionally, Figure 3 is a distribution of the pre-test scores for the direct-instruction class.

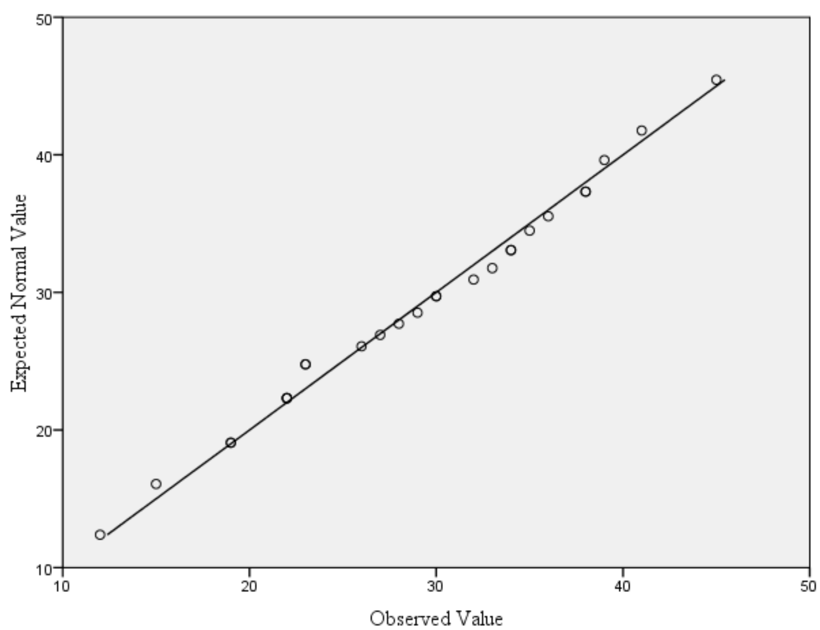

Figure 2. **Q-Q plot showing normal data for direct-instruction pre-test scores.**

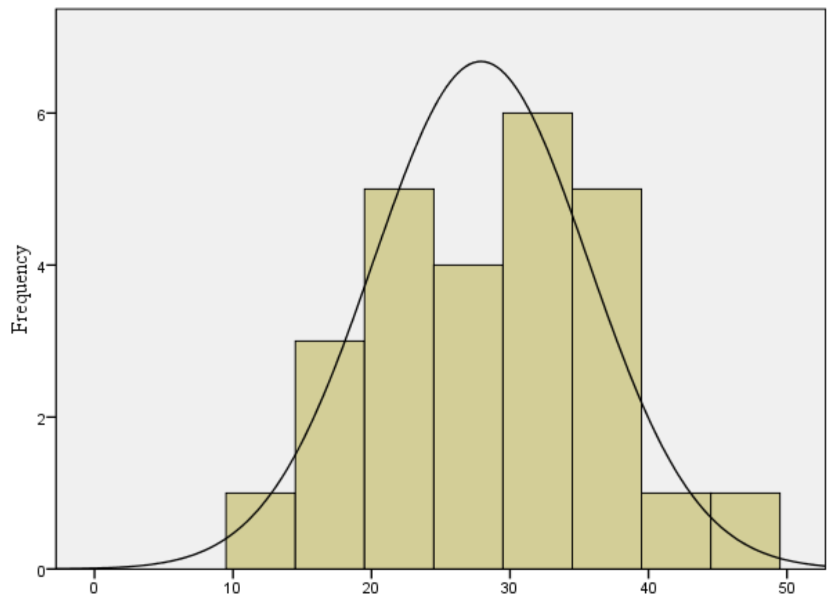

Figure 3. **Direct-instruction pre-test scores.**

The direct-instruction pre-test scores ranged from 12 to 45 points (*M* = 28.92, *SD* = 8.35). The pre-test scores were normally distributed, with skewness of -0.12 (*SE* = 0.46) and kurtosis of -0.61 (*SE* = 0.89). The magnitude of the ratio of skewness to its standard error was 0.26 and the magnitude of the ratio of kurtosis to its standard error was 0.69. Both of these magnitudes were less than two thus indicative of a normal distribution.

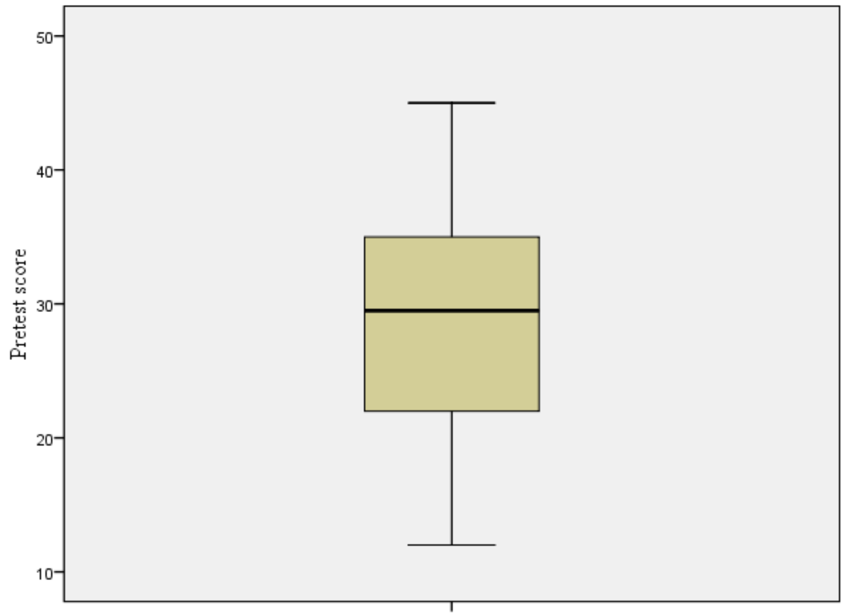

Figure 4. **Direct-instruction box-plot of pre-test scores.**

The normally distributed pre-test data also did not exhibit any outliers, as seen in Figure 4 above. The first, second, and third quartiles were 22.0, 29.50, and 35.25 respectively. The minimum score was 12 and the maximum score was 45. Now that the pre-test data has been shown to be reasonably normally distributed an investigation of the post-test data is appropriate.

The procedures for determining normality of the post-test data will mirror the procedures for the pre-test data. Figure 5, is a Q-Q plot of the post-test scores and Figure 6 is a distribution of the post-test scores for the direct-instruction class.

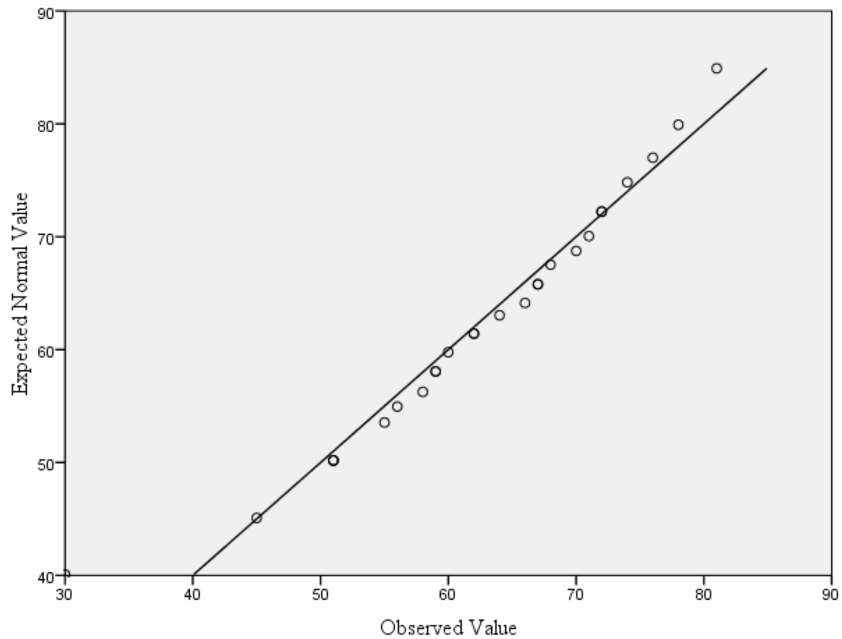

Figure 5. **Q-Q plot showing normal data for direct-instruction post-test scores.**

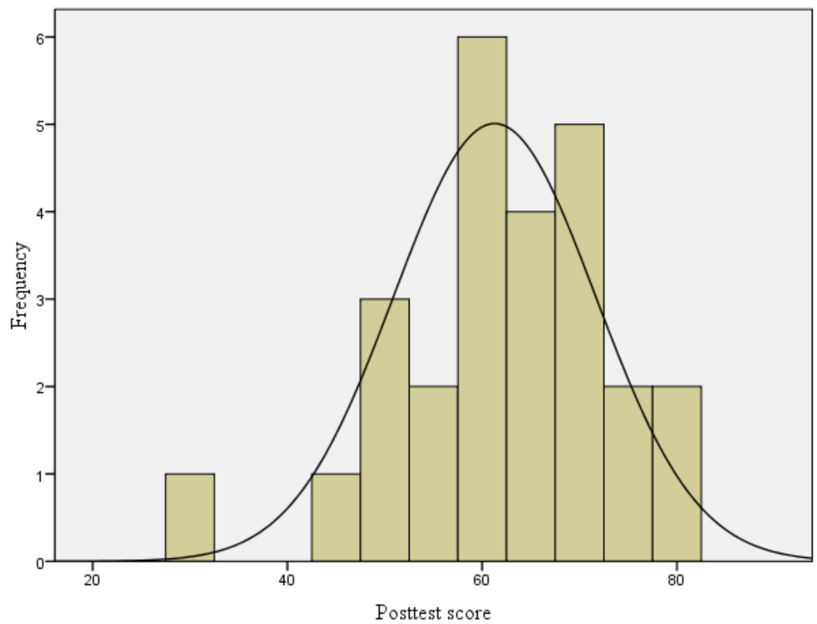

Figure 6. **Distribution of direct-instruction post-test scores.**

The direct-instruction post-test scores ranged from 30 to 81 points (*M* = 62.50, *SD* = 11.32). Post-test scores were normally distributed, with skewness of -0.84 (*SE* = 0.46) and kurtosis of 1.32 (*SE* = 0.89). The magnitude of the ratio of skewness to its standard error was 1.83 and the magnitude of the ratio of kurtosis to its standard error was 1.48. Both of these magnitudes were less than two thus indicative of a normal distribution.

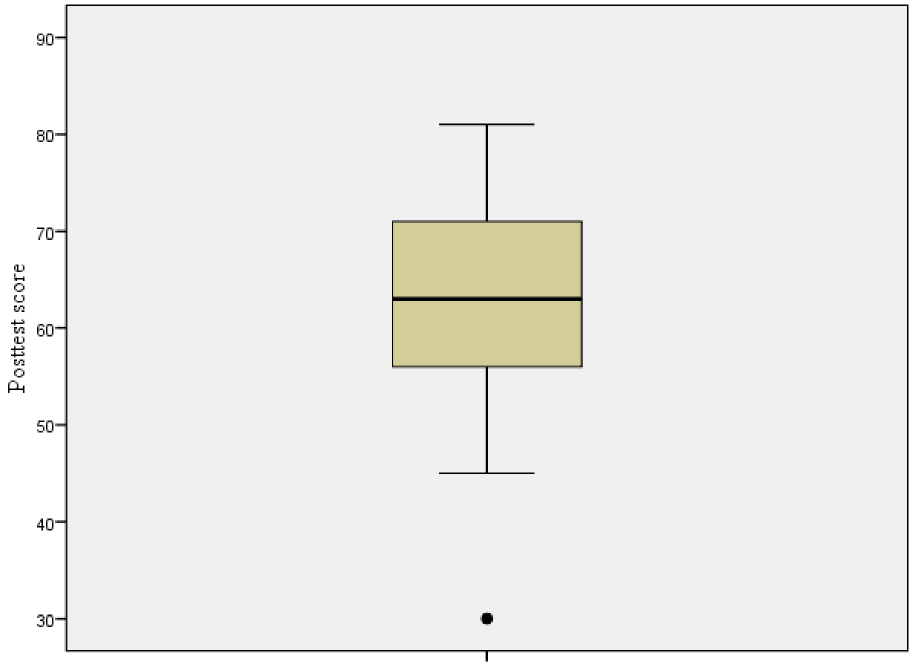

Figure 7. **Box-plot of direct-instruction post-test scores.**

Figure 7 above is a box plot of the direct-instruction post-test scores. The first, second, and third quartiles were 55.75, 63.00, and 71.25. The minimum was 30 and the maximum was 81. One student scored a 30 on his/her post-test (7 points higher than his/her pre-test) which is1.66 times the interquartile range below the 25th quartile (just beyond the 1.5 *IQR* threshold), as a result this data point is marked as an outlier. However this case is within 3 standard deviations (2.87 standard deviations) from the mean. Additionally, the standard deviation changed little with the exclusion of the outlier. It changed from 11.32 with the data point to 11.6 without it. Furthermore, the class differences will ultimately be compared with medians which are not as susceptible to outliers as means are. As a result it is not important to delete this outlier.

Because both sets of data were normally distributed a paired-samples *t*-test was used to compare the relative change from pre-test to post-test for the direct-instruction group. The direct-instruction group had a statistically significant improvement $t(25)=13.60$, $p < .001$ ($M_{pre}=28.92$, $SD=8.35$; $M_{pst}=62.50$, $SD=11.32$). The magnitude of the gain was dramatic with a Cohen's *d* of 3.38, demonstrating the effectiveness of the direct-instruction for the students involved.

Hypothesis 2

There is a difference between the pre and post-test scores on the customized exam by the remedial student group in the personalized-instruction class.

The analysis of the data for hypothesis 2 began like that of hypothesis 1, with an examination of the distribution of the personalized-instruction pre-test data in order to match appropriate parametric or non-parametric analytic methods. Normality of the pre-test data is displayed in Figure 8 with a Q-Q plot, followed by Figure 9, a graph of the distribution of pre-test scores for the personalized-instruction class.

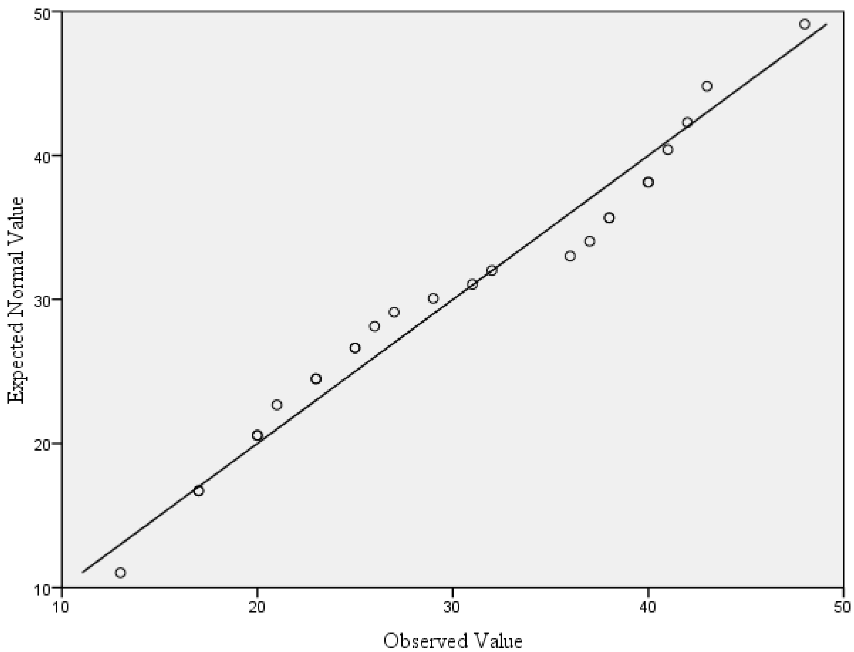

Figure 8. **Q-Q plot for personalized-instruction pre-test scores.**

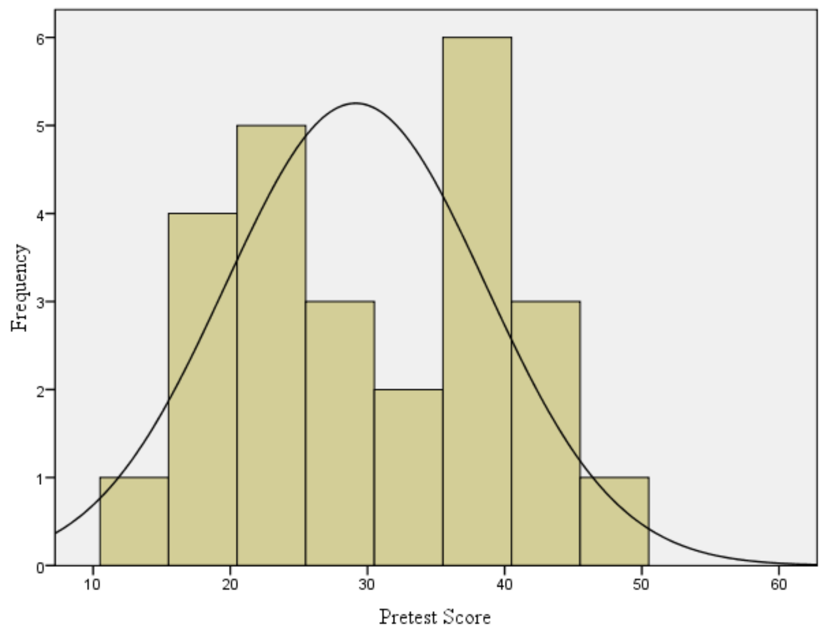

Figure 9. **Distribution of personalized-instruction pre-test scores.**

The personalized-instruction pre-test scores ranged from 13 to 48 points (*M* = 30.08, *SD* = 9.70). Pre-test scores were normally distributed, with skewness of 0.05 (*SE* = 0.46) and kurtosis of -1.15 (*SE* = 0.90). The magnitude of the ratio of skewness to its standard error was 0.11 and the magnitude of the ratio of kurtosis to its standard error was 1.28. Both of these magnitudes were less than two and therefore indicative of a normal distribution.

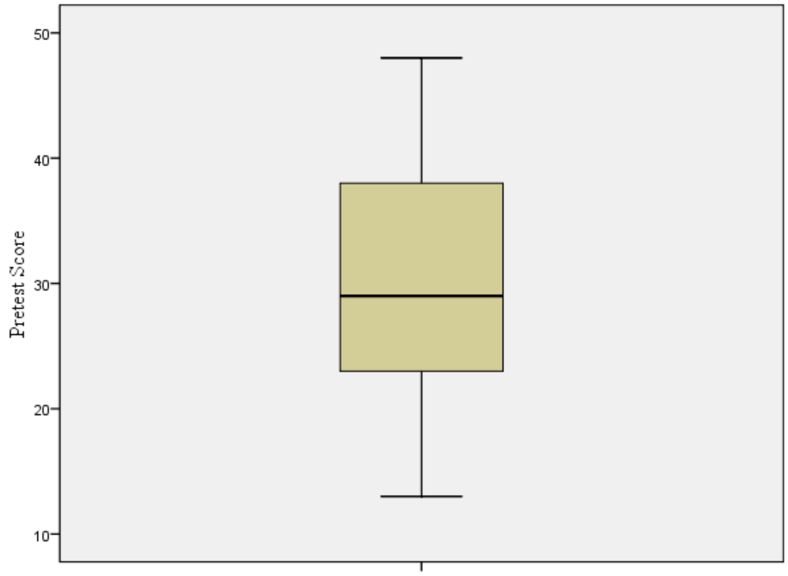

Figure 10. **Box-plot of personalized-instruction pre-test scores.**

Figure 10 is a box plot of the normally distributed personalized-instruction pre-test scores. The first, second, and third quartiles were 22.0, 29.0, and 39.0. The pre-test scores for the personalized-instruction class had a minimum of 13 and a maximum of 48. No outliers were found. Now that the pre-test data has been shown to be reasonably normally distributed an investigation of the post-test data is appropriate.

The distribution of post-test scores for the personalized-instruction class is again explored with a Q-Q plot, followed by skewness and kurtosis values. Figure 11 below is a Q-Q plot for the personalized-instruction post-test scores and Figure 12 is a distribution of the same post-test scores.

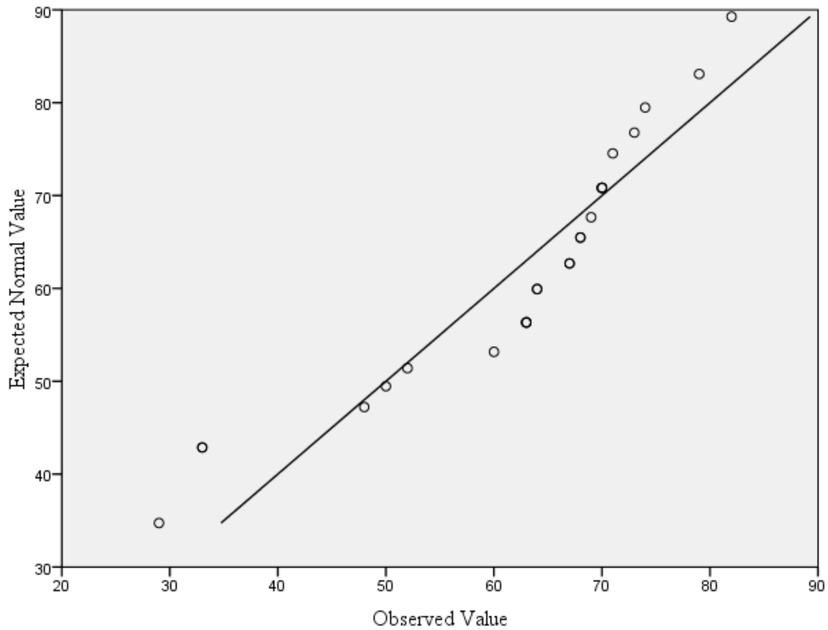

Figure 11. **Q-Q plot for personalized-instruction post-test scores.**

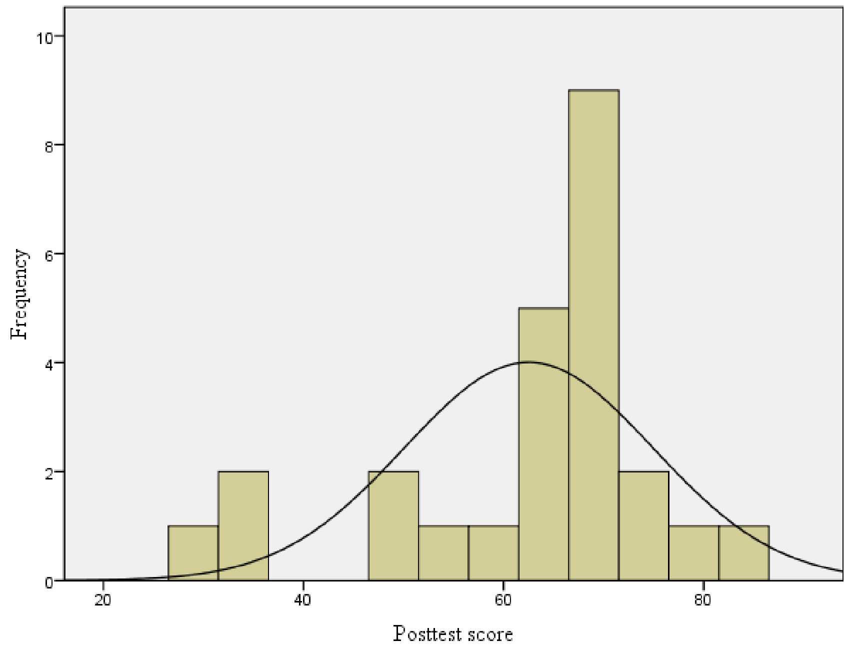

Figure 12. **Distribution of personalized-instruction post-test scores.**

The personalized-instruction post-test scores ranged from 29 to 82 points (*M* = 62.00, *SD* = 13.88). Post-test scores were distributed with skewness of -1.20 (*SE* = 0.46) and kurtosis of 0.87 (*SE* = 0.90). The magnitude of the ratio of skewness to its standard error was 2.6. This magnitude, and the fact that skewness was negative, indicated that the distribution of post-test scores was left-skewed. This meant that for the personalized-instruction class more of the post-test scores were found in the upper range than the lower end. The magnitude of the ratio of kurtosis to its standard error was 0.97.

Because the post-test data are non-normal the analysis is accomplished via non-parametric methods. In particular, hypothesis 2 was analyzed with the Wilcoxon Signed-

Rank Test. The Wilcoxon test is an appropriate non-parametric test as it was developed to analyze repeated-measures designs. This test evaluates differences between paired scores to determine whether the medians of the variables are statistically significantly different. The assumptions of this test are random assignment of treatment condition to members of a pair, no zero differences, and no ties. Effect size is calculated by dividing Z by the square root of N (King & Minium, 2008).

The Wilcoxon Signed-Ranks test conducted to compare the pre-test and post-test scores under personalized-instruction shows there to be a significant difference between the median scores of the pre-test and post-test for the students in the personalized-instruction class. The Wilcoxon test indicated that the median post-test score (Mdn_{pst} = 67.0) was statistically significantly greater than the median pre-test score (Mdn_{pre} = 29.0), Z=4.38, p<.001, r=0.88.

To compare the differences in the obtained effects the r from the Wilcoxon test was converted to Cohen's d using the following formula $d = \frac{2r}{\sqrt{1-}}$ (Becker, 2000). This translates r=0.88 to d=3.71. As in the analysis of the direct-instruction data the personalized-instruction pre-test/post-test differences are remarkable with a Cohen's d of 3.71, demonstrating the effectiveness of the personalized-instruction for the students in this classroom.

Both instructional methods produced statistically significant gains. The difference in improvement between methods, however, remains to be analyzed. The differentiation between classes can be determined by observing the post-test scores from each class. To determine if the comparison of post-test scores, by condition, is warranted box plots were compared to examine median and spread of the data.

Figure 13 is a Box-plot for both conditions; the box-plot display indicates that the two teaching methods showed similarities in median score, interquartile range and spread of the data. Therefore, it is appropriate to compare post-test scores in the determination of instructional differences.

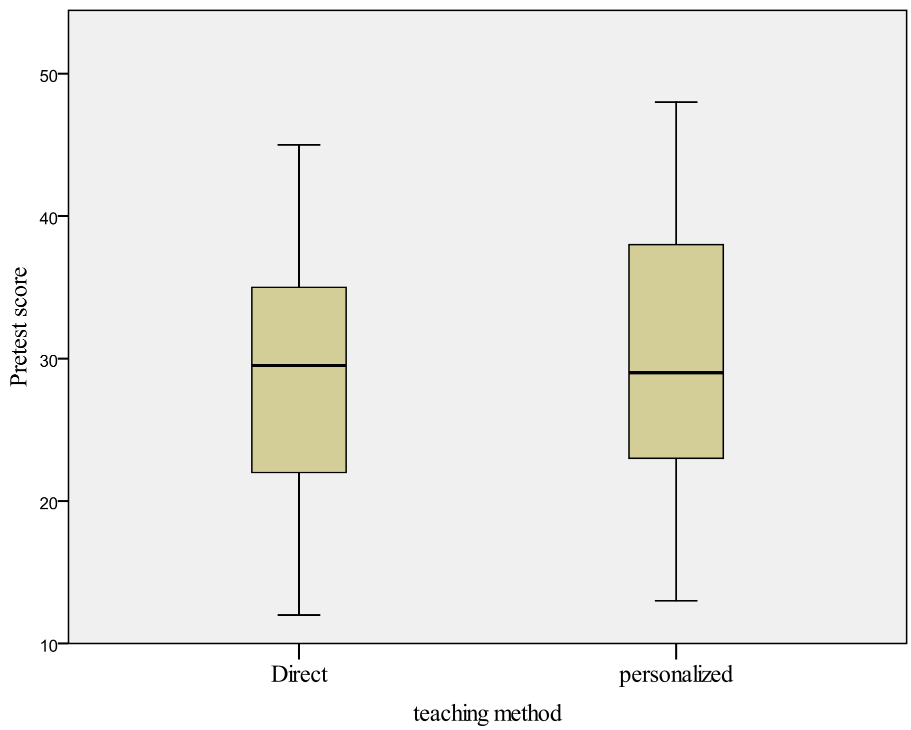

Figure 13. **Box plot of pre-test scores for the two samples.**

Hypothesis 3

There is a difference in the median post-test score on the customized end-of-course exam by teaching method.

To demonstrate the magnitude and variations of the median scores the 95% confidence interval was chosen because it is the corollary to choosing the .05 critical value. The post-test scores in the personalized-instruction classroom were non-normal therefore the non-parametric Mann-Whitney U Test is performed to compare the medians of the two conditions.

The post-test scores for students experiencing direct-instruction ranged from 30 to 81. The post-test scores for students experiencing personalized-instruction ranged from 29 to 82. A Mann-Whitney *U* test indicated that the median score (*Mdn*=63) for students experiencing direct-instruction, was not statistically significantly different from the median score (*Mdn*=67.0) of the students experiencing personalized-instruction, U=307.0, p=0.73, r=0.05. For facility of comparison the r=0.05 is converted to d=0.10 which is indicative of a non-important difference.

Though the paired-sample *t*-test and the Wilcoxon signed-rank test showed that test scores improved from pre-test to post-test in the direct-instruction and the personalized-instruction classrooms, respectively, A Mann-Whitney U Test (employed on two groups of randomly divided subjects different from each other) revealed there was no significant difference between the two classes' post-test scores.

Figure 14 shows that students in both classes statistically significantly improved their scores. The confidence intervals for the median display reducing from pre-test to post in the personalized-instruction classroom but not as distinctively in the direct-instruction classroom. The Interquartile range in the direct-instruction class at the start of the study (*IQR*=13.25) and at the end of the study (*IQR*=15.5) were similar, a difference of 2.25 points was experienced. This shows that on average while all students improved the relative spread was not decreased, in fact, it slightly increased. Therefore the gap among students remained relatively statistically unchanged. In contrast, the interquartile range in the personalized-instruction class was *IQR*=17.0 at the start of the study and *IQR*=14 at the end of the study which a decrease of 3.0. This shows that, on average, the students improved as a group, but most importantly, the gap between the highest achievers and the lowest achievers was reduced.

The customized exam employed for data collection consisted of short-answer and extended-answer items which were used to distinguish between depth and breadth of knowledge acquired within the two conditions. Question 2 addresses the influence of teaching method on question type.

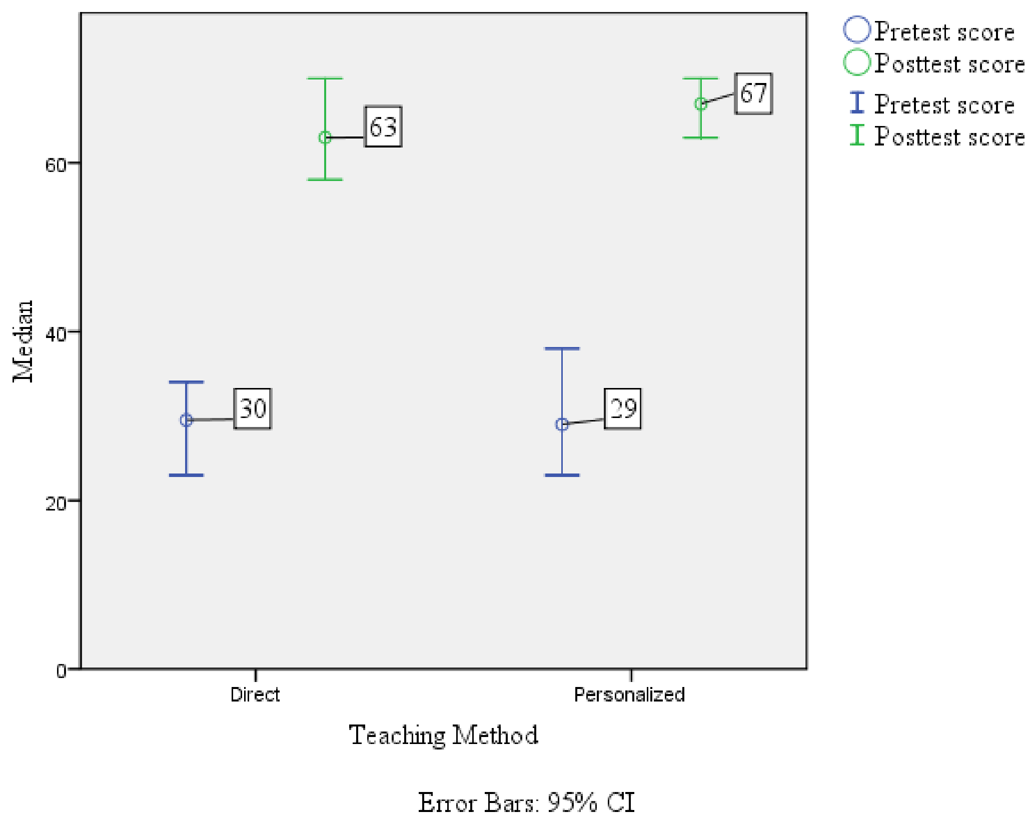

Figure 14. **Median achievement scores, pre/post-test, by teaching method.**

Question 2: Does personalized-instruction or direct-instruction differentially impact student performance on rote knowledge (short-answer items) as compared to synthesis and analysis questions as measured by extended response?

This question involved four hypotheses. As seen in Table 3 below, there were scores from four groups that are compared. The scores on short-answer and extended-answer questions were compared for students under direct-instruction (D_S versus D_E) and then for those students under personalized-instruction (P_S versus P_E). Additionally, the scores of students under direct-instruction and personalized-instruction were compared for just short-answer questions (D_S versus P_S) and for just extended-answer questions (DE versus PE).

Table 3

Symbols for Test Scores from Four Categories

	Short-answer	Extended-answer
Direct Instruction	D_S	D_E
Personalized Instruction	P_S	P_E

Hypothesis 4

Direct-instruction affects student performance on short-answer (rote-knowledge) questions differently than on extended-answer (deductive-reasoning) questions (D_S versus D_E).

The analysis of hypothesis 4 began with an examination of the distribution of the pre-test and post-test short-answer scores from the direct-instruction class in order to determine the normality of distribution. The pre-test short-answer scores were normally distributed, with skewness of -0.49 (*SE*=0.46) and kurtosis of -0.27 (*SE*=0.89). The magnitude of the ratio of skewness to its standard error was 1.07 and the magnitude of the ratio of kurtosis to its standard error was 0.30. Both of these magnitudes were less than two thus indicative of a normal distribution. Analysis of the direct-instruction post-test short-answer scores also revealed a normal distribution. The short-answer scores had a skewness of -0.81 (*SE*=0.46) and a kurtosis of 1.23 (*SE*=0.89). The corresponding ratio magnitudes were 1.76 and 1.38.

Furthermore, the direct-instruction pre-test and post-test extended-answer scores were also normally distributed. The pre-test scores had a skewness of 0.66 (*SE*=0.46) and kurtosis of 0.36 (*SE*=0.89). The magnitude of the ratio of skewness to its standard error was 1.43 and the magnitude of the ratio of kurtosis to its standard error was 0.40. Lastly, the direct-instruction post-test extended-answer scores had a skewness of -0.65 (*SE*=0.46) and a kurtosis of 0.26 (*SE*=0.89). The magnitudes of the appropriate ratios again indicate a normal distribution (1.41 and 0.29 respectively).

Figure 15 displays the differences between the mean short-answer score and mean extended-answer score for both pre-test and the post-test under direct-instruction.

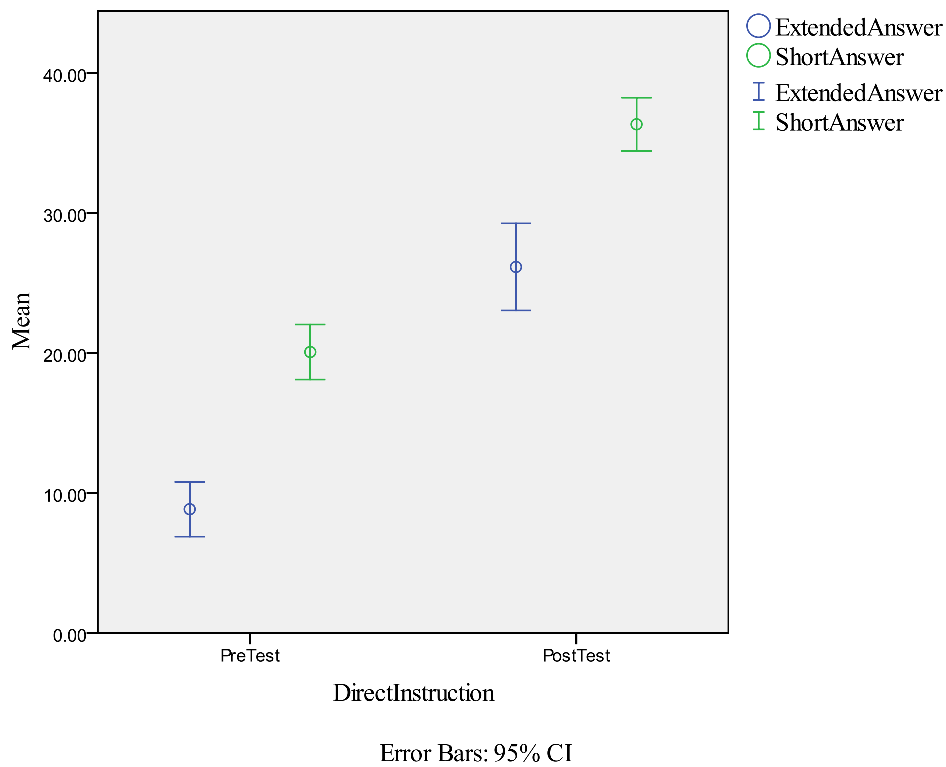

Figure 15. **Direct-instruction short-answer/extended-answer differences.**

Subtracting the direct-instruction pre-test short-answer scores from the direct-instruction post-test short-answer scores produces the improvement scores for the short-answer questions. This was done again with the extended-answer questions. A paired-samples *t*-test was employed to analyze the mean difference of the improvement scores for the short-answer and extended-answer scores in direct-instruction.

The paired-samples *t*-test indicated that there was not a statistically significant difference between the average short-answer improvement (*M*=16.27, *SD*=6.79) and the average extended-answer improvement for the direct-instruction group (*M*=17.31, *SD*=7.35), *t*(25)=-0.821, *p*=0.420, *d*=-0.15.

Hypothesis 5

Personalized-instruction affects student performance on short-answer (rote-knowledge) questions differently than on extended-answer (deductive-reasoning) questions (P_S versus P_E).

The analysis of hypothesis 5 began with verification of the distribution of the personalized-instruction score improvement data. Score improvement data was created by subtracting pre-test data from the post-test data. This was done for both short-answer questions and extended-answer questions. The short-answer improvement scores were normally distributed with a skewness of -0.10 (*SE*=0.46) and a kurtosis of -0.28 (*SE*=0.90). The magnitude of the ratio of skewness to its standard error was 0.22, and the magnitude of the ratio of kurtosis to its standard error was 0.31. The extended-answer improvement scores were also normally distributed with a skewness of -0.31 (*SE*=0.46) and a kurtosis of -0.70 (*SE*=0.90). The magnitude of the corresponding ratios was 0.67 and 0.78 respectively. All ratios are less than 2 and indicative of normal distributions.

A paired-samples *t*-test was employed to analyze the mean difference of the improvement scores for the short-answer and the extended-answer questions in the personalized-instruction class. These differences are displayed in Figure 16.

The paired-samples *t*-test indicated that there was not a statistically significant difference between the average short-answer improvement (*M*=15.52, *SD*=5.13) and the average extended-answer improvement for the direct-instruction group (*M*=16.40, *SD*=8.51), $t(25)=-0.53$, $p=0.60$, $d=-0.13$.

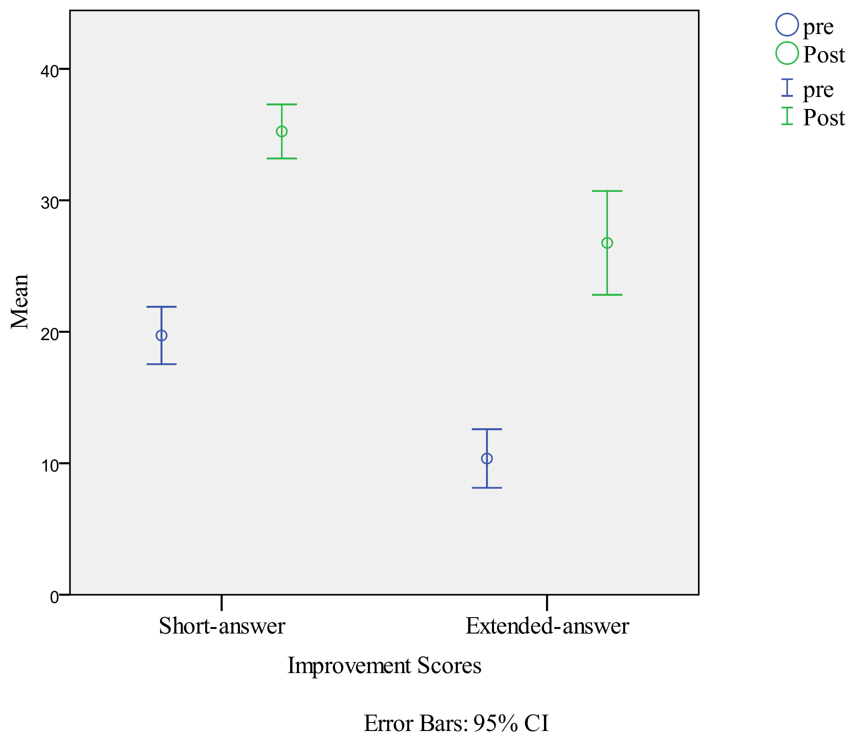

Figure 16. **Personalized-instruction short-answer/extended-answer differences.**

Hypothesis 6

Direct-instruction affects student performance differently than personalized-instruction on short-answer questions (D_S versus P_S).

Hypothesis 6 (D_S versus P_S) was first analyzed with a check on the normality of the distribution of short-answer scores. The direct-instruction short-answer test score differences ranged from 3 to 33 points (*M*=16.27, *SD*=6.79). The score differences were normally distributed, with skewness of 0.18 (*SE* =0.46) and kurtosis of 0.37 (*SE* = 0.89). The magnitude of the ratio of skewness to its standard error was 0.39 and the magnitude of the ratio of kurtosis to its standard error was 0.42. Both of these magnitudes were less than two thus indicative of a normal distribution.

The personalized-instruction short-answer test score differences ranged from 5 to 26 points (M=15.52, SD=5.13). The score differences were normally distributed, with skewness of -0.10 (SE =0.46) and kurtosis of -0.28 (SE = 0.90). The magnitude of the ratio of skewness to its standard error was 0.22 and the magnitude of the ratio of kurtosis to its standard error was 0.31. Both of these magnitudes are less than two thus indicative of a normal distribution.

This hypothesis was then analyzed by employing an independent-samples t-test to compare the means from the short-answer differences in the direct-instruction classroom and the personalized-instruction classroom. The independent-samples t-test is appropriate in this case because the two groups being compared are independent of each other, and the Levene's Test for equality of variances produced a p-value of 0.23 which indicated the null was not to be rejected and the two variances were approximately equal.

The independent-samples t-test, which determines if the average difference between instructional methods test-improvements (with respect to short-answer questions) is significantly different from zero, failed to reveal a statistically significant difference between the mean test-improvement of students in the direct-instruction class (M=16.27, SD=6.79) and those in the personalized-instruction class (M=15.52, SD=5.13), $t(49)=0.44$, p=0.66, d=0.12.

Hypothesis 7

Direct-instruction affects student performance differently than personalized-instruction on extended-answer questions (D_E versus P_E).

Analysis of hypothesis 7 (D_E versus P_E) began with a check on the assumptions of the independent samples *t*-test. The independent-samples *t*-test compared the means from the extended-answer improvements in the direct-instruction classroom to those in the personalized-instruction classroom. The independent-samples *t*-test is appropriate because the two groups being compared are independent of each other and because the Levene's Test for equality of variances produced a *p*-value of 0.32 which indicated the two variances were approximately equal.

The direct-instruction extended-answer test score differences ranged from 4 to 36 points (*M*=17.31, *SD*=7.35). The score differences were normally distributed, with skewness of 0.45 (*SE* =0.46) and kurtosis of 0.53 (*SE* = 0.89). The magnitude of the ratio of skewness to its standard error was 0.98 and the magnitude of the ratio of kurtosis to its standard error was 0.60. Both of these magnitudes were less than two thus indicative of a normal distribution.

The personalized-instruction extended-answer test score differences ranged from -2 to 29 points (*M*=16.40, *SD*=8.51). The score differences were normally distributed, with skewness of -0.31 (*SE* =0.46) and kurtosis of -0.71 (*SE* = 0.90). The magnitude of the ratio of skewness to its standard error was 0.67 and the magnitude of the ratio of kurtosis to its standard error was 0.79. Both of these magnitudes were less than two thus indicative of a normal distribution.

The independent-samples *t*-test, which determines if the average difference between instructional methods test improvements (with respect to extended-answer questions) is significantly different from zero, failed to reveal a statistically significant difference between the mean test improvement of students in the direct-instruction class (M=17.31, SD=7.35) and those in the personalized-instruction class (M=16.40, SD=8.51), $t(49)$=0.41, p=0.69, d=0.11.

After the investigation of interaction between teaching method and assessment method, the question of student experience arises, hence research question three.

Question 3: Does the perception (of instruction) of students in direct-instruction (based on the SIR II® categories) differ from the perception of students in personalized-instruction?

Hypothesis 8

The perception that their received instruction contributes to their learning is different among students experiencing direct-instruction from those students experiencing personalized-instruction.

In this case the dependent variable, student perception of instruction received, was taken from the SIR II® questionnaire from 7 questions (numbers 2, 3, 4, 6, 8, 9, and 11). The students' perceptions were Likert scale responses to rating the quality of instruction received,1 indicating ineffective and 5 indicating very effective. Likert-type data is ordinal, not continuous, and should not be analyzed using parametric methods (Wiersma & Jurs, 2009). A Mann-Whitney U test (which only assumes that the samples being analyzed are random and independent of each other) is a more appropriate non-parametric test that was employed to compare the perception difference between teaching methods.

Both classes ranged from a minimum of 19 to a maximum of 35. A Mann-Whitney U test indicated that the median perception score for students experiencing direct-instruction (Mdn_{di}=28) was not statistically significantly different from the median score of students experiencing personalized-instruction (Mdn_{pi}=29), U=247.5, p=0.56, r=-0.09. The converted Cohen's d=-0.18.

After investigating teaching methods, assessment methods, and the students' perception of instruction, the question concerning the degree to which students believed they could understand mathematics was analyzed. Determining whether the two classes were similar in their beliefs concerning ability led to research question four.

Question 4: Does the self-efficacy of students in direct-instruction (based on SIR II® categories) differ from the self-efficacy of students in personalized-instruction?

Hypothesis 9

The self-efficacy of students from the personalized-instruction class is different than that of the students from the direct-instruction class.

Self-efficacy was measured from scores obtained on the SIR II®. The 5 questions employed (numbers 29 – 33) were again Likert-scale questions and the analysis of this hypothesis began with the non-parametric Mann-Whitney U.

A mann-Whitney U test indicated that the median score for students experiencing direct-instruction (Mdn=18) was not statistically significantly different from the median score of the students experiencing personalized-instruction (Mdn=18), U=271.0, p=0.93, r=0.01. The converted Cohen's d=0.03.

Interview Results

Interviews with 5 students from each treatment (a total of 10) provided additional insights besides those found in the previous data analysis. Interviews were conducted only with students who had taken one class each from the two participating professors. Students answered questions about their course experiences during the semester of the study (Math 011) and about their experience immediately following in Math 012 with the alternate professor. Of the ten students selected two chose to take their follow-up class from the alternate professor because they were not happy with their experiences in the first class. Both of the disgruntled students went from direct instruction to personalized instruction. The remaining 8 took the class that best fit their schedule.

Though no students were interviewed that did not have experience with both methodologies, 6 additional students that maintained the same professor for their follow up class were asked why they remained with the professor they started with. Three of these (from personalized-instruction) replied they enjoyed the professor and his "style." The other three (from direct instruction) replied they were either "used to" the way they were being taught (2 students) or their schedule just worked out that way (1 student).

The interview questions (Appendix C) were formulated to ascertain the student experience in a classroom taught with personalized or direct instruction. Questions focused on four general areas: feelings concerning the quality of teaching received, learning environments, personalized instruction, and direct instruction. After preliminary results the technique of member check, or respondent validation, was employed to ensure accurate interpretations were being made.

Four emergent themes were revealed from the interview responses; superior instruction was said to be highly prized, an active and welcoming environment was desired, the rate of instruction needed to be just right, and all students felt they absolutely had to succeed regardless of instructional quality. Each of these four themes is addressed below.

Superior Instruction

Regardless of methodology, one re-emergent theme was that of superior-quality instruction. Students who started the experiment in a direct-instruction or a personalized-instruction class both mentioned they wanted a teacher that could provide exceptional instruction along with a thorough explanation of expectations. Understanding how and where to concentrate their educational efforts was of paramount interest. Though students commented that they appreciated quality instruction of any kind, the majority of students' comments, concerning the ideal instructor, described characteristics associated with personalized instruction.

Comments of students who started with personalized instruction tended to be focused on the personality of the instructor. Remarks concerning personalized instruction were more often than not about how nice the teacher was and how much students enjoyed class because of the professor's likeability. Students demonstrated a relationship with this professor that was closer than that of the direct-instruction professor's class. More than once, a test would have graffiti on the side reading "Algebra Rocks" or there would be a heartfelt note at the end of the test to the teacher wishing the teacher well and hoping for a good grade on the test. Although personalized-instruction students as a whole really liked their instructor, they freely admitted they did not like the subject (mathematics).

Comments of students who started in the direct-instruction class were directed toward the highly productive level of learning that occurred and the immediate help provided by the professor. Students appreciated the availability and continuous guidance provided by the instructor. Student remarks about direct instruction were positive regarding genuine learning of new material. It is interesting to note that test questions of direct-instruction students were frequently answered with clichés either heard from friends, or the instructor, such as "irrationals never stop," "Commutative means to move," or "irrationals (are numbers that) don't make sense."

The Active and Welcoming Environment

A second theme to emerge from the interviews was that of milieu or environment. All interviewed students described the most desirable environment as one where they could work on their own, as long as guidance was available. These students revealed a genuine desire to understand mathematics, and a need to be continually involved during class. Overall students called for an environment with more activity, less listening, and continual engagement.

Personalized instruction students commented on the how they enjoyed starting class with a reflection of their week or a short story by the professor. Personalized-instruction students further mentioned they wanted more step-by-step directions and they preferred to have some questions answered straight away without having to construct the knowledge themselves.

Direct instruction students appreciated notes and guidance as provided by the instructor. However, many student comments formed around the idea of lack of activity, many felt bored with class. Though students appreciated the daily guide/notes provided for them, they felt as though they did not get to do enough in class. Students felt there was too much teacher-talk, not enough student-activity. In fact, most negative environmental issues mentioned were those of direct-instruction students who felt there was too much talking and not enough doing. One student claimed that though he enjoyed personalized instruction, he felt direct instruction was better for him for motivational reasons because he felt he needed structure in order to stay responsible.

Rate of Instruction

Thirdly, after synthesizing the interviews it became apparent that many students were concerned with the speed at which class progressed. A few students felt the rate of instruction was too fast but most claimed instruction progressed too slowly. In one case a student simultaneously felt that his class was too slow and too fast, depending on the topic. This student said that some topics had too much time devoted to them while others were addressed much too quickly.

Many students from direct instruction claimed they did not like to wait on other students who were not progressing as fast as they were. Still others in direct instruction alluded to this same feeling when they talked about how boring and slow class was at times. These students said they preferred personalized-instruction qualities to direct-instruction qualities because of this.

Students who experienced personalized instruction stated that though class often progressed slowly, they liked being able to work on their own without feeling pushed. These students also wanted a classroom where repetition was called for and guidance was quickly available. The ability to try several times and have help at all times were considered important factors to have in a classroom.

Completion – Regardless

A final theme to materialize was the importance of completing class regardless of how class was taught or who was teaching the class. When students were asked whether they thought it mattered that their developmental mathematics class was taught with a particular method, the common answer (unanimously) was that it did not matter. Typical responses included: "I just wanted out," "I had to learn (in order) to get out," "I just had to set my mind to it," "I needed to pass the class," and "I have got to do this." All interviewed students described a sense of taking responsibility for succeeding. Students said that the particular teaching method was not the key element for determining whether or not they passed.

Summary

In conclusion, analyses of the data provided some significant results that can assist in further understanding remedial mathematics pedagogy. Parametric and non-parametric methods were useful in analyzing the pre-test/post-test differences, pedagogical methods, and the Sir II ® questionnaire data (concerning perception of instruction and self-efficacy) provided by the students. Interviews with participating students and professors further provided insight into the pedagogy of the college-level remedial mathematics classroom.

Interviews provided thoughtful comments about the instructional methods; students welcomed the opportunity to talk and appeared forthright and open. Students felt as though they did as well in mathematics (or better) than they did in their other classes taken at the same time. The most encouraging result of the interviews was the finding that most students wanted to learn and wanted to be involved in the classroom. There was little evidence from the interviews that students were opposed to either methodology. Most students recalled their personalized-instruction class with fondness and their direct-instruction class as a time when they learned much. The students showed an eagerness to learn and a desire to be active in the classroom in order to promote more learning. It was obvious that some of the actions indicative of the method were not always enjoyed. Students did not like hearing an indirect answer from the personalized-instruction teacher, nor did they enjoy being talked to for 50 minutes without the opportunity to work on their own for a while.

Four primary concepts were investigated: 1) pre-test/post-test improvement, 2) direct-instruction and personalized-instruction, 3) short-answer and extended-answer assessment, and 4) self-efficacy and student perception of instruction in the remedial classroom. While more research will be necessary to fully understand the influence of teaching methods and the impact of assessment type in college-level remedial mathematics, this study provided insight into the process of learning in college-level remedial mathematics. Overall, further research will be necessary in order to adequately assess the most appropriate methods in teaching remedial mathematics students.

The questions that guided this study were centered on effective pedagogy for the college-level remedial mathematics classroom and the most appropriate way to assess the learning of incoming college students deemed remedial. Interpreting results of the research questions is contingent on data coming from students that were willing to work towards successfully passing (self-efficacious). The final section addresses more interpretation of the interview results and the interpretation of the questions that assisted in exploring the elements within the process of teaching the remedial mathematics student. Section 5 also speaks to the insights found in the literature review as well as the contributions of this study and possible future research needs based on the findings of this study.

5. SUMMARY AND CONLUSIONS

Introduction

This final section starts with an introduction that briefly reviews the problem statement, the theoretical perspective, and the methodology. Then the results from section four are presented followed by a summary and discussion of results, implications for further practice and research, recommendations, relationship of results to theory, limitations, and, finally, the summary and conclusions.

Problem Statement

This project follows the advice of researchers such as Taylor (2008) who concluded that further research was needed to determine best practices in developmental mathematics courses and Jorgensen (2010) who found that there are a limited number of studies with post-secondary developmental mathematics (none of which were randomized controlled experiments) and that there is a great need for more pedagogical research. The prominence of modern college-level remediation prompts action into effective guidance for the remedial mathematics classes.

Theoretical Perspective

There are two theoretical perspectives that maintain opposing views with respect to where instructional effort is concentrated. These two common pedagogical methods are constructivism and behaviorism. Accordingly, either the student (the constructor of knowledge) is the center of pedagogical attention or it is the teacher (the modifier of behavior). As pointed out by numerous researchers (Baxter & Smith, 1998; Venville, Sheffield, Rennie, & Wallace, 2008; Waycaster, 2001), pedagogy affects the success of remedial students and math scores are sensitive to instruction type.

Methodology

Rather than focus on a single ideology, Jones and Southern (2003) found a need for more research in the area of efficiency and effectiveness in mathematics education. Furthermore, the National Mathematics Advisory Panel (2008) indicated that future research should take into account more than one focus such as student only or instruction only. As a result, the methodology of this investigation accounted for numerous variables including teaching method, assessment, and student self-efficacy.

This study focused on two differentiated instructional methods by defining specific actions for teachers to exhibit after which student learning was measured, as marked by pre-test/post-test improvement, within two classes taught by these teachers. Furthermore, the instrument employed for measuring consisted of two different assessment methods. The analysis explored the relationship between pedagogy, assessment, and the college-level remedial student's self-efficacy. Interviews further defined student perceptions of the instructional methods and their ability to succeed.

Summary of Results

The present study's questions focused on the experience of college-level remedial mathematics students. The first research question was designed to reveal the achievement of remedial students after experiencing varying methodologies. Analyses related to question one revealed that students experiencing direct instruction significantly improved their test scores demonstrating the effectiveness of this methodology (Hypothesis 1). Similar results were uncovered with the analysis of students experiencing personalized instruction (Hypothesis 2). However, the significant gains made in each class were not found to be different from each other (Hypothesis 3). The general direct-instruction student, though making great progress during the experiment, did not progress any more or less than the general personalized-instruction student.

The second question was designed to elicit information concerning the assessment of the college-level remedial mathematics student. This question was analyzed in four parts in order to account for interaction. First, it was found that direct instruction produced improvement in short-answer questions and extended-answer questions in relatively similar amounts (Hypothesis 4). Direct instruction did not merely teach students to memorize and regurgitate information as might be expected with short-answer questions. The students from this methodology were also able to use deductive reasoning as observed in the nearly equivalent gains as measured on the extended-answer questions.

Secondly, it was found that personalized instruction also produced similar gains in short-answer questions as compared to extended-answer questions (Hypothesis 5). Though improvements were found, again as measured with the two question types, improvements were not significantly different. Personalized-instruction students just as readily responded to synthesis and analysis questions as they did to rote-memorization questions. Though it was discovered that students improved dramatically from pre-test to post-test in short-answer questions as well as extended-answer questions, neither question type held an advantage over the other in measuring student achievement.

Thirdly, it was found that direct-instruction students did no better than personalized-instruction students when it came to short-answer questions (Hypothesis 6). Though both methodologies produced gain in short-answer questions, neither had an advantage over the other for reproducing short-answer mathematical knowledge.

Lastly, analysis revealed there to be no significant difference between direct-instruction and personalized-instruction gains as measured on extended-answer questions (Hypothesis 7). This result is also interpreted as one methodology being as efficient as the other for allowing students to synthesize and produce meaning from mathematical knowledge.

Question 3 was included in this research to understand the students' perceptions about the instruction they were receiving (Hypothesis 8). Student perception of instruction was similar in both treatments; both classes considered the instruction received to be effective. Analysis revealed students tended to feel the same about direct instruction as they did about personalized instruction.

The final research question was structured to determine whether or not the two classes in this study contained students with similar feelings of self-efficacy (Hypothesis 9) because students with low self-efficacy tend to respond differently than students with higher self-efficacy. Analysis revealed similar scores across treatments; both classes considered their self-efficacy to be about the same in mathematics as any other course they were taking. Therefore, neither class had an advantage (or disadvantage) by having a disproportionate number of students with differential self-efficacy scores.

Discussion of Results

Analysis of the research questions produced mixed findings. As expected, teaching methodologies produced achievement in both classes. Analyses of pre-test/post-test differences indicated statistically significant improvement. However, no support emerged from the current study for concluding personalized instruction produces greater results than direct instruction, or vice versa.

The results of question one, both treatments had students excelling yet not differentially, are not surprising after reading student comments concerning their desire to succeed regardless of teaching method. Indeed, interview results showed students formed a mindset to successfully complete remedial mathematics regardless of the methodology they experienced. Students were motivated to succeed academically in order to continue with their college career, and they felt that one goal surpassed the effect of teaching method.

Alternatively stated, the nearly equal effect of teaching method shows students were learning while experiencing various teaching methods, and they were putting in at least the minimum effort required to get to the next level of their academic career. As Belcheir (2002) suggested, motivated students will take advantage of the provided pedagogy. Future research should concentrate on the proper motivating factors to create strong student effort. Administrative attempts to generate student exertion will create greater support for students throughout their college career.

Question two revealed that though both assessment methods indicated improvement, the data provided no support for the hypothesis that assessment method provides differential results. This outcome is to be expected with classes that are a genuinely random mix and, therefore, have similar variances in ability. Previous researchers (Hailikari et al., 2007; Muro & Terry, 2007) pointed out that students exhibit their knowledge in different manners, and the classes in this experiment contained similar ratios of students that prefer rote-knowledge questions to deductive-reasoning questions. As a result, the progress made, as measured with different assessment methods, is similar in the two classes.

Furthermore, it is also concluded that both professors were adept at their practice, and, as a result, the students achieved through the experience of superior pedagogy. Considering that both professors were well trained in their practice, this finding is similar to the results found by other researchers that stated excelling in remedial mathematics is accomplished with superior instruction. This finding was mentioned by

Rowe (2003) and Hattie (2003), both of whom found excellence in teaching as a powerful influence on achievement.

Indeed, data analysis revealed the perception of teaching quality in the two instructional methods showed no significant differences. The results of this third research question demonstrated that students did not feel much differently about direct instruction than they did about personalized instruction. The study provided no support for the hypothesis that students preferred one methodology over the other. Interviews corroborated that students were generally content with their instructors. Synthesis of the interview comments produced results that made the clear point that personalized-instruction students tended to like their instructor and the direct-instruction students felt as though they learned new material in their class. Both of these student feelings can be translated as students appreciating the pedagogy they experienced.

The results of the final research question demonstrated that students' feelings of self-efficacy were not significantly different across treatments. Both classes finished the semester with similar feelings of self-efficacy. This result corresponds with comments from the interviews in which several students remarked that they felt the material was beneath their ability, others said that they were fairly familiar with the topics and found them simple, while still other students commented on the slow pace of presentation they experienced. Ironically, not all of these students passed with high scores. This is not too surprising because modern students may be found to be impatient (Latterell, 2007), and the technology of successive generations makes it easier and easier to have factual knowledge at hand without having to apply an in-depth thought process. At the same time, it does seem surprising that with the increased ease of access to information so little of it is actually maintained and recalled for further creative thinking.

Summary Statement

Several conclusions can be drawn from this study, each of which deserves consideration with respect to the college-level remedial mathematics classroom and the larger education community in general. I start with three conclusions I derived from my study that include: 1) Students will succeed regardless of methodology when they feel compelled, 2) High quality teaching of a specific methodology leads to achievement, and 3) Students want to play an active part in their learning. I believe consideration of each of these conclusions, when designing classroom pedagogy, will result in a productive, achieving student.

The implications of this study's findings are important for post-secondary institutions dealing with the increasing masses of remedial students. Millions of dollars are being spent each year in an attempt to successfully educate and advance students to higher education. The inability to transfer more than 5% of remedial students from community college to a 4-year institution (Maxwell et al., 2004) needs to be remedied. Continued failures at remediation are the result of an inability to communicate with and/or evaluate the modern student and can only result in yet higher costs. Future questions to address would be how to compel students to succeed, how to ensure instructors are employing high quality pedagogy, and what ratio of lecture and activity will keep the student involved and learning.

Implications for Further Research

This section addresses conclusions that have been made after reflection on the completed research and poses directions for further study. Additional quantitative studies regarding the college-level remedial mathematics student are warranted, I believe. While some of my conclusions are in concert with the findings of researchers like Wadsworth et al. (2007) who found one of the most important factors for predicting success to be motivation, and Wood et al. (2007) who found that direct instruction was inspiring and motivated students to learn, and Jones and Southern (2003), who stated the appropriate type of remedial mathematics instruction is a matter of continuing debate, other findings are contrary to research such as that of Mathews (1996) who stated direct instruction was ineffective for higher-order thinking.

Future research must focus on the existence of highly motivating factors and ways of identifying them. There is great value in properly motivating the remedial student to perform regardless of circumstances. This particular treatment leads to a different, perhaps higher understanding of the nature of teaching/learning in that it recognizes the ultimatum (pass remedial mathematics or drop out of college) as a primary influence. Using techniques similar to those utilized in this study, it would be possible to perform analyses of other remedial classes exposed to further specific pedagogical actions with students motivated differentially. Finally, further studies addressing measures not considered in this study, such as gender, race, and age, would be beneficial, and additional work could be done in narrowing the reasons for high remedial placement rates in the first place. This study contributes to the current literature and clarifies the affect of instructional method for college-level remedial mathematics.

Implications for Practice and Recommendations

The most significant implications to come from this study derive from interpretation of results, i.e. understanding must precede prescription. It appears that college-level remedial mathematics students benefit from a clear and present knowledge of consequences, in-class activities that promote involvement, and, of course, high quality instruction.

Therefore, the first implication is that mature students who understand the ramifications of success/failure and are faced with an ultimatum are motivated to perform regardless of instructional style. In fact, a theory proposed by Hammerman and Goldberg (2003) states that instruction of remedial students should focus on situations in which students learn best. Secondly, students desire to be a part of their education and actually want to be involved in activities that promote learning, an idea supported by Latterell (2007). Finally, well trained instructors in touch with student needs are imperative to student success (a concept promoted by Rowe (2003). In fact, even though there is a marked preference for personalized instruction in the literature, the findings of this study show, in practice, high quality direct instruction also produces achievement as well as students who feel that they are learning the material.

The benefit this study found from personalized instruction was the reduction in the size of the learning gap from pre-test to post-test. Personalized instruction produced a smaller difference in learning between the minimum and maximum achievement scores than did direct instruction. This information is important for the counseling and advising of students placed into classes considered personalized or direct. Whereas direct instruction produces achievement in all students, personalized instruction narrows the difference between the high achievers and the low achievers. The benefit of direct instruction is the high level of structure for students for whom this is a recognized need.

Relationship of Results to Theory

The conceptual frameworks for this study were behaviorism and constructivism with an understanding that their effectiveness was dependent upon the epistemological theory that self-efficacy affects effort and performance. These two instructional methods were employed because they tend to concentrate efforts in distinctly different areas. However, it is determined from the results of this study that an overriding influence to instructional method is the students' motivational factors. For example, one student expressed his fear of having to leave college if he were not able to finish remedial mathematics. In fact, Texas Education Code 51.907 limits the number of courses a college student may drop. After 6 drops the student cannot drop another class with a "W." Other interviewed students stated the instructional method they experienced was not as important as the fact that they wanted to get the class behind them in order to begin other credit bearing courses. The desire to successfully complete remedial mathematics is supported by Hall and Ponton (2005) who found that many students see remedial classes as a stigma.

The idea of students performing when they must is consistent with the Koller and Baumert (2001) perspective that student beliefs are of primary importance in learning. Similar views are also put forth by Young (2002) who stated that student determination was a strong factor in remedial mathematics and Wadsworth et al. (2007) who pointed out that college students find themselves in need of being more responsible for their own learning.

Perhaps the reason students desire to have an active role in the classroom is because they recognize the need to truly learn in order to successfully complete remedial mathematics. Latterell (2007) confirmed that the modern student wants to be engaged and be part of an interactive class. White-Clark, DiCarlo, and Gilchriest (2008) also recommended a cooperative class with hands-on activities. The active role requested by students can even be said to be a necessity as Latterell (2007) said when she found the modern student has a shorter attention span and, therefore, classroom involvement is requisite.

This study found that students were more interested in high quality teaching than they were about specific actions taken by the teacher. This idea follows the findings of Thiel et al. (2008) who stated that college students' success is the result of effective instruction. Furthermore, Stunkel (1999) claimed authentic learning was the result of high quality instruction, Rowe (2003) found that quality teaching is of utmost importance for student achievement (Rowe, 2003), and Hattie (2003) stated the single most powerful influence on student success is that of excellence in teaching.

Limitations

Aside from the commonplace limitations of working with human beings, who are affected by numerous non-controllable variables, some study-specific limitations also exist. The most apparent limitation within the scope of this study was an inability to control the out-of-class activities of the students. Some students had jobs and worked numerous hours, had other responsibilities, had health issues, or had distances to travel, and, therefore, more or less outside study time to put into the class. Exposure to teaching method is difficult to isolate as the sole factor influencing achievement.

While it is the opinion of the researcher that presenting both teaching method and assessment method was an innovative approach, it remains that some of the numerical data was incomplete and did not yield as conclusive results as might have otherwise been achieved with larger numbers. There were other limitations to this study that restrict the generalization of its results. The results of the present study have been generated by the students of a small private parochial school, the sample size was 51 students in both groups combined (ideally, more students should be involved in a validation study), and the ratios of ethnicities may be different in other situations. The sample mostly consisted of freshmen and only a few returning students of greater maturity. Due to the nature of the campus and the unique population, it would have been extremely difficult to generalize to all remedial mathematics students attending a university.

Due to the small interview sample size and the limited number of students who were exposed to both forms of instruction, some conclusions are based upon the feelings of a minority of the experiment participants. While the students who have participated in this study were most likely no different than these sample students, the data gathered is being extrapolated to the group.

Interpretation and Recommendations

Literature exists that is supportive of direct instruction as well as personalized instruction. As a result of this study, the dual views substantiated by literature are confirmed for small parochial schools, such as the one in this study, as well. Students achieved nearly equally after experiencing personalized or direct instruction. Furthermore, student perceptions of instructional methods employed were not considered significantly different. In addition, the differences in achievements were measured in two different ways, and neither assessment method was found to be advantageous over the other or was affected more strongly by a particular teaching method.

Interview information provided insight into reasons for these conclusions. For instance, students revealed a desire to successfully complete remedial mathematics in order to continue with credit bearing classes. They exhibited a genuine interest in understanding mathematics and a desire to be actively involved during the class period. Furthermore student comments demonstrated an appreciation for high quality instruction regardless of specific teacher actions. Though comments ranged from a preferred rate of learning and instant feedback to explicit instructions and repetition, the most revealing statements involved the students' conscious decision to do what was necessary in order to move on with college-credit courses.

College-level remedial mathematics students find themselves in a sink or swim situation. Many who realize their predicament rise to the occasion and succeed when high quality instruction of any type is available. College students who understand their situation will do what is necessary to make progress in their education. Often times this means actually learning the material at a deeper level than their previous experience, and, as a result, many students become interested in their education and want to play a more active role.

Contrary to expectations, personalized instruction showed no commanding advantage over direct instruction. Personalized-instruction classroom students enjoyed activities during the class period and the way the general atmosphere was structured at the beginning of class so as to create a general comfort level. Though many personalized-instruction students tended to like their teacher and felt comfortable openly communicating with him, a few mentioned they still did not like mathematics. Conversely, though direct-instruction students did not like to sit and listen during class, many replied that they felt they were progressing and learning. Interviews with the direct-instruction students also revealed the participants greatly appreciated their instructor's willingness to help and his quick feedback response.

The increasingly prevalent aspect of remedial mathematics in American society demands further investigation and the provision of quality instruction. The experimental results in this study failed to support the notion that one instructional method is superior to another (regardless of assessment type), students successfully passed remedial mathematics and went on to college level courses. Nearly equivalent achievement rates regardless of instructional method, suggests that the key to success is found outside of instructional method alone and likely in student motivation. These findings provide the basis for future experiments into the student incentive to succeed.

In conclusion, this study was an attempt to investigate instructional methods and assessment methods and their effect on remedial students. This study has also shown that instructional method appears to be of secondary concern with students who desire to successfully complete remedial mathematics. Although this study failed to provide compelling evidence in support of personalized instruction or direct instruction, it seems highly probable that the combination of high quality instructional method and student aspiration will yield positive results.

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APPENDIX A

CUSTOMIZED END-OF-COURSE EXAM

Name______________________________

Introduction to Algebra

Math 011

Final Exam

December 13, 2009

Instructions: This exam has 33 questions, point values are listed. **Answer all questions**. No notes, book, neighbors, or other aid allowed (except a calculator, pencil or pen, and eraser). It is suggested that you look over the entire test first and answer those questions that you feel you know the best. **Budget your time!** Show your work and/or include reasoning and explanations to receive partial credit where appropriate. Mark your final answer. If you need extra space, use the back of these sheets and direct the reader to them. Put all graphs on graph paper. Make one space worth one point on graph paper. Unless otherwise noted only these pages will be graded.

1] (2 points) Circle any irrational numbers from the set

$$\left\{ \qquad \right\}$$

2] (2 points) Explain the difference between the union of two sets and the intersection of two sets.

3] (8 points) What is the order of operations agreement about and why must there be an order of operations agreement?

4] (4 points) Demonstrate the order of operations agreement by evaluating the following expression. Show each separate step of your work: $\left[\quad \right]$

5] (2 points) $3+ \quad + \quad = \quad + \quad +$ is an example of what property?

6] (6 points) Consider an expression requiring several operations.
Order the following operations from first performed to last:

Division, Multiplication, Exponents,

Parenthesis, Addition, Subtraction

____________ , ____________ , ____________ ,

____________ , ____________ , ____________

7] (2 points) Explain the difference between the commutative and associative properties of addition.

8] (2 points) Explain the difference between rational and irrational numbers.

9] If $A=$,5 and $B=$ 3 then…

a. (1 point) $A \cup \quad =$

b. (1 point) $A \cap \quad =$

10] (6 points) Evaluate the following expressions:

a. 3^2

b. $-$

c. $3-$

d. $- \quad \div$

e. $2+ \quad \cdot$

f. $2+ \quad \cdot$

11] (2 points) How does an equation differ from an expression?
Explain the difference between solving an equation and simplifying an expression.

12] (3 points) What different scenarios arise when attempting to solve a system of linear equations? Describe what each occasion means graphically.

13] (3 points) Consider the following system of equations: $\begin{aligned} y &= \quad + \\ y &= \quad - \end{aligned}$

Is this system independent, dependent, or inconsistent?

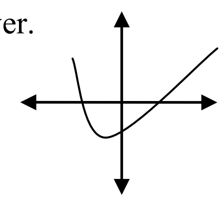
14] (2 points) Graph the point $-$.

15] (2 points) Which quadrant is the point $-$ in?

16] (3 points) Explain what "like terms" are, give examples, and show one counter example when you do not have like terms.

17] (2 points) Is it possible for a function to have two different output values for the same input value? Is it possible for a function to have the same output value for two different input values? Briefly explain your answers to these questions.

18] (2 points) Is the following graph the graph of a function?
Using the vertical line test, draw a line to demonstrate your answer.



19] Simplify (if possible)

a. (1 point) $3x +$

b. (1 point) $3x - \quad +$

c. (1 point) $2x^2 - \quad +$

d. (1 point) $3x + \quad - \quad + \quad +$

20] (2 points) John and Sue both had some apples. John was eating one of his apples when he asked Sue how many she had; Sue only gave John a clue. She said you <u>had</u> three times as many apples as I did before you ate that one. If John has 20 apples left then demonstrate how you can help John figure out how many Apples Sue has.

21] (2 points) How does the vertical-line test work and what is it used for?

22] (1 point) Multiple Choice: Which sentence most accurately describes the general definition of a function?

a. A function is any set of ordered pairs.

b. A function is a set of ordered pairs in which no two pairs have the same first coordinate and different second coordinates.

c. A function is a set of ordered pairs in which no two pairs have the same second coordinate and different first coordinates.

d. A function is a set of ordered pairs in which each pair has different first coordinates and different second coordinates.

23] (1 point) Which of the following is <u>not</u> considered a functional relation:

a. $y =$

b. $x^3 + \ =$

c. $y =$

d. $x^2 + \ =$

24] (3 points) What is the difference between an inscribed angle and a central angle of a circle? How is the measure of an inscribed angle related to the measure of a central angle?

25] (4 points) Describe a rectangular coordinate system.
Include in your description the concepts of axes, ordered pairs, and quadrants.

26] Solve the following equations for x.

a. (2 points) $3x- \quad =$

b. (1 point) $x + \quad = -$

27] a. (1 point) Suppose lines L_1 and L_2 are parallel and that L_1 has slope 3. What would be the slope of L_2?

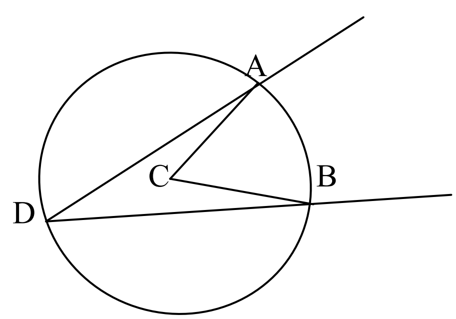
b. (1 point) Suppose lines L_1 and L_2 are perpendicular and line L_1 has slope 3. What would be the slope of line L_2?

28] (3 points) Consider the wheelchair ramp going into Pachero Hall. Suppose the contractor wanted to build the ramp with a slope that was undefined. What would this ramp look like and explain why other choices would be better. Could this ramp be built with a slope of zero?

29] (2 points) What is an intercept and what number is guaranteed to be associated with an intercept? Consider both the x-intercept of a graph and the y-intercept of a graph.

30] (3 points) If point C is the center of the circle and points A,B, and D are on the circle,

and if m$\angle$ = then m$\angle$ =



31] What is the slope of a line that contains the points:

a. (1 point) $- \quad -$ and $3,4$?

b. (1 point) (2,3) and (5,3)?

c. (1 point) (5,-4) and (5,3)?

32] (2 points) Consider two different lines. How are the values of their slopes related if the lines are parallel, and how are the slopes of these lines related if the lines are perpendicular?

33] (2 points; 1 point each)

a. What is the x-intercept of the line given by the equation $2x + \quad = \quad$?

b. What is the y- intercept of the line given by the equation $2x + \quad = \quad$?

APPENDIX B

RUBRIC

The math 011 customized end-of-course exam contains questions that come in pairs; one short answer and one extended answer. They are matched as follows:

Question Topic	***Short Answer*** *Exam number and value*	***Extended Answer*** *Exam number and value*
Differentiating rational from irrational numbers	#1 (2 points)	#8 (2 points)
Defining union and intersection	#9 (2 points)	#2 (2 points)
Using the order of operations	#6 (6 points) #10 (6 points)	#3 (8 points) #4 (4 points)
Recognizing the properties of real numbers	#5 (2 points)	#7 (2 points)
Recognizing the difference between “simplify” and “solve”	#19b (1 point) #26b (1 point)	#11 (2 points)
Solving systems of equations	#13 (3 points)	#12 (3 points)
Using Cartesian coordinates	#14 (2 points) #15 (2 points)	#25 (4 points)
Adding like terms	#19 a,c,d (3 points)	#16 (3 points)
Defining “function”	#22 (1 point) #23 (1 point)	#17 (2 points)

Question Topic	***Short Answer*** *Exam number and value*	***Extended Answer*** *Exam number and value*
Understanding the vertical line test	#18 (2 points)	#21 (2 points)
Problem solving with algebra	#26a (2 points)	#20 (2 points)
Relating inscribed and central angles	#30 (3 points)	#24 (3 points)
Understanding parallel and perpendicular slopes	#27 (2 points)	#32 (2 points)
Describing slope	#31 (3 points)	#28 (3 points)
Defining intercepts	#33 (2 points)	#29 (2 points)
Total Score 92 points	*Short answer total* 46 points	*Extended answer total* 46 points

APPENDIX C

IINTERVIEW QUESTIONS FOR THE REMEDIAL MATHEMATICS STUDENT (POST HOC)

Preamble: I want to ask you 10 questions concerning the learning and teaching of mathematics. Try to avoid any answers that focus on the personality of the teacher, instead focus on teaching qualities.

1. Describe the ideal characteristics of a mathematics teacher.

2. How do you best learn? In other words, what is most efficient for you, and/or what is most preferred by you to learn well?

3. With respect to the class you were in, what do you think enabled your learning?

4. With respect to the class you were in, what do you think distracted your learning?

5. How did you do in class relative to your other classes?

6. What actions/qualities of your teacher can you name that facilitated your learning? I am not asking whether or not you liked or disliked the teacher, and I am not looking for answers like "they were nice" or "they always let me…", I am wondering what they did as a teacher that promoted your ability to learn.

7. Think of a time when you were not successful in a class. Now, set aside your feelings about the teacher of that class. What instructional qualities of that class distracted you?

8. Which of these character sketches would you best learn from:

Teacher X – This teacher is well acquainted with you, he/she not only knows your name but he/she also gives you the impression that he/she knows a lot about you; your likes/dislikes, your hobbies, and he/she understands your personality. This teacher cares about your success inside and outside of the classroom. Teacher X asks you questions about your life outside the classroom and asks math questions that apply to your interests. This teacher allows you to discover, on your own time, how to do math and guides you as you figure out how to work and how to learn.

Teacher Y – This teacher has each day mapped out for you, he/she has the day, as well as the semester, planned out and he/she knows exactly what he/she wants you to learn and how each topic will be important later. The teacher makes sure that you do not fall behind on any day by continually assessing you with daily verbal questions. He/she usually asks you questions that you are able to answer, and if not he/she immediately is able to help you. This teacher not only tells you exactly what you need to know but also when you need to know it. This teacher provides notes and a guide for you to study in order to show you what is important and when you will be tested on it.

9. In the previous question the first description, teacher X, was that of a personalized-instruction professor, the second description, teacher Y, was that of a direct-instruction professor. If you had the choice of a teacher/class-room that was personalized-instruction or direct-instruction which would you rather experience?

10. Does it matter that your teacher was direct-instruction or personalized instruction, or did you adapt to your surroundings?

APPENDIX D

TRAINING COMPONENTS FOR THE TEACHING METHODS

Training component: Direct-instruction

●Pacing

There will be 18 minutes of review material, 24 minutes of new material, and 8 minutes of future material (i.e. teacher paced).

●Dialogue/Prompting

The instructor will ask the class a nearly continuous stream of simple questions and will continually prompt the students for answers to these questions. Non-academic talk will be minimized. The instructor asks the students questions concerning the building blocks or basics of the topic being discussed. The instructor will ask numerous questions concerning the basics. Questions will be directed towards collective groups.

●Guidance

The instructor has a correction procedure in place to immediately correct student misunderstandings or lack of information. For instance, the instructor will tell the students whether their answers are correct or not and will correct any incorrect answers. Guidance from the teacher is for instructional purposes (i.e. direct guidance).

●Instructional Delivery

The instructor will present new material in a thoughtfully sequenced manner that leads the student. The instructor will model new ideas, prompt the students for understanding, and test their collective knowledge, en-mass.

Training component: Personalized-instruction

●Pacing

Review of previous material will carry on as long as the students ask questions. New material can be presented only as student questions either subside or are guided toward new material (i.e. student paced).

●Dialogue/Prompting

Class begins with 2 – 5 minutes of personal reflections, i.e. a rating of the students' day/week or an inspirational story by the instructor. The instructor will promote student generated academic questioning in the classroom only after this intro. The instructor will encourage conversation in the classroom as long as conversation is relevant and all are communicating. The instructor will keep conversation focused on student questions and student interests. The instructor will ask the students mathematical questions concerning college life or student life at the university. The instructor will direct questions by name.

●Guidance

The instructor directs the student towards generating questions and performing correct procedures by coaching and encouraging the student. The goal of the instructor is to have the students discover, find, or describe in their own words the topic of the day. Guidance from the teacher is for motivational purposes (i.e. indirect guidance).

●Instructional Delivery

The instructor will present new material via manipulatives, activities, and projects. Activities include group work, and student presentations (jigsaw groups). Projects include poster presentations, and reports.

APPENDIX E

FIDELITY CHECK SHEETS FOR THE TEACHING METHODS

Fidelity checklist for the direct-instruction classroom

1] Pacing

●18 minutes of review material

_______ minutes of review material completed

●24 minutes of new material

_______ minutes of new material completed

●8 minutes of future material

_______ minutes of future material completed

2] Dialogue/Prompting

●Non-academic talk was held to a minimum

_______Did the class discussion get off topic?

_______ How long till the instructor brought the class back to focus?

●The instructor's questions concerned basic skills

_______ Were the questions focused on basic skills?

_______ Did the instructor emphasize repetition and drill?

●The instructor asked the class more than 50 questions per period

_______ How many questions were asked during the period?

●The instructor questioned the class and smaller groups.

_______ Did the instructor question groups or individuals?

_______ Did the instructor prompt everyone for an answer?

3] Guidance

●The instructor used a correction procedure when students' answers were incorrect

_______ Did the instructor re-ask questions to students that did not reply?

_______ Did the instructor immediately correct misapplications of information?

_______ Did the instructor model and re-ask students that lacked knowledge?

4] Instructional delivery

●The instructor modeled required skills

_______ Did the instructor model skills in a sequential leading manner?

●The instructor referred to the daily program/schedule for the students to follow along

_______Did the instructor provide a daily schedule of events?

_______Did the instructor refer to the daily schedule of events?

_______Did the instructor follow the daily schedule of events?

●The instructor prompted the students for understanding

_______ Did the instructor prompt the students for affirmation of understanding?

____

●The instructor questioned the class/groups and corrected any misunderstandings

_______ How many times did the instructor question and correct the class on new material?

Fidelity checklist personalized-instruction classroom

1] Pacing

●Review is continued until student questions are satisfied

_______ Did the instructor offer the opportunity for student review questions?

_______ Was the students questioning cut short or did the students appear to be satisfied with the time allowed?

_______ How much time was given to the review?

●The main lesson proceeds at the students' pace of discovery

_______ Did the professor allow the students to discover ideas at their own pace?

_______ Were new ideas imparted and revealed by the instructor or was discovery encouraged?

_______ How much time was devoted to the main lesson?

2] Dialogue/Prompting

●2 – 5 minutes of students sharing concerns was permitted at the beginning of class

_______ Were all students given the chance to offer a rating?

_______ How long did was dialogue permitted?

●Students were encouraged to share academic questions and thoughts

_______ Did the instructor offer the opportunity to question and share academically?

_______ Did the instructor encourage questioning?

_______ Did the instructor offer any leading questioning in order to promote student queries?

●The instructor asked questions concerning college life and/or student life

_______ How many examples were used in the main lesson that involved campus activity and/or authentic questioning to the students life?

________ What ratio of the instructors questions were open-ended?

________ Did the instructors line of questioning appear to elicit student conversation or curiosity?

●The instructor addressed all students by name
________ How many names did the instructor use during the lesson?

________ Did the instructor forget, or appear not to know, any names during instruction?

3] Guidance
●The instructor coached replies from the students
________ Did the instructor keep the student inquiry moving forward?

________ Was the instructor encouraging and/or leading in his prompting?

●The instructor encouraged/motivated/cheered the student to reply
________ Does the instructor appear to have a rapport with the students?

________ Did the instructor offer praise when it was called for?

________ Did the instructor promote discovery?

________Did the instructor encourage the student to use their own words in explanation?

________ Did the instructor appear to be motivational?

4] Instructional delivery

●The instructor delivered information via an interactive or discovery type method.

_______In what manner did the instructor deliver instruction?
(small group activity, presentation, group discussion, manipulatives, projects, posters, report, Socratic questioning…)

_______ On a scale of 1 to 10, how would you describe the participation level of the class?

_______ Did the instructor make himself available during any discovery type activity?

_______ Did the instructor coach the students in any manner like engaging in leading question and answer discussions with the students?

_______ Did the instructor attempt to determine student understanding during the lesson?

VITA

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