EVALUATION OF THE EFFECTS OF A CURRICULUM-BASED MATH INTERVENTION PACKAGE WITH ELEMENTARY SCHOOL-AGE STUDENTS IN A SUMMER ACADEMIC CLINIC

By

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The purpose of this study was to empirically evaluate the effects of the Math to Mastery intervention package versus the effects of immediate corrective feedback with elementary school students who were performing at least one year below grade level in mathematics. Students were participants in a one-month summer academic clinic for remediation of reading, writing, and mathematics deficits held at a university in the southeastern United States. A combined-series multiple baseline design across participants was used to evaluate the effects of both interventions for gains in fluency as measured by digits correct per minute on one minute curriculum-based measurement probes. Implications for implementation in applied settings and future research are provided.
DEDICATION

I would like to dedicate this research to my wife, Jill Hoda, for giving me the support and motivation to accomplish the many demanding tasks of graduate school, for providing insight into the “real world” trials and tribulations posed to teachers every day, and for the poised demonstration of principles of learning and behavioral psychology that can be creatively used to inspire children to enjoy school while they are learning skills to prepare them for life ahead. Thank you for being a teacher to me.
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CHAPTER I
INTRODUCTION AND LITERATURE REVIEW

Currently, there are relatively few researched and proven tools for teachers to use to address student shortcomings in mathematics. The following pages are the product of a study in which the effect of a mathematics packaged intervention, Math to Mastery, which is composed of several empirically-proven individual components, was evaluated with six elementary school-age students in a summer academic clinic. The intervention was evaluated in a university-based summer academic clinic setting as a preliminary study for its use in schools to increase fluency with basic math fact skills in school settings. In order to understand why there is need for an empirically-proven and effective intervention for basic math skills, the following review of literature includes: the increase in academic demands and responsibility of schools and teachers (i.e., No Child Left Behind Act of 2002), the traditional approach (i.e., standardized assessment for a learning disability using the IQ-Achievement Discrepancy model) to and shortcomings of the traditional approach for providing assistance to children with academic difficulty, a proposed alternative approach (i.e., Response to Intervention, RTI) to and advantages and disadvantages of the alternative approach for providing assistance to children with academic difficulty, current math remediation practices and effectiveness, current math standards, stages of skill development, fluency (i.e., speed and accuracy) as a measure
skill development, the use of curriculum-based assessment (i.e., Curriculum-based Measurement, CBM) to measure fluency, current researched and proven math intervention components which address fluency, and the creation and components of *Math to Mastery*.

**No Child Left Behind**

The No Child Left Behind Act of 2001 (NCLB, 2002) was enacted, in part, to emphasize the need for accountability in teaching practices including the responsibility to increase academic achievement of disadvantaged students and to achieve academic proficiency for all students (Yell, Katsiyannis, & Shiner, 2006). To this author, it appears that the NCLB authors have made an assumption that all children can attain some minimum criteria of achievement. However, the amount of instruction needed for a child to master a specific skill is idiosyncratic. In other words, some students may master a novel skill after the initial presentation of the new skill in a class lesson, whereas other students may require more instruction ranging from additional practice to more intensive, individualized instruction. Additional resources (i.e., alternative instructional approaches including additional time for practice and feedback, general education and special education personnel, additional worksheets and other materials) are needed to help ensure that those students who have difficulty understanding are not left behind. The traditional pathway for the allocation of those resources and the limitations of this approach are discussed below.
Traditional Pathway to Intervention

In 1977, the U.S. Office of Education established the diagnostic criteria for the Specific Learning Disability (SLD) as (a) failure to benefit from adequate instruction; (b) a severe discrepancy between achievement and intellectual ability; and (c) exclusion of sensory impairments, mental retardation, emotional disturbance, or environmental, cultural, or economic disadvantage (Speece, Case, & Malloy, 2003). Though not required by law, the most frequently used procedure for determining if a low-achieving student has a learning disability has been for the general education teacher, or the child’s parent, to refer the student for a psychoeducational assessment, typically comprised of aptitude (intelligence quotient, IQ) testing and ability (achievement) testing, with the emphasis on finding a significant discrepancy as outlined by federal or state regulations. Despite the fact that most state departments of education utilize this approach, there is no single agreed upon operational definition of a severe discrepancy (Fuchs, Moch, Morgan, & Young, 2003). The result has led to a variety of ways in which the discrepancy is computed, variations in the size of the discrepancy, and which specific IQ and achievement tests are used. Further, the resulting inconsistency in definitions and assessment practices has led to a great deal of variability in SLD prevalence rates (Scruggs & Mastropieri, 2002).

Aptitude by Treatment Interaction (ATI) Model

Those students with a “severe” discrepancy, as defined by each state, meet the diagnostic criteria for a specific learning disability and are then eligible for special education services (Reschly & Ysseldyke, 1995). Proponents of this model assume that
either (a) the results from the standardized assessment of a student’s IQ and achievement can be used to develop an effective intervention by considering the student’s performance on several aptitudes (e.g., verbal and nonverbal (visual/perceptual) performance) and prescribing a treatment from the area of higher performance on the measured aptitudes (e.g., phonics for verbal learners, whole-word for visual learners) or that (b) an additional evaluation of the student’s abilities will need to be conducted in order to design an intervention to target specific skills. Unfortunately, prescribing treatments based on the standardized assessment of aptitudes does not necessarily lead to the enhancement of student performance. The ineffectiveness of this practice should not be a surprise given the lack of empirical substantiation of an aptitude by treatment interaction (ATI, Gresham, 2002). That is to say, there is a lack of useful results from the traditional Discrepancy model of assessment of aptitude which can be used to guide treatment. For example, the assessment of a student with a math learning disability (LD), as diagnosed by a severe discrepancy between IQ and achievement scores, can provide little information regarding which math skills the student has and has not learned and even less information regarding what intervention approaches may be effective with the remediation of those poor skills. Fletcher, Coulter, Reschly, and Vaughn (2004) reported on the ineffectiveness of the special education for learning disabled children concluding that many LD-diagnosed students receiving special education services show minimal improvements and are rarely transitioned from special education back into the general education classroom. Additionally, the many low-achieving children who do not qualify for special education services are left at the mercy of the general education system whose personnel often do not have the skills to meet these students’ needs (Lentz & Shapiro,
A rationale for these results and further expansion of these concerns will be presented below.

Over the past several decades the validity of the traditional Discrepancy model approach to defining and identifying SLD has been questioned based on several problems with the conceptualization and measurement of the IQ-achievement discrepancy (Vaughn & Fuchs, 2003). First, the “test to treat” discrepancy model approach denies services for students currently demonstrating academic difficulty who do not yet meet the discrepancy level criteria. Instead of offering intervention early to reduce the likelihood of failure, the traditional approach offers no assistance and requires the student to “wait to fail” academically in order to create an IQ-achievement discrepancy before intervention can be offered (Fletcher et al., 2004). Also the traditional discrepancy model makes the following assumptions, which have not been empirically supported: (a) severity of LD can be determined by severity of the IQ-achievement discrepancy, (b) there is a difference in academic achievement between students with and without a discrepancy, (c) information provided from an IQ-achievement discrepancy is reliable, (d) identification of a discrepancy provides useful information for remediation, and (e) LD identification requires IQ testing (Vaughn & Fuchs, 2003). As early as 1975, opponents of ATI methodologies called for assessments based on the problem and the use empirically valid treatment, which can be monitored and adjusted as needed (Cronbach, 1975). Responsiveness to intervention (RTI), as a concept for the identification of LD, stems from this notion (Gresham, 2002).
Response to Intervention (RTI) Model

LD has generally been conceptualized as an intra-individual deficit that inhibits learning processes and, therefore, the RTI approach seeks to identify an individual with a learning disability by measuring lack of improvement (unresponsiveness) to an empirically-supported intervention. Whereas the education of both low achieving students and students with a learning disability may include environmental variables such as lack of exposure and poor quality instruction, the responses to empirically proven methods of intervention can be used to delineate the two groups.

Although LD is conceptualized differently from low achievement (LA), there has yet to be definitive support that the two can be quantitatively or qualitatively distinguished from each other. Ysseldyke, Algozzine, Shinn, and McGue (1982) suggested that the two groups were essentially one population due to their findings in that 96% of scores on a variety of psychoeducational measures of LD and LA students were within an acceptable range of variation of each other. However, Kavale, Fuchs, and Scruggs (1994) refuted the previous study after reanalyzing the original Ysseldyke et al. data using a Cohen’s $d$ to control for each groups’ variability (pooled standard deviation) when comparing means. Kavale et al. (1994) concluded that only 37% of the scores of the participants were within a range of overlap and that almost 80% of the LD group could be differentiated from the LA group simply by lower achievement alone. Shaywitz, Fletcher, Holahan, and Shaywitz (1992) concluded groups of LD and LA students were similar when compared along a number of child-, teacher-, and parent-based measures. Shaywitz et al. (1992) then added further confusion when they suggested that both of these populations should be considered eligible for special education services. Fuchs,
Mathes, Fuchs, and Lipsey (2001) were unable to resolve this confusion when they found a .61 effect size for differences in reading achievement to differentiate LD from LA quantitatively or qualitatively in a review of 79 studies. Fuchs et al. (2001) then concluded that the .61 effect size was a large effect size and suggested that it was possible to differentiate LD from LA by lower reading achievement of the former group. However, large effect sizes are typically considered to be .80 or greater (Cohen & Cohen, 1983). The findings of Fuchs et al. translate into a standard score difference of $+9.48$ ($M = 100$, $SD = 15$) standard score difference, which is not particularly large, and does not include allowances for error of the dependent measures. Therefore, the debate continues as to the diagnostic validity of LD and of the notion that LD is a distinct population separate from LA. Unfortunately, many low achieving students have been misclassified as LD students as this is the only means by which to provide intervention through special education services.

Because of the focus on identification of unresponsiveness to intervention, the RTI approach must evaluate treatment effects. In essence, this model also incorporates the use of a discrepancy. In this case, however, the discrepancy is measured by a pre-test and post-test of student performance. As with any expected learning, there should be a difference in performance before and after intervention. Therefore, the lack of response to an empirically-proven, effective intervention delivered with acceptable levels of treatment integrity may be useful in identifying a true learning disability.
General Approach of Response to Intervention

The Response to Intervention approach is one of the leading alternatives to the IQ-Achievement discrepancy model for LD identification and is based on Bergan’s four stage problem-solving model of behavioral consultation consisting of (a) problem identification, (b) problem analysis, (c) plan implementation, and (d) problem evaluation (Fuchs et al., 2003). Problem identification involves operationalizing the problem behavior in observable, measurable units and obtaining a reliable estimate of current performance. Problem analysis consists of validating that the problem behavior exists, identifying student and environmental variables that may be beneficial in addressing the problem, and creating an appropriate plan. Plan implementation entails assessment of treatment integrity and provision of corrective feedback as needed. Problem evaluation is the final step in which the efficacy is evaluated and the plan is modified if ineffective.

Models of Response to Intervention

The following three types of models utilizing an RTI approach are presented in the literature: (a) Predictor-Criterion models, (b) Functional Assessment models, and (c) the Dual-Discrepancy model (Gresham, 2002). The Predictor-Criterion models emphasize instruction on the core skills that are the best predictors of success within a given area. For example, reading fluency and comprehension are generally used to measure reading ability. Direct instruction models of reading intervention emphasize instruction in phonemic awareness, word recognition, and other strong predictors of reading ability. The goal of these models is to remediate poor performance. Functional assessment models are based on the applied behavior analysis literature and attempt to
identify environmental events influencing student performance. The identified factors causing poor performance are then used to inform the design of interventions to improve the performance. These models seek to answer the “why” in regard to poor academic performance. The Dual-Discrepancy model compares the referred student’s level of academic performance to same grade peers using national or local norming procedures and evaluates their rate of growth before, during, and after the receipt of an empirically-based academic intervention over the course of the school year using curriculum-based assessment and single subject design procedures. Despite good theoretical rationale for each of the three models, the Dual-Discrepancy RTI model has received the most attention in the current literature (Gresham). Therefore, the use of Math to Mastery within the framework of the Dual-Discrepancy Model is further detailed below after providing additional information about the RTI model (i.e., rationale for development, tiers, benefits, limitations).

A 1982 National Research Council study posited that three prerequisites are needed to ensure a legitimate special education classification (Vaughn & Fuchs, 2003). First, the general education programming must be of such quality as to expect learning to occur. Second, the special education programming must be capable of improving student performance in order to justify placement. Third, any assessment used to identify a student for special education must be accurate and meaningful; indicating that the testing results should inform remediation. From the RTI model perspective the measurement of the learning of all students within the general education classroom is needed to make sure that learning can be expected. Students demonstrating difficulty learning are thus provided with further support or resources and learning is reassessed to ensure that the
students are receiving effective intervention. The data from the assessment of the student in the general education setting and then after receiving additional intervention should be able to provide information to assist with planning an intervention. In 1995, L.S. Fuchs incorporated curriculum-based measurement (CBM) into the Dual-Discrepancy RTI model as the means for measuring learning. The tiers of intervention and the utilization of CBM procedures within the Dual-Discrepancy model will be further discussed below.

Tiers of Response to Intervention

The Dual-Discrepancy RTI model was designed to be implemented through three tiers of prevention according to Fuchs and Fuchs (1997). The first tier, primary prevention, ensures provision of quality instruction where learning can be expected to occur and to enable identification of students whose level of performance and rate of improvement are below their peers as evidence of unresponsiveness to the general education curriculum. The second tier, secondary prevention, provides systematic evaluation of general classroom adaptations to determine if a quality learning environment can be reasonably created for students identified in tier one. The third tier, tertiary prevention, provides students identified as unresponsive in step two with a fixed duration trial of intensive services in individual or small group tutoring in which a standard, validated intervention is implemented. At the conclusion of the trial remediation, students that have responded to an intervention are returned to the general education classroom or continue to receive Tier III interventions as needed. These students who have responded to an intervention are considered to be disability-free. If a student does not improve in (a) level or the (b) rate of progress is such that the student
will not achieve grade level performance within expected time constraints, special education under the diagnosis of LD may be considered, which is often considered a fourth tier of intervention (i.e., special education and IEP determination; Fuchs et al., 2003, Vaughn & Fuchs, 2003). Figure B.1 presents the pathway for identification of LD based on the Dual-Discrepancy model by Gresham (2002), adapted from the Heartland Area Education Agency.

According to Gresham (2002), the Dual-Discrepancy model makes several assumptions: (a) The intervention intensity (and cost) corresponds to the level of unresponsiveness to treatment, (b) unresponsiveness to a level of intervention implemented with integrity is the criteria for moving to a more intensive intervention, (c) data are collected to guide movement along the pathway, (d) the amount of data and information about student responsiveness and unresponsiveness will continue to be collected while moving along the pathway and all information will be utilized to inform decision-making, and (e) consideration for special education is a result of unresponsiveness at all previous levels of intervention.

_Benefits of Response to Intervention_

Speece et al. (2003) pointed out that, prior to this reconceptualization of LD, academic difficulties were viewed as a “within-child deficit” or assumed that effective instruction was delivered as outlined by the curriculum. The RTI approaches recognize the within-child and environmental influences on learning and make no assumptions about the initial cause of failure to master academic skills. Proponents of this approach also argue that an RTI approach accomplishes several goals of which the traditional
discrepancy model falls short (Fuchs et al. 2003). First, through the “treat to test” model additional assistance is provided sooner to students. Second, RTI approaches differentiate students with a disability from those with academic difficulty due to a lack of adequate instruction by ensuring that individualized and intensive empirically-based interventions are provided with adequate levels of treatment integrity. The traditional discrepancy model has failed to accomplish this goal based on previous research. Third, RTI approaches provide a cost-efficient method of remediating problems and reducing inappropriate referrals to special education. Fourth, RTI approaches avoid the social class bias of the discrepancy model by providing effective intervention to all low achieving students. The IQ-Achievement Discrepancy model points out the responsibility of society to “bring up the achievement of individuals whose achievements fall short of their IQs, rather than simply to bring up the skills of those with low skills, period” (Stanovich, 1999, p. 353). Fifth, by providing noncategorical interventions, RTI approaches avoid potentially stigmatizing, and possibly misdiagnosed labels, such as learning disabled.

Limitations of Response to Intervention

Concerns about the RTI approach are evident in the literature primarily regarding the following issues yet to be resolved: (a) choosing the “best” intervention, (b) optimal levels of intervention length and intensity, (c) treatment integrity measurements of interventions, and (d) cost of RTI approach versus IQ-Achievement Discrepancy approach (Gresham, 2002). Given the available interventions for any specific academic difficulty, it continues to be difficult to determine which intervention is most appropriate to implement. Frequently direct comparisons between empirical studies of interventions
are limited due to the variations in intensity, length of study, and outcome measures. In other words, there is little empirical evidence to guide the decision making process of choosing an intervention.

Further, given the task of identifying LD as a measure of responsiveness to intervention, it is important to determine the appropriate length and intensity of an intervention. In general, this principle is guided by the individual student’s response to each level of intervention. A multiple gating procedure is currently being used in Iowa in the Heartland Area Education Agency to guide identification of students needing special education (Reschly & Tilly, 1999; Reschly & Ysseldyke, 1995). Fuchs and Fuchs (1997, 1998) proposed more specific guidelines, which begins with general educators providing two interventions for a maximum of 6 weeks (i.e., Phases II and III). Nonresponders are then referred to Tier IV involving a maximum of 8 weeks of intense intervention (i.e., special education trial period). At the conclusion of the eight week trial period, the assessment team must make a data-based decision of whether to continue, enhance, or discontinue the intervention. Several researchers (Swanson & Hoskun, 1999, Torgesen, Alexander, Wagner, Rashotte, Voeller, & Conway, 2001, Vellutino, Scanlon, Sipay, Small, Pratt, Chen, & Denckla, 1996,) have studied intervention lengths reported in the literature. However, there is no accurate method for predicting the effect of altering the number of minutes in daily instruction, number of times of intervention per week, or number of sessions.

A prerequisite for determining unresponsiveness to an intervention is ensuring that an intervention is implemented as intended, which is frequently referred to as treatment integrity (Gresham, 2002). The LD literature is reportedly barren of reported
measurements of treatment integrity (Gresham, MacMillan, Beebe-Frankenberger, & Bocian, 2000; Swanson, Carson, & Saches-Lee, 1996). Therefore, Gresham proposed four recommendations for conducting treatment integrity measurements. First, intervention steps should be operationalized in the same manner as dependent variables. Intervention steps should then be either directly observed and measured or observed via videotaping. The treatment integrity rater could then measure the occurrence or non-occurrence of each step. A rating of component integrity (i.e., the correct implementation each specific step across sessions) and session integrity (i.e., the correct implementation of all steps for a given session) can be used to ensure unresponsiveness is not due to the fidelity of the treatment implementation. Lastly, instructional manuals, permanent products, behavior rating scales and other indirect methods of measuring treatment integrity should be used to supplement direct observations. However, given the frequent lack of agreement between direct and indirect methods, caution should be used with the interpretation of indirect measurements (Gresham, 2002).

The issue of cost effectiveness is another area of concern for the RTI approach to identifying students with LD. Specifically, there is no literature reporting the cost of utilizing the RTI approach versus the traditional IQ-Discrepancy approach. However, Gresham (2002) estimates that Torgesen et al.’s (2001) intensive reading intervention could be implemented with integrity in two 50-minute sessions per day for two children at a time for three sets of children per day (6 children per day total). Torgesen et al. reported an intervention length of 80 sessions, which Gresham estimated to be 10 weeks, given typical school disruptions to the academic routines. Therefore, Gresham estimated that with a 37-week school year, one teacher could work with three cycles of students
resulting in the identification and treatment of approximately 18 students. Gresham then estimated a cost of identification (and treatment) using an RTI approach by multiplying cost per tutoring session ($50 in his estimate, which may vary by locale) by number of sessions (Torgesen et al.’s intervention used 80 sessions) and dividing the product by half (Torgesen et al. reported that nearly half of the students in the study no longer needed special education at the conclusion of the intervention). Gresham’s estimate yielded a cost of approximately $2000 per year to identify and treat a student with this approach. Gresham reported the cost of simply identifying a student with a learning disability using the traditional approach costs approximately $2500 per year. Also, it is important to note that the traditional approach requires the reevaluation of all LD students every three years, provides little improvement in student performance, and continues to cost schools increased expenditures per child as most LD-identified students are never dismissed from special education (Gresham, 2002).

**Current Mathematics Remediation**

Many general education and special education students have difficulty mastering mathematic skills (Phillips, 1990). Data from the National Assessment of Educational Progress indicates that less than half of students’ math and reading skills are at the proficient level (National Assessment of Educational Progress, 2002). Of those students with a learning disability, more than 50% have Individualized Education Program (IEP) goals in mathematics (Kavale & Reese, 1992). Also, the lower-achieving students are not learning as fast as, or as much as, higher-achieving students. Without providing more
effective instruction, this difference in skill acquisition rates is creating an even larger gap between advantaged and disadvantaged students.

As much as one-third of all time spent in instruction in special education classrooms is used to remediate deficiencies in mathematics (Carpenter, 1985). Despite such a large proportion of time allotted for mathematics remediation, researchers (e.g., Fuchs & Fuchs, 2001) have concluded that the time appears to be used for ineffective teaching practices as there is little data to demonstrate performance improvement. In general education and special education settings, ineffective mathematics teaching strategies continue to be used to teach mathematics perhaps as a result of the limited availability of quality interventions that have been empirically evaluated and proven to be effective.

Researchers (e.g., Jitendra, Salmento, & Haydt, 1999) have devised several academic variables that compose effective instruction: (a) clarity of objective, (b) additional concepts and skills taught, (c) prerequisite skills taught, (d) explicit teaching explanations, (e) efficient use of instructional time, (f) sufficient and appropriate teaching examples, (g) adequate practice, (h) appropriate review, and (i) effective feedback.

For example, Jitendra, Salmento, and Haydt (1999) evaluated seven mathematics programs for adherence to the important instructional principles listed above. A lesson from each program on teaching fourth grade subtraction across zeros was rated on a 3-point Likert-style scale of 0 to 2, where 0 represented lack of the effective instruction component and 2 represented satisfactorily demonstrated the effective instruction component. Only clarity of objective and additional concepts and skills taught were included in all of the math programs. The extent to which any single effective instruction
component was included in each program ranged from 33.3% to 88.9%, with an average rating of 63.5%.

These ineffective instructional practices often lead to a lack of learning necessary skills. For example, Fuchs and Fuchs (2001) examined the mathematical skills of average achieving 14-year-old students found that only 85% mastered computational addition, 81% mastered subtraction, 54% mastered multiplication, and 54% mastered division. As such, there is a need for a more effective procedure to increase proficiency with mathematics.

Mathematics Standards

Mathematics instruction has been evolving in United States classrooms since the early 1900s. As the pedagogical process has evolved, mathematics reform has followed. Miller and Mercer (1997) surmised that these reforms and their educational strategies have been ineffective in part because of the lack of inclusion of fundamental principles of learning, such as attention, metacognition, memory, and perception.

The most recent reform, spearheaded by the National Council of Teachers of Mathematics (NCTM, 2003), has emphasized learning through discovery. Learning through discovery primarily utilizes hands-on activities to teach mathematics in order for children to understand the problem first and then to focus on learning a new skill to solve the problem with a more applied focus. The traditional approach utilizes learning skills on worksheets and then taking the learned skills to apply to real world problems. Unlike the previous reform efforts, the NCTM established objective standards that included outlining measurable components of effective curricula and empirically-based methods to
teach new material (Miller & Mercer, 1997). These NCTM standards were designed to emphasize the understanding of mathematical language and processes, rather than rote memorization, to facilitate problem-solving skills and application of such skills in society, which are relatively recent explicit educational goals, as well. In order to reach these increased expectations for students, more advanced skills are taught at earlier stages of the education process.

Skill Development

The natural progression of learning new skills moves through a sequence of four steps: (a) acquisition, (b) fluency, (c) generalization, and (d) adaption (Haring & Eaton, 1978; Smith, 1989). Acquisition involves the introduction of a new skill and measures the ability to provide an accurate answer. Once an accurate response can be routinely provided, the focus moves to increasing the rate of responding or fluency (i.e., speed and accuracy). After fluency has been accomplished, generalization to novel problems with similar stimulus patterns as previously mastered skills takes place. Lastly, when previously mastered skills are used in new ways or with new problems adaption has been achieved. Following accomplishment of this learning sequence, frequent practice with material covering newly acquired skills is used to promote maintenance.

Fluency as a Measure of Skill Development

Fluency as a rate can be used to measure mathematics performance by calculating the number of correct or incorrect digits written per unit of time. Four empirically-based reasons to use fluency as a measure of student learning are presented in educational literature (e.g., Miller & Heward, 1992). First, fluency rates provide a more accurate
measurement of student performance than traditional measures of accuracy alone. In other words, when using accuracy alone as a performance measure, there is no method to further evaluate improvement when a student provides all of the answers accurately. With this ceiling effect there appears to be no difference between performances of a student who completes the assignment in 1 minute at 100% correct versus the student who spends 5 minutes to answer 100% correct. Secondly, fluency rates are more sensitive to change than are accuracy measurements. Fluency rates are able to indicate a change in a students’ performance of a skill in a given amount of time, generally measured as the number of correct responses. Third, fluency is measured by many standardized tests (e.g., Woodcock-Johnson III) used to make educational decisions about students and is required in many out of school situations. As such, students need to learn not only the methods to perform math skills, but also need to become fluent with the performance of their skills. Lastly, several researchers have indicated that fluency is positively related to the maintenance and generalization of skills (e.g., Ivarie, 1986; Haughton, 1972; Van Houten, 1980).

Students who are fluent with skills have been found to reach higher levels of academic and social success than those students who are less fluent with skills (Lloyd, 1978; Marston, 1989). Several reasons for this discrepancy in achievement have been given. The concept of automaticity, where fluent responding alleviates cognitive energy that can be focused on higher level skills, has been used to explain the discrepancy in achievement (Gagne, 1983). In line with the concept of automaticity, responses that require less effort have been found to be more likely to be given than are responses requiring more effort (Horner & Day, 1991). Also, the number of opportunities to
respond typically increases when the time used to provide an answer decreases (Skinner & Schock, 1995). An increase in the number of opportunities to respond provides more practice to encourage discrimination, generalization, adaptation to new material in new ways, and maintenance. Overlearning is another term often used in the literature to refer to the automatic, low-effort ability to provide a response. Students who have overlearned skills have maintained skills longer than those students who had not overlearned the skill (Haring & Eaton, 1978). Therefore, students who do not acquire a skill or become fluent with the skill application may be at risk of lower levels of achievement.

As accuracy and fluency with basic skills are prerequisites for learning and mastering these new increased expectations (DuVall, McLaughlin, & Sederstrom, 2003), the NCTM standards specifically included fluency goals for all students (NCTM, 2003). Mathematics researchers (e.g., Mastropieri, Scruggs, & Shah, 1991; Mercer & Miller, 1992; Dixon, 1994) have cited several empirically-validated teaching techniques including (a) implementing demonstration, modeling, and feedback procedures, (b) providing reinforcement for fluency building, (c) setting goals, (d) combining demonstration with permanent models, (e) using verbalization while solving problems, (f) monitoring progress, (g) teaching math skills to mastery, and (h) teaching generalization in an ongoing fashion.

Assessment of Fluency

An effective methodology to assess academic skills should include several key components (Shapiro & Elliott, 1999). First, the method of assessment should be representative of the method in which the skill is used in the classroom. In order to draw
valid conclusions about a student’s performance, the manner in which the student is required to perform should be as naturalistic as possible. The validity of the outcome measure of an assessment increases as the assessment task more closely approximates the method by which the skill was taught and practiced. Second, a valid assessment tool should be based on curriculum that has been taught. Only by using procedures taken from the curriculum can direct assessments draw conclusions about which specific skills have been mastered and which skills need to be further practiced. Third, the goal of all assessments is to provide information that can be used to develop effective strategies to remediate problems. Assessments should always be used as part of a problem solving process to make educational decisions. Fourth, effective assessment methodologies should be able to sensitively track progress. In order to effectively utilize instruction, an assessment tool should be capable of monitoring when change is occurring in order to make decisions about continuing or discontinuing interventions. Fifth, the outcome measurement of assessments should be idiographic. The measurement should be individualized in order to make within-subject comparisons across time. Sixth, an assessment should seek to determine if a problem is a skill deficit or a performance deficit as different methods of intervention are used for can’t do problems versus won’t do problems. Lastly, the assessment procedure should be cost-efficient. The methodology should include outcome measurements that can be used for a variety of educational planning decisions (Lentz & Shapiro, 1986).

Curriculum-based assessment (CBA) is a general assessment methodology designed to measure academic skill performance. Many versions of CBA have been designed, but they can be classified into two categories: general outcome measure model
and specific subskill mastery model (Fuchs & Deno, 1991). The general outcome measurement model is a global measurement in that it utilizes the same standardized assessment tool across time to measure progress with the curriculum (Shapiro & Elliott, 1999). The specific subskill mastery model utilizes criterion-referenced, teacher-made, single-skill tools across time to measure progression through the curriculum (Shapiro & Elliott, 1999).

**Curriculum-Based Measurement**

One of the most well known examples of a curriculum based assessment procedure is curriculum-based measurement (CBM) developed by Stanley Deno (1985). CBM has been utilized as an ecologically valid assessment tool and part of instructional procedures in reading, math, computation, spelling, and written expression. The procedure yields objective, reliable, and valid measurements of performance to assess a student’s skills within the framework of the school curriculum (Deno, 1985; Shinn, 1989). The psychometric properties of CBM have been reported to be sound throughout the literature (Deno, 1985; Deno, Mirkin, & Chiang, 1982; Fuchs, Fuchs, & Maxwell, 1988; Fuchs & Shinn, 1989; Marston, 1989; Marston & Magnusson, 1985).

CBM was originally classified as a general outcome measurement model type of CBA. However, as a dynamic measurement instrument, it has been utilized as a simultaneous general outcome measurement model and specific subskill model. CBM was designed to be derived from the student’s curriculum in order to draw stronger conclusions about the student’s competence based on the student’s performance. This direct measurement allows for more individualized decision making in a student’s IEP
(Deno, 1985). The use of the student’s curriculum adds instructional relevance, increases ecological validity, and guarantees content validity by testing the student on the same curriculum on which he or she is being instructed (Hargis, 1987; Knutson & Shinn, 1991).

Implementation of CBM involves direct observation procedures to evaluate student performance by counting the number of correct and incorrect responses provided by the student in a fixed time period (i.e., rate; Deno, 2003). The hallmark of CBM is the ability to assess, simplicity to assess, and short time required to assess both short- and long-term progress by taking repeated measurements. The use of repeated measurements allows for progress tracking and is designed to be very sensitive to change. The curriculum is used to derive different, but equivalent, materials to which students respond. Also, CBM procedures are time efficient, as performance samples last in duration from 1 to 3 minutes.

**Intervention Components to Address Math Fluency**

CBM is often expressed as a rate of response in order to reflect a measure of fluency. When fluency is applied to mathematics, the rate is often the number of correct or incorrect responses per some unit of time. Several types of interventions have been developed to address fluency problems with mathematics. Many of these interventions contain common components by which their success may be explained (Skinner, Turco, Beatty, & Rasavage, 1989). These components are: (a) instructional level materials, (b) previewing, (c) repeated practice, (d) immediate corrective feedback, (e) performance feedback, (f) self-charting of progress, (g) mastery-based progression, (h) reinforcement
for mastery performance, and (i) limited time for instruction. Each component will be explained in the following sections. Each of these are briefly described in the following sections.

**Instructional Level Materials**

Instructional level materials are defined as materials which the student has acquired knowledge of, but has yet to perform fluently. Conversely, mastery level materials are defined as materials which the student has acquired knowledge of and can perform fluently. Below instructional level range, frustrational level materials are defined as materials which the student has yet to acquire knowledge of and has yet to perform fluently. Utilizing a curriculum either too difficult or too simple has been correlated with disruptive and off-task behavior in the classroom. Gickling and Armstrong (1978) found that when the percent of known material to unknown material increased to 85% or higher, students’ on-task behavior began to decline. If the percentage moved too far in the other direction (i.e., more than 30% unknown material), students’ behavior becomes more disruptive, as well. Martens and Witt (2004) suggested an approximate ratio of three to one known to unknown stimuli to provide the most effective instructional range.

**Previewing**

Previewing as an intervention involves demonstration of the correct procedure for a student. For mathematics previewing, the interventionist reads the mathematics problem aloud and then verbalizes the steps necessary to solve the problem. Previewing has been found an effective component of remedial instructional packages (Frederick, 1995; Tingstrom, Edwards, & Olmi, 1995). However, the researchers indicated that the effects
of previewing were limited to the students’ ability to attend to the interventionist during
the previewing session.

Repeated Practice

Repeated practice is a commonly used procedure to provide multiple chances to
respond (i.e., practice). Researchers have found that the availability of trials to actively
practice new skills is one of the most essential components to learning (Anderson, 1982;
Darch, Carnine, & Gersten, 1984; Greenwood, Delquadri, & Hall, 1984; Skinner &
Shapiro, 1989). Opportunities to respond were defined by Greenwood et al. (1984) as the
association between antecedent stimuli and consequent responses. Increasing the number
of available associations (i.e., practice opportunities) has been shown to increase learning
(Greenwood et al.).

Immediate Corrective Feedback

Another common component of effective interventions is immediate corrective
feedback. The feedback, which may be delivered in forms ranging from computer
response to peer response, derails the practice of incorrect responding. Through
immediate correction of an error the likelihood of learning an incorrect response to the
novel stimuli is reduced (Pellegrino & Goldman, 1987; Seigler & Shrager, 1984). Also
important in corrective feedback is the recency principle. The concept requires the correct
response to immediately follow an incorrect response. This practice leads to the final
response to a task as the correct response (Greenwood et al., 1984).

Immediate corrective feedback may also involve the provision of the correct
response for no response after a given amount of time. For instance, when a student
hesitates 3 seconds without providing a response, the interventionist provides the correct answer. If the interventionist provides the correct response, which is then repeated by the student, the intervention is said to cue the correct response. The cueing of correct responses has been shown to be effective at increasing the amount of times a student will provide correct responses as opposed to allowing the student to continue to struggle to provide an answer that may or may not be correct (Skinner, Shapiro, & Turco, 1992). If the student provides the correct response unassisted, the provision of some type of reinforcer is often given. The immediate provision of a reinforcer following the correct response further serves to increase the likelihood of correct responding.

The provision of the correct response allows for a stronger association between the antecedent stimuli and the response and decreases the relationship between the stimuli and an incorrect response. The stronger relationship between the math problem and the correct response and lessening the relationship between the math problem and the incorrect response may be accomplished through an overcorrection procedure requiring the exhibition of the correct response several times. The increased effort and disruption to work flow required to repeat the correct response following an incorrect response may serve to punish incorrect responses causing incorrect responses to be avoided as a much as possible (Skinner, Bamberg, Smith, & Powell, 1993). The principle of contiguity is employed within many of these interventions by using short intervals between the presentation of a stimulus and the response to achieve greater increases in creating a stimulus response relationship between novel stimuli and the correct response (Moeller, 1954).
**Performance Feedback**

Performance feedback involves the indication of the student’s current performance level and may be given in relation to the goal and previous performance levels. Performance feedback may be visual (i.e., charting performance on a graph) or verbal (i.e., “you answered 20 digits correct in that minute”) and may be provided by the interventionist or by the student (e.g., self charting of progress), which will be discussed below. Providing performance feedback has been shown to effectively increase mathematics fluency (Coding, 2003; Rhymer, Dittmer, Skinner, & Jackson, 2000). When using CBM materials, the feedback includes indication of the performance level to the student. For example, a mathematic CBM would provide a fluency rate, which is measured as the number of digits written correct per unit of time, as the performance feedback.

**Progress Monitoring**

Progress monitoring is also often an included component of effective CBM interventions. As such the monitoring may serve to perpetuate self-reinforcement of short-term correct responding and more global progression with fluency of a skill (Skinner et al., 1993). As a form of evaluation, monitoring may also be responsible for self-punishment of incorrect responding or lack of increasing fluency with a skill (Skinner et al.).

**Self-Charting of Progress**

Self charting refers to the visual representation of performance. Self charting involves the student being responsible for visually representing his or her own
performance. Methods of charting to monitor progress have been used to increase a variety of desired behaviors (Brown, Copeland, & Hall, 1986; Jackson & Mathews, 1995; Skinner, Cashwell, & Skinner, 2000) and decrease numerous undesired behaviors (Galvan & Ward, 1998; Kehle, Bray, Theodore, Jenson, & Clark, 2000; Musser, Bray, Kehle, & Jenson, 2001; Ragnarsson & Bjoergvinsson, 1991; Staub, 1990).

**Mastery-Based Progression**

Mastery-based progression through a curriculum refers to an individualized pace with which new skills are presented to and mastered by a student. The presentation of new material is withheld until the student has mastered the prerequisite or laterally presented skills. Haring and Eaton (1978) and other researchers have enumerated the sequence of stages in which new material or skills are learned (i.e., acquisition, fluency, maintenance, generalization, adaption). However, given the limited time constraints of the typical school year and the number of skills that must be presented, traditional education practices are unable to (and are not expected to) pace the speed of presentation of new material on mastery of each skill by all students in the classroom. Therefore, those students who do not master a skill within this limited period of instruction may never have the opportunity to master the skill.

**Reinforcement for Mastery Performance**

Reinforcement for mastery performance is used to reward a student for reaching a goal. In order for reinforcement to be most effective requires a two step process: (a) description of the performance contingencies for reinforcement, and (b) deliverance of the reinforcement upon successful completion of the mastery criterion. Also, the
consequence must be preferred over the lack of reinforcement in order for the student to be motivated to earn the reinforcer or reward. Reinforcement of the successful completion of a task at a mastery level has increased the frequency with which the mastery criteria are met (Ayllon & Roberts, 1974).

**Limited Time for Instruction**

Most interventions are limited to a specific amount of time for instruction (i.e., allocated time). The limited time frame for the intervention creates an outcome measurement that is based on rates of responding. In the context of a limited period of time for instruction with an immediate corrective feedback procedure, the production of an error requires time to address the error, thereby decreasing the amount of time in which to answer more digits correct. In this sense an incorrect response may act as a punisher as the student attempts to avoid an error to have more time to work on novel problems. When the limited number of available opportunities to respond in a timed trial is paired with a reinforcer provided at some rate of responding, an environment is created that encourages fluency. The environment allows for more available reinforcement as fewer errors are made because the necessary time to address and provide the correct response reduces the time available to earn more reinforcers. Such an environment reinforces quick, correct responses by allowing more reinforcers to be earned and avoiding correction procedures. These methods are effective for increasing the rate of work completed (Van Houten, Morrison, Jarvis, & McDonald, 1974).
The effects of immediate corrective feedback on math fluency has been evaluated individually, in comparison to noncontingent reinforcement and in combination with noncontingent reinforcement (immediate corrective feedback + noncontingent reinforcement) at a university-based summer academic clinic by Harber, Henington, and Baylot (2003) and Harber, Henington, Dickens, and Baylot (2004). In 2003, the researchers evaluated the effects of peer implemented interventions on math fluency of three elementary school students in specific single skill areas, such as addition without regrouping. Both interventions in isolation produced increases in level of performance over baseline or sharper increases in trend than in baseline. However, the combination of interventions (i.e., immediate corrective feedback + noncontingent reinforcement) produced both increases in level and trend over baseline and either intervention alone. In 2004, the researchers replicated the study with multiple-skill probes (e.g., addition and subtraction without regrouping). Again, immediate corrective feedback and noncontingent reinforcement each produced increases in level or performance over baseline and the combination of the interventions (i.e., immediate corrective feedback + noncontingent reinforcement) increased the level further still over either intervention alone.

Immediate corrective feedback and noncontingent reinforcement were studied in the same summer academic setting in which this study takes place and demonstrated gains in math fluency. However, mastery levels of achievement were not attained. These studies provide impetus for many other additional questions including could further gains be demonstrated by adding other effective, empirically-based intervention components as
a package treatment on the pathway from instructional to mastery level materials and performance to grade level curriculum and performance. It is hypothesized that an intervention which includes multiple empirically-based strategies proven effective in isolation but packaged together to address math fluency may have a greater likelihood of success in increasing performance.

Creation of *Math to Mastery*

Given the paucity of effective math interventions, *Math to Mastery* was adapted from *Reading to Read*, an empirically validated CBM-based intervention package that addresses reading fluency (Edwards, Tingstrom, & Cottingham, 1993; Kastner, Tingstrom, & Edwards, 2000; Tingstrom, Edwards, & Olmi, 1995). The intervention involves the use of instructional level materials with previewing, repeated practice, immediate corrective feedback, performance feedback, self charting of progress, mastery-based progression, reinforcement, and limited time instruction to increase the rate of correctly read words per minute. The student attempts an instructional level reading passage for one minute receiving no immediate feedback from the interventionist. The student and interventionist then calculate the words read correctly per minute (WCPM) and plot the performance on a graph. The interventionist then previews the instructional words the student read incorrectly. The student is then instructed to read for 1 minute and the interventionist records and corrects any mistakes. The student repeats the corrected mistakes and continues reading until the minute has elapsed. The student and interventionist then calculate the words read correctly per minute (WCPM) and plot the performance on a graph. The process is repeated, except for the previewing, and the
Given the effectiveness of *Reading to Read*, the intervention package was adapted for mathematics as *Math to Mastery*. The *Math to Mastery* intervention package utilizes the same techniques as *Reading to Read* and measures math fluency in digits correct per minute (DCPM).

**Statement of the Problem**

Immediate corrective feedback and noncontingent reinforcement have been empirically studied and compared as individual and combined treatments (Harber et al., 2003; Harber et al., 2004). Both treatments have been found to improve fluency in basic math computational facts. The *Reading to Read* package has been empirically proven to effectively increase fluency rates in reading (Edwards, Tingstrom, & Cottingham, 1993; Kastner, Tingstrom, & Edwards, 2000; Tingstrom, Edwards, & Olmi, 1995), however, there is no reported literature regarding the efficacy of *Math to Mastery* at this time. The *Math to Mastery* intervention package was designed with the same components as the *Reading to Read* intervention package and was adapted to mathematics (Lestage, Everett, & Mudgal, 2004). Even though the individual components have been proven effective in remediating mathematics skills and the proven effectiveness of the same package components with reading curricula, the effect of the *Math to Mastery* intervention package on mathematical fluency has not been evaluated. More specifically, *Math to
Mastery incorporates instructional level material, previewing, repeated practice, immediate corrective feedback, visual progress monitoring, goal setting, and reinforcement and needs to be empirically evaluated as a complete package.

Purpose of the Study

Tier III of the three-tier model of the RTI approach to intervention requires the use of empirically validated interventions. Intervention components based on CBM have been shown to be effective for improving fluency with basic math facts in elementary school children with math difficulties. However, the efficacy of the Math to Mastery intervention package, which is a collection of empirically-based CBM strategies, has not been evaluated.

The primary purpose of this study was to empirically evaluate the effects of the Math to Mastery intervention package with elementary school students who were attending a summer academic clinic and were performing at least one year below grade level. A secondary purpose of this study was to evaluate the effects of the Math to Mastery intervention in comparison to immediate corrective feedback which has been found to be effective in previous research conducted in the same setting. A between-series multiple baseline design across participants was used to evaluate the effects on fluency (i.e., speed and accuracy) of the Math to Mastery intervention package in comparison to immediate corrective feedback on curriculum-based math probes.
Research Questions

*Research Question 1.* Does implementation of the *Math to Mastery* intervention improve the number of digits correct per minute on curriculum-based measurement probes beyond baseline levels for identified elementary school students?

*Research Question 2.* Does implementation of immediate corrective feedback improve the number of digits correct per minute on curriculum-based measurement probes beyond baseline levels for identified elementary school students?

*Research Question 3.* Does implementation of the *Math to Mastery* intervention improve the number of digits correct per minute on curriculum-based measurement probes beyond the use of immediate corrective feedback alone for identified elementary school students?
CHAPTER II

METHODOLOGY

Participants and Setting

Participants included six students selected from participants in a summer academic skill remediation clinic conducted at a university in southeastern United States. At the conclusion of the academic school year, each local public elementary school was given fliers to send home with each child. The clinic targeted students entering second grade through sixth grade who were experiencing academic difficulty in reading, writing, or arithmetic.

The clinic is held for four weeks during the month of July each year. The clinic is designed to approximate a school environment on a small scale with a schedule of classes the children rotate between for instruction. The clinic students are grouped into small classes of six to eight students each, and every class receives instruction in all three areas each day. Each academic area (i.e., reading, writing, mathematics) is taught for 40 minutes, during which varied amounts of time are spent in instruction, modeling, practice, and feedback. Each academic foci is located within a central classroom, however, students were also pulled out for individual remediation strategies in smaller rooms. The clinic was established as a training opportunity for graduate-level school psychology students to design, implement, and evaluate academic and behavioral
interventions while serving grade school students and families in need of assistance. The clinic staff included masters, specialist, and doctoral-level school psychology graduate students, university-based supervisors, a certified elementary education teacher, as well as undergraduate and high school students as interventionists.

Participants identified as having an exceptionality of Mental Retardation (MR) or Pervasive Developmental Disorder (PDD), based on parent report at the initial intake for the clinic, were excluded from the study. The participants for this study were selected based on below grade level performance in math as measured by three initial curriculum-based measurement (CBM) probes. Participants performing at least one year below grade level as measured by CBM were included in the study. The grade in which the student was entering the upcoming school year was considered the student’s current grade level.

Nine students were recruited for the study; however, only six students completed the study due to attrition. Three students who began the study were not included due to attrition, which was largely due to an illness many of the staff and participants experienced (i.e., completed less than 5 sessions per phase). The remaining participants included one male and five females. Three of the females and the only male were African-American and the other two females were Caucasian. For the upcoming school year, one student was repeating the second grade, two students were entering the third grade, one student was entering the fourth grade, one student was entering the fifth grade, and one was student entering the sixth grade. The demographic information was obtained prior to clinic as is presented in Table B.1. Additionally, the instructional level of each student was measured during the pre-treatment assessment. The pre-treatment
performance is presented below as well as in Table B.1) Pseudonyms were used to maintain the confidentiality of the participants.

April

April was a 9-year-old African-American female. She was entering the third grade and had never received special education services. According to parental report, she was assessed for gifted services the previous year but did not qualify. According to the pre-treatment assessment using curriculum-based measurement, April’s instructional level was identified at the second grade level in math, with a median score of 26 digits correct per minute. April’s pre-treatment assessment should have continued with third grade material as she performed at the rate of 26 digits correct per minute, which is at the mastery level. During baseline, the error was realized, April was correctly placed at a third grade level for instructional materials, and she was allowed to continue in the research project. Given her third grade placement and third grade instructional level, April was not performing at least one year below her grade level. Her results and implications from those results will be discussed later. Once placed at the appropriate instructional level, April worked on skills such as one to four digit addition and subtraction with regrouping.

Bridgette

Bridgette was a 9-year-old African-American female. She was entering the third grade and had never received special education services. According to the pre-treatment assessment using curriculum-based measurement, Bridgette’s instructional level was identified at the second grade level in math with a median score of 10 digits correct per
minute. Bridgette worked on skills such as one and two digit addition and subtraction with and without regrouping.

Carley

Carley was a 9-year-old Caucasian female. She was entering the third grade and had never received special education services. According to parental report, she was taking Cephalon for allergies. Based on the pre-treatment assessment using curriculum-based measurement, Carley’s instructional level was identified at the second grade level in math, with a median score of 12 digits correct per minute. Carley worked on skills such as one and two digit addition and subtraction with and without regrouping.

Deanna

Deanna was a 9-year-old African-American female. She was repeating the second grade and had been receiving special education services for one year. She was identified as a student with a Specific Learning Disability in mathematics and speech/language. Also, Deanna was easily distracted during sessions and had difficulty focusing her attention on the worksheets. According to the pre-treatment assessment using curriculum-based measurement, Deanna performed at the frustrational level at the first grade level in math, with a median score of 1 digit correct per minute. Deanna worked on skills such as one digit addition and subtraction without regrouping.

Edward

Edward was a 12-year-old African-American male. He was entering the sixth grade and had previously received special education services for a speech/language
ruling. According to parental report, he was taking Singulair, Allegra, and Albuterol for allergies and Concerta for attention problems. According to the pre-treatment assessment using curriculum-based measurement, Edward’s instructional level was identified at the third grade level in math, with a median score of 14 digits correct per minute. Edward’s pre-treatment assessment should have continued with lower grade level materials as his rate of performance was at 14 digits correct per minute, which is in the frustrational level given that he is in the sixth grade. His results and implications from those results will be discussed later. Edward worked on skills such as one to four digit addition and subtraction with regrouping.

Frances

Frances was a 10-year-old Caucasian female. She was entering the fifth grade and had never received special education services. According to the pre-treatment assessment using curriculum-based measurement, Frances’ instructional level was identified at the second grade level in math, with a median score of 36 digits correct per minute. Frances worked on skills such as one and two digit addition and subtraction with and without regrouping.

Materials

A web-based computer program, Math Worksheet Generator, was used to generate curriculum-based addition and subtraction worksheets (Wright, 2003). The program allows the user to design worksheets requiring the use of specific skills. Addition and subtraction were the only skills included in order to increase fluency with basic computational facts. State benchmarks from the Mississippi Department of
Education (MDE) were used to determine which skills were representative of each grade level. The program was then used to create a worksheet specific to a particular grade level. The computer program randomized: (a) the order of problems within a worksheet and (b) the order of the factors within each problem. The assessment sheets listed mixed skill problems in six rows of four problems in portrait orientation on a regular $8\frac{1}{2}$ by 11 inch sheet of white paper. Each worksheet contained the same number of problems on the front and back. The top of the sheets included a code for the grade level difficulty; a number to identify the worksheet within the grade level; and blank lines for name, date, and examiner. A running total and cumulative total column were written on the right side of the page to provide a measure of fluency. An example is presented in Figure B.2.

Fluency Measure

Fluency was measured as the number of digits correct per minute (DCPM). The following formula was used to calculate DCPM:

$$\frac{\text{Number of digits correct}}{\text{Number of seconds worked}} \times 60 = \text{Digits Correct Per Minute}$$

Each participant was instructed to complete problems on a mixed skill mathematics worksheet for 1 minute, after which the number of digits written correctly (i.e., DCPM) was calculated. Digits correct, but written backwards were not scored as errors. The scores for each worksheet were recorded on the grade level placement form.

According to Deno and Mirkin (1977), for students in grades one to three, performance at a rate of less than 10 DCPM indicates a frustrational level. A performance rate of 10 to 19 DCPM indicates an instructional level and mastery level is indicated by a
performance rate of 20 or more DCPM. For grades four to six, frustrational level is indicated by performance rate of less than 20 DCPM. A performance rate of 20 to 39 DCPM indicates an instructional level and mastery level is indicated by a performance rate of 40 or more DCPM. When a student from grades four through six are performing on first to third grade material, the performance level criteria from the student’s current grade level is used (i.e., a sixth grade student performing on third grade material must demonstrate 20 to 39 DCPM for instructional level and 40 or more DCPM to demonstrate mastery.

An evaluation of the number of errors per minute (EPM) was conducted after all of the data was collected to examine the effect of the procedures on incorrect responses. The following formula was used to calculate EPM:

\[
\text{Number of errors} \div \text{Number of seconds worked} \times 60 = \text{Digits Correct Per Minute}
\]

Procedures

*Pre-treatment Assessment*

A pre-treatment assessment was conducted to determine each student’s current level of performance with CBM methods using mathematics worksheets created with the web-based *Math Worksheet Generator*. The interventionists administered CBM probes to determine the current performance level of each of the participants. The participant completed one worksheet at his/her current grade placement in school. He or she was given 60 seconds to complete each worksheet. The score on each worksheet was
determined by the number of digits written correctly divided by the number of seconds worked and multiplied by 60. The formula is presented below.

\[
\text{Number of digits correct} \times 60 = \text{Digits Correct Per Minute (DCPM)}
\]

Number of seconds worked

If performance was in the instructional level range, a worksheet at the same grade level was administered. If performance was in the frustrational level range, a worksheet at a lower grade level was administered. If performance was in the mastery level range, a worksheet at a higher grade level was administered. These procedures were followed until a median instructional level performance was obtained across 3 worksheets within the same grade level. The procedures for each of the three phases (baseline, Math to Mastery, immediate corrective feedback) will be discussed below. Treatment integrity checklists for the pre-treatment assessment and three phases are located in Appendix A.

**Baseline**

The interventionist removed each student individually from the math classroom and escorted them to a small room with a table and chairs, implemented the procedure as delineated in the procedural integrity protocol for each phase (See Appendix A), and returned the participant to his or her classroom. For each student, a minimum of nine baseline sessions were conducted across three days before either intervention was implemented. During baseline, the interventionist sat beside the participant and provided a math worksheet to each participant individually. The worksheet difficulty was based on the level determined to be instructional during the pre-treatment assessment. The participant was asked to complete the worksheet and was allowed to work for 1 minute. The interventionist recorded the DCPM. Visual inspection was used to evaluate stability
in the series of data points on trend, level, and variability (Hayes, Barlow, & Nelson-Gray, 1999). Because of the brevity of the baseline conditions (i.e., one minute probes), all students received three probes per day during the baseline conditions. As such, baseline data were collected for a minimum of 9 sessions for participants one and two, 18 sessions for participants three and four, and 24 sessions for participants five and six.

**Intervention**

As in the baseline conditions, the interventionist removed each student individually from the classroom and escorted them to a small room with a table and two chairs, implemented the procedures as outlined in the treatment integrity protocol for each phase of intervention (i.e., *Math to Mastery* versus immediate corrective feedback). Because of the brevity of each intervention (i.e., less than 20 minutes), one to two sessions were conducted per day during the intervention phase of the study. When more than one session was conducted in one day, at minimum of one hour lapsed between sessions in order to reduce the influence of extraneous variables such as fatigue or carry over effects. Additionally, each student received a minimum of five days of each intervention condition (i.e., *Math to Mastery*, immediate corrective feedback) to provide a more equitable comparison between the two intervention conditions. All participants received a minimum of ten treatment sessions.

**Math to Mastery**

The treatment integrity checklist for *Math to Mastery* is presented in Appendix A. During the *Math to Mastery* condition, the interventionist sat beside the participant
and provided a math worksheet to each participant on his or her baseline performance level. The participant was read the following instructions:

Begin working right here [interventionist pointed starting place] and work across this row and then go to the next row. Write each answer quickly and clearly enough so that I can read it. I will say stop after one minute.

Ready. Begin.

At the conclusion of one minute, the interventionist stopped the student and scored the worksheet for DCPM. The interventionist then provided a colored pencil and a graph for the student on which to plot the current DCPM (i.e., progress monitoring and self charting of progress). After the student plotted the DCPM, the student was told the number at which they would have to get to stop for the session (i.e., the Mastery level) and a line was drawn across the graph at the corresponding performance level (i.e., goal setting). The interventionist then reviewed the problems with which the participant had difficulty and previewed the problems necessary to reach mastery level (previewing and reviewing). The interventionist stated each problem aloud and talked out the process required to solve each problem (e.g., “Ten plus fifteen. Zero plus five equals five and one plus one equals two. Twenty five.”). The interventionist then provided a new copy of the same worksheet (i.e., repeated practice) and then read the following instructions:

We are going to do it again. If you make a mistake, I will tell you ‘that’s not quite right’ and you can try the problem again. If you make a mistake on the same problem I will give you the correct answer which you should copy over and continue working. Put your pencil down when I say stop.

Begin.
The interventionist then monitored the participants’ performance and provided immediate corrective feedback for incorrect answers and lack of responses within three seconds by indicating the wrong answer was provided and then subsequently writing the correct answers and saying the answer (i.e., immediate corrective feedback). Omissions and digits provided to the participant by the interventionist after a three-second hesitation were scored as errors. Praise was also provided as immediate feedback for correct answers. At the completion of 1 minute the interventionist said “Stop. Put your pencil down and let’s count the number of digits correct.” After the DCPM had been counted, the interventionist again provided the colored pencil and the same daily graph to plot the number of digits correct per minute (see Figure B.3 for sample session graph). The interventionist then repeated the process by providing a new copy of the same worksheet and instructing the participant to begin. The process was repeated until mastery level was reached, the student attempted the worksheet ten times, or thirty minutes elapsed. The student was provided the same worksheet each session until mastered.

*Immediate Corrective Feedback*

The treatment integrity checklist for immediate corrective feedback is presented in Appendix A. The interventionist sat beside the participant and provided a math worksheet to each participant on his or her baseline performance level. The interventionist then read the following instructions:

When I say ‘begin,’ start working the problems. Begin with the first problem and work across the page then go to the next row. If you make a mistake I’ll tell you ‘that’s not quite right” and you can try the problem
again. If you make a mistake on the same problem I will give you the correct answer which you should copy over and continue working. Put your pencil down when I say stop. Ready. Begin.

The interventionist then monitored the participants’ performance and provided immediate corrective feedback for incorrect answers and lack of responses within 3 seconds by writing the correct answers and saying the answer. Omissions and digits provided to the participant by the interventionist after a 3-second hesitation were scored as errors. Praise was also provided as immediate feedback for correct answers. At the completion of 1 minute the interventionist said “Stop. Put your pencil down.” The participant received only one trial per session and was then returned to class.

Experimental Design

A combined-series multiple baseline across participants design (Hayes, Barlow, & Nelson-Gray, 1999) was used to evaluate the effects of the Math to Mastery intervention in comparison to immediate corrective feedback on rates of fluency (i.e., DCPM) on mathematics worksheets. The multiple baseline design was used to control for extraneous factors (e.g., maturity, selection bias, pre-treatment effects, reactive experimental arrangements, other interventions) that could affect student performance. The multiple baseline design utilized three phases (i.e., conditions); baseline, immediate corrective feedback, and Math to Mastery, each of which were designed to include a minimum of 5 data points. When the phase changes are staggered across participants and immediate changes in student performance (i.e., changes in the level, trend, variability of the data) are observed only after the introduction of new condition or phase for each participant.
included in the multiple baseline design, more confidence is placed in the effectiveness of the intervention as opposed to unknown external factors increasing the confidence in the internal validity of the study.

In addition to the staggered introduction of phases, a counter-balanced control was used with the first student (i.e., received A/C/B rather than A/B/C). The opposing order was used to control for sequential confounding or order effects. Sequential confounding and order effects refer to situations in which a change in the level, trend, and variability of data are observed because of the order in which the conditions were presented and not because of the effectiveness of the intervention components in remediating deficits in mathematics fluency. However, if the conditions (i.e., Math to Mastery, immediate corrective feedback) are presented in a different order for some of the participants and immediate changes in level, trend, and variability are noticed each time the conditions are changed regardless of the order of presentation of the conditions, then more confidence can be placed in the effectiveness of the interventions as opposed to other factors (i.e., order of the conditions).

Training of Interventionists

Two school psychology graduate students and a certified elementary school teacher with three years of professional experience served as the interventionists. The primary researcher trained the second graduate student and the teacher to implement the procedures of the study including the pre-treatment assessment, Baseline, Math to Mastery, and immediate corrective feedback. Each interventionist was taught to identify a student’s frustrational, instructional, and mastery level (See Appendix A).
Interventionists were trained, allowed to practice, and supervised through direct observation and feedback to ensure for treatment integrity. After the interventionists demonstrated accurate administration of the procedures with at least 80% integrity three consecutive trials, direct observation was no longer required. Only one interventionist worked with each child for the duration of the study.

Procedural and Treatment Integrity

Gresham, Gansle, and Noelle (1993) defined treatment integrity as the degree to which procedures or treatments are implemented as they were designed. Poor treatment integrity can compromise the validity of the findings of an experiment. If change occurs during the intervention that was not implemented as designed, one cannot conclude the change was a result of the intervention. Therefore, a checklist of the required steps for each phase was designed and completed for each session. A review of all of the checklists was completed as a measure of treatment integrity to determine the degree with which the interventions were implemented as prescribed by the experimenter. Treatment integrity was calculated by the number of items on the checklist completed correctly divided by the total number of items on the checklist and multiplied by 100. The formula is presented below.

\[
\text{Number of items completed correctly} \times \frac{100}{100} = \text{Treatment integrity}
\]

Treatment integrity for pre-treatment assessment, baseline, Math to Mastery, and immediate corrective feedback was 100% according to the self-reported checklists. However, upon review of the data, it is apparent that the pre-treatment assessment procedure for determining instructional level for April and Edward were conducted
incorrectly. The pre-treatment assessment of April’s math fluency skills was discontinued despite her mastery level achievement of below grade level material. The pre-treatment assessment of Edward’s math fluency skills was also prematurely discontinued as he achieved 14 DCPM on third grade material. Given that Edward is entering the sixth grade, his instructional level criterion is 20-39 DCPM and therefore he performed in the frustrational range. The implications of the lack of integrity in the pre-treatment assessment will be addressed in the discussion section of this paper.

**Interobserver Agreement**

Interobserver agreement (IOA) is the percent of agreement between two raters of the same instance. In the current study a second observer was used to ensure treatment integrity for 80% of the sessions. IOA for the treatment integrity was calculated by dividing the agreed upon number of steps completed for each session divided by the number of available steps to complete for each session and multiplying this ratio by 100. The formula is presented below.

\[
\text{Number of steps completed in agreement} \times \frac{100}{\text{Number of steps available in agreement + disagreement}} = \text{IOA}
\]

The percentage of IOA of treatment integrity was 100%.

**Interscorer Agreement**

Worksheets were scored by a second experimenter for 80% of the sessions in order to obtain interscorer agreement data for the dependent variable. Interscorer agreement was calculated by dividing the number of DCPM recorded in agreement by the
number of available correct digits and multiplying this ratio by 100. The formula is presented below.

\[
\frac{\text{Number of DCPM in agreement}}{\text{Number of DCPM in agreement + disagreement}} \times 100 = \text{Interscorer Agreement}
\]

Interscorer agreement was 100% for the DCPM in all phases.

Data Analysis

DCPM were visually analyzed with regard to changes in level, variability, and trend (Hayes, Barlow, & Nelson-Gray, 1999). Level refers to the average value of the measure. As such, the identified mean of each phase is also referred to as the level of the series of data points for that phase. Trend refers to the direction of change from the beginning of the series of data points to the end of the series of data points. In the current study, an increasing trend was desirable during intervention conditions as such an observation would indicate that the student was improving in ability to obtain more digits correct in a one minute period of time. Variability refers to the spread of data points around the level and trend. The more variable the data are in a phase, the more difficult it is to identify the student’s true level of performance as extreme data points skew the calculation of the mean. A large amount of variability in a phase usually suggests the influence of other extraneous variables (e.g., distractions, illness, other interventions), or lack of uniform knowledge in the area being assessed (i.e., knows some basic math facts but not others). However, the observation of more stable data during intervention conditions as opposed to baseline conditions has been suggested to be an important intervention effect regardless of changes in level and trend (Hayes et al., 1999). Thus, it
is sometimes necessary to proceed to intervention despite having less stable data in a pre-treatment phase.

In the current study, the first two participants, April and Bridgette, received the baseline assessment for 9 sessions. Participants three and four, Carley and Deanna, received 18 baseline sessions, and participants four and five, Edward and Frances, received 24 sessions. Changes in level, trend, and variability were visually analyzed across all three phases (i.e., baseline, Math to Mastery, immediate corrective feedback) to evaluate the effect of the intervention procedures. Sudden, large changes in these elements (e.g., level, trend, variability) immediately after each phase change were desired to produce more confidence in the effectiveness of each intervention procedure (Hayes et al., 1999). Additionally, mastery lines based of guidance from Deno & Mirkin (1977) were drawn on the graph for each participant across all three phases to assist in visually analyzing when a participant achieved the mastery criterion across sessions.

Basic statistical procedures were also performed across all three phases of the study. Rarely, are complicated statistical procedures used in single-subject designs due to the idiosyncratic nature of the data collection (Kazdin, 1982). Therefore, simple means were calculated for each phase to evaluate the average performance for each participant across each phase. The use of conventional t-tests was not conducted to statistically evaluate changes across phases due to the concern that serial dependency existed in the data. In other words, mastery of basic math facts was a skill that could not be unlearned across the different phases of the study once each participant had experienced one of the interventions.
CHAPTER III

RESULTS

Due to the individual nature of each participant’s response to the different phases included within the current study, the results for each individual participant across baseline, Math to Mastery, and immediate corrective feedback conditions will be presented first. Specifically, the data of the individual students were analyzed by visual inspection of the data for observable changes in trend, level, and variability between baseline and treatment conditions (Hayes et al., 1999). Additionally, individual means were calculated for each participant to evaluate the average performance across each phase. The mean number of DCPM is depicted in Table B.2. The results section of the manuscript will conclude with a discussion of overall findings across all participants as related to each of the three research questions posited in the introduction of the manuscript.

Individual Student Responses

Due to participant attrition, April was the only participant to receive the counterbalanced order of treatments (i.e., baseline, immediate corrective feedback, and Math to Mastery). The other five participants received baseline, Math to Mastery, and immediate corrective feedback. The following results are also presented in Figure B.4.
April

No change in level and a slight decrease in variability were observed in DCPM between baseline and immediate corrective feedback conditions. However, an immediate change in level and slightly increasing trend was observed from the immediate corrective feedback to Math to Mastery conditions. In fact, all five of the data points (100%) in the Math to Mastery condition were at or above the mastery level whereas no data points in immediate corrective feedback are above the mastery criterion. When comparing the mean DCPM in the baseline condition ($M = 10.3$, range 3-17) to the mean DCPM in the immediate corrective feedback condition ($M = 10.2$, range 7-14) and the mean DCPM in the Math to Mastery condition ($M = 22.4$, range 20-27), only the Math to Mastery condition resulted in an increase of DCPM to the mastery criterion of at least 20 DCPM. During the Math to Mastery intervention, April was administered an average of 3.6 repeated practices per session (range 1-5) before achieving mastery level. April made an average of 1.1 EPM (range 0-3) in the baseline condition, improved to 0.6 EPM (range 0-2) in the immediate corrective feedback condition, and further improved to 0.4 EPM (range 0-2) in the Math to Mastery condition.

Bridgette

Although a slightly increasing trend was observed during baseline, an immediate change in level was still observed between the baseline and Math to Mastery conditions. A decrease in level was observed between Math to Mastery and immediate corrective feedback conditions. No change in level was observed between the baseline and immediate corrective feedback conditions. Four of five data points (80%) were obtained
at the mastery criterion for the *Math to Mastery* condition whereas only one of ten data points (10%) were at the mastery criterion for the immediate corrective feedback condition. When comparing the means of the DCPM in the baseline condition ($M = 12.0$, range 8-17) to the mean DCPM in the *Math to Mastery* condition ($M = 19.8$, range 17-21) and to the mean DCPM in the immediate corrective feedback condition ($M = 11.3$, range 10-19), only the *Math to Mastery* condition resulted in an increase of DCPM near the mastery criterion of at least 20 DCPM. During the *Math to Mastery* intervention, Bridgette was administered an average of 4.8 repeated practices per session (range 1-5) before achieving mastery level or reaching the discontinue rule of ten practices. Bridgette made an average of 0.2 EPM (range 0-1) in the baseline condition, improved to 0.0 EPM in the *Math to Mastery* condition, and stayed at 0.0 EPM in the immediate corrective feedback condition.

*Carley*

An immediate change in level and variability were observed between baseline and *Math to Mastery* conditions. An immediate decrease in level was observed between the *Math to Mastery* and immediate corrective feedback conditions. The data are more stable in the immediate corrective feedback condition than in baseline. However, there is no change in level and a slightly decreasing trend was observed. When comparing the mean DCPM in the baseline condition ($M = 10.3$, range 6-15) to the mean DCPM in the *Math to Mastery* condition ($M = 21.1$, range 19-26) and the mean DCPM in the immediate corrective feedback condition ($M = 13.0$, range 10-15), only the *Math to Mastery* condition resulted in an increase of DCPM to the mastery criterion of at least 20 DCPM.
During the *Math to Mastery* intervention, Carley was administered an average of 4.9 repeated practices per session (range 1-10) before achieving mastery level or reaching the discontinue rule of ten practices. Carley made an average of 3.6 EPM (range 0-19) in the baseline condition, improved to 0.0 EPM in the *Math to Mastery* condition, and stayed at 0.0 EPM in the immediate corrective feedback condition.

*Deanna*

An immediate change in level was observed between the baseline and *Math to Mastery* conditions. An immediate decrease in level was observed between the *Math to Mastery* and immediate corrective feedback conditions. A slightly increasing trend was noted for both intervention conditions. Additionally, the data obtained during the *Math to Mastery* condition are more variable that in the other two conditions. When comparing the mean DCPM in the baseline condition (\(M = 1.1\), range 0-4) to the mean DCPM in the *Math to Mastery* condition \(M = 10.0\), range 4-15) and the immediate corrective feedback condition \(M = 2.8\), range 1-7), neither intervention resulted in an increase of DCPM to the mastery criterion of at least 20 DCPM. However, *Math to Mastery* did result in nearly a fivefold increase in DCPM over the immediate corrective feedback condition. During the *Math to Mastery* intervention, Deanna was administered 10 repeated practices per session before reaching the discontinue rule of ten practices. Deanna made an average of 7.7 EPM (range 1-40) in the baseline condition, improved to 0.2 EPM (range 0-1) in the *Math to Mastery* condition, and declined to 1.0 EPM (range 0-2) in the immediate corrective feedback condition.
Edward

Although a slightly increasing trend was observed during baseline, an immediate change in level was observed between the baseline and Math to Mastery conditions. An immediate decrease in level was observed between Math to Mastery and immediate corrective feedback conditions with a slightly decreasing trend being observed in the immediate corrective feedback condition. Additionally, the data are more variable during the Math to Mastery condition than in the other two conditions. When comparing the mean DCPM in the baseline condition ($M = 13.3$, range 6-24) to the mean DCPM in the Math to Mastery condition ($M = 32.1$, range 15-40) and the immediate corrective feedback condition ($M = 18.6$, range 17-20), only the Math to Mastery condition yielded results close to the mastery criterion of at least 40 DCPM. The Math to Mastery condition did result in a threefold increase of DCPM over the immediate corrective feedback condition. During the Math to Mastery intervention, Edward was administered an average of 9.1 repeated practices per session (range 2-10) before achieving mastery level or reaching the discontinue rule of ten practices. Edward made an average of 1.3 EPM (range 0-4) in the baseline condition, improved to 0.6 EPM (range 0-2) in the Math to Mastery condition, and improved to 0.0 EPM in the immediate corrective feedback condition.

Frances

Although a slightly increasing trend was observed in baseline, an immediate change in level was observed between the baseline and Math to Mastery conditions. An immediate decrease in level was observed between the Math to Mastery and immediate
corrective feedback conditions. A slightly increasing trend was observed during the *Math to Mastery* condition with less variability than the other two conditions. When comparing the mean DCPM in the baseline condition ($M = 22.2$, range 13-33) to the mean DCPM in the *Math to Mastery* condition ($M = 39.2$, range 31-43) and the immediate corrective feedback condition ($M = 23.0$, range 14-28), only the *Math to Mastery* condition resulted in an increase of DCPM approaching mastery criterion of at least 40 DCPM. Also, the *Math to Mastery* condition resulted in eight of ten (80%) of the sessions at or above the mastery level. During the *Math to Mastery* intervention, Frances was administered an average of 7.5 repeated practices per session (range 4-10) before achieving mastery level or reaching the discontinue rule of ten practices. Frances made an average of 1.9 EPM (range 0-6) in the baseline condition, improved to 0.0 EPM in the *Math to Mastery* condition, and declined to 0.4 EPM (range 0-2) in the immediate corrective feedback condition.

Research Questions

Three specific research questions were posed at the beginning of the manuscript designed to evaluate the ability of two empirically-based interventions to increase the DCPM for identified students enrolled in a summer academic clinic. Results for each research question will be addressed below.

*Research Question 1*

*Does implementation of the Math to Mastery intervention improve the number of digits correct per minute on curriculum-based probes beyond baseline levels for identified elementary school students?* For all six students (100%) included in the current study,
exposure to the Math to Mastery intervention resulted in a mean increase in DCPM over baseline levels. Additionally, the mean level of performance was at or above the mastery criterion for two of the six students (33%; $M = 22.4$ DCPM for April, $M = 21.1$ DCPM for Carley) and within 1 DCPM for two other students ($M = 19.8$ DCPM for Bridgette, $M = 39.2$ DCPM for Frances).

Research Question 2

Does implementation of the immediate corrective feedback intervention improve the number of digits correct per minute on curriculum-based probes beyond baseline levels for identified elementary school students? Four of the students (67%) included in the study improved their mean level of performance over baseline levels in the immediate corrective feedback condition. However, none of the students’ mean performance, or even a single session performance, reached the mastery criterion in the immediate corrective feedback condition.

Research Question 3

Does implementation of the Math to Mastery intervention improve the number of digits correct per minute on curriculum-based probes beyond the use of immediate corrective feedback for identified elementary school students? As discussed previously, the Math to Mastery intervention resulted in improvement in DCPM above baseline levels for all six participants (100%) with two of the six (33%) reaching the mastery criterion based on mean level of performance and two other students within less than one DCPM from achieving the mastery level criterion. Overall, data obtained from the present study indicated that the Math to Mastery intervention was better than the
immediate corrective feedback condition and the immediate corrective feedback condition was slightly better than the baseline condition with regard to visual inspection of changes in level, trend, and variability of the data or mean level of improvement in DCPM.
CHAPTER IV
DISCUSSION

The *Math to Mastery* intervention resulted in a mean increase in digits correct per minute over baseline levels for all six participants including achieving the mastery criterion for two students and increasing to within one digit correct per minute of achieving mastery for two other students. The package as a whole appears to have provided the necessary modeling, practice, corrective action, incentive via goal setting, and reinforcement for achieving goals for students to improve their math fluency in terms of digits correct per minute. According to Frederick (1995) and Tingstrom et al. (1995), modeling (i.e., previewing) has been an effective intervention for remediation of academic skills. In this package, we believe modeling was an effective component because it provided an example of the correct manner in which to solve math problems, the appropriate rate at which the math problems should be completed, and the expected digits correct per minute to achieve mastery and discontinue the session. Repeated practice and immediate corrective feedback have been shown to be effective at increasing academic performance by Anderson (1982), Darch et al. (1984), Greenwood et al. (1984), Harber et al. (2003), Harber et al. (2004), Skinner and Shapiro (1989). The inclusion of the combination of repeated practice and immediate corrective feedback is believed to be responsible for the increased and correct practice with difficult problems (i.e., problems
on which the student made an error). Goal setting, progress monitoring, self-charting, and reinforcement for achievement of goals have been found to be effective intervention for improving a number of behaviors including academics (Ayllon & Roberts, 1974; Coding, 2003; Brown, Copeland, & Hall, 1986; Jackson & Mathews, 1995; Rhymer et al., 2000; Skinner, Cashwell, & Skinner, 2000). In the Math to Mastery intervention package, these components are believed to be responsible for increasing motivation to improve performance via intrinsic reinforcement. The package also includes external reinforcement in the form of positive social attention and negative reinforcement in termination of the task for achieving mastery levels.

Two of the students were unresponsive to the immediate corrective feedback intervention and the other four students demonstrated some improvement but failed to reach the mastery level at any time during the intervention. The finding that the immediate corrective feedback intervention did not result in gains similar to those evidenced during the Math to Mastery phase is interesting given that two previous studies (e.g., Harber et al., 2003; Harber et al., 2004) have found immediate corrective feedback to be effective in this setting with other students.

Several explanations could exist for the little or lack of improvement with the immediate corrective feedback intervention in this study. In this study, immediate corrective feedback was conducted for a maximum of one to two weeks, whereas the previous studies implemented intervention for a longer period of time. Therefore, the opportunity to respond to each intervention in this study was shorter than in previous studies. If exposed to the immediate corrective feedback intervention for a longer period of time, the students in this study may have made greater gains under this condition.
Additionally, automaticity with academic targets requires the student demonstrate both \textit{accuracy} and \textit{speed} with the identified skill. The students in the present study demonstrated problems primarily with speed across both the \textit{Math to Mastery} conditions and immediate corrective feedback conditions. In other words, the student’s committed very few errors per session across the two intervention conditions. However, the students included in the previous immediate corrective feedback conditions may have demonstrated deficits with both accuracy and speed when completing the problems. As such, other studies should evaluate the efficacy of these interventions with students who are identified to demonstrate difficulty with one or both of the two skills in an a priori fashion to truly address this hypothesis.

A majority of the students in this study received the \textit{Math to Mastery} package first before receiving the immediate corrective feedback intervention. This may have led to a decrease in performance in DCPM as the immediate corrective feedback intervention only included a single component of the \textit{Math to Mastery} package. The students may have noticed the contrast between the instructional and motivational components in \textit{Math to Mastery} versus the individual component in immediate corrective feedback. In other words, the students may have noticed that the immediate corrective feedback intervention was less effective than the \textit{Math to Mastery} based on their performance (i.e., increase in fluency and accuracy) on the curriculum-based probes. However, one student received immediate corrective feedback prior to implementation of Math to Mastery and still performed similarly to students who received the immediate corrective feedback following Math to Mastery. Therefore, this argument is somewhat minimized by the counterbalanced order of interventions.
Another difference may lie within the populations included in each study. The students in the previous studies could have been performing at different levels in the instructional hierarchy (i.e., acquisition, fluency, generalization, adaptation; Haring et al., 1978). Also, the previous studies used peers as the interventionists and did not assess for treatment integrity, whereas the current study had either a graduate student or an elementary school teacher provided both interventions with integrity. Therefore, it is unknown if the integrity with which the intervention was implemented is responsible for the difference in effects between these studies. That is not to say that the previous studies of immediate corrective feedback were not conducted with integrity, rather this information and the exact procedures by which to replicate the procedures, were simply not provided.

The Math to Mastery intervention appears to be more effective at improving math fluency in comparison to immediate corrective feedback in this study. Overall, the immediate corrective feedback condition was no better than baseline, whereas with Math to Mastery, all of the students had increases in the mean DCPM over baseline, two students achieved mastery criterion, and two students were within one DCPM of the mastery criterion. The lack of repeated practice is likely to have been an important factor in the lower performances during immediate corrective feedback than during Math to Mastery as nearly all of the Math to Mastery data points were taken after several trials.

The degree to which the effects of the two treatment conditions (i.e., Math to Mastery, immediate corrective feedback) differ may have been affected by the ordering of the interventions. As April received the immediate corrective feedback intervention first, no goal was set for her to work toward in immediate corrective feedback, however,
a goal was established in the *Math to Mastery* intervention condition. Still, several of the other participants, who received the *Math to Mastery* intervention first, continued to attempt to reach the *Math to Mastery* intervention goals during the immediate corrective feedback condition as evidenced by statements that they were frustrated at having not reached a particular performance level or asked to repeat the worksheet again in order to reach the criteria previously established in the *Math to Mastery* intervention.

As noted earlier, the pre-treatment assessment of April and Edward were conducted without integrity despite self-report of following the instructions. April’s pre-treatment assessment should have continued with third grade material, which would have precluded her from the study as she was entering the third grade and, therefore, would not be performing at least one grade level below. During baseline, April’s instructional level was increased to third grade level appropriately. April was then performing at grade level and *Math to Mastery* was designed to remediate skills rather than teach new material to which she had not been previously exposed. However, as with the students whose performances were below current grade level, her performance demonstrated obvious improvements from the *Math to Mastery* intervention.

Edward’s pre-treatment assessment should have continued by measuring his performance on second grade material to determine his actual instructional level. Instead, Edward began baseline and intervention at a frustrational level. Edward was able to demonstrate relatively large gains in performance with *Math to Mastery*; however, he was only able to master 2 worksheets in 10 sessions. It is believed that Edward would have demonstrated more success and a greater rate of progress through the curriculum, had the correct instructional level materials been used.
Implications

The current study demonstrated that Math to Mastery is effective in increasing mathematics fluency, even more effective than immediate corrective feedback, a commonly used instructional procedure. The amount of time needed to implement the intervention is minimal and parents may also be able to use the intervention at home in order to supplement school lessons and assignments. The Math to Mastery intervention package was designed to be implemented in sessions no longer than 30 minutes and was generally implemented in approximately 15 to 20 minutes. Interventionists were trained in one 45 minute session. The performance improvement in math fluency as measured by digits correct per minute for all students in this study can be attributed to the unique combination, sequencing, and presentation of the individually empirically validated intervention components used in the Math to Mastery intervention package. As such, the Math to Mastery intervention package appears to be effective at closing the gap between the level of performance and rate of progress (i.e., dual discrepancy) of low achieving and typical students. Upon evaluation of the effects on math fluency, visual analysis of the Math to Mastery intervention package suggests that it is potentially an effective tier III intervention for remediation of math fluency skills. Given the common school constraints on limited time for intervention, available resources, knowledge of and access to effective interventions especially in math, this package provides another empirically-based intervention that can be implemented within the educational system as a potential their III intervention in the RTI model.
Limitations

Although the findings of the current study are relatively consistent across students, there are several limitations that need to be identified. Even though impressive gains were demonstrated, most students were not exposed to benchmarks at their current grade level. The participants were only given the opportunity to master the benchmarks at the curriculum level in which they were placed according to the pre-treatment assessment. Time constraints simply did not allow participants to be exposed to additional benchmarks progressing toward grade level expectations. In other words, a four week summer academic clinic does not provide long enough of an evaluation period to assess long term gains and maintenance of skills across various benchmarks.

The results are limited in their generalizability to mathematics other than the basic addition and subtraction facts used in the current study. Also, effects on performance with other academic skills (e.g., multiplication and division) were not assessed. Generalization studies could evaluate if the Math to Mastery intervention package is as effective for other types of computational problems not included in this study as this study focused on gains with addition and subtraction problems.

Edward, who was incorrectly identified as having an instructional level at third grade material, and Deanna, who is going to repeat the second grade and receives special education services for a learning disability in math, received fewer worksheets during the Math to Mastery intervention as the intervention includes mastery-based progression through the curriculum. In other words, these two students routinely needed several days of 10 trials with their respective curricula in order to achieve mastery levels. These two students may have been at the acquisition stage of learning, as opposed to being ready for
the fluency stage, suggesting a longer duration of intervention would be expected. That is to say, Edward and Deanna may not have known their basic addition and subtraction facts well enough to be prepared to focus on learning to complete such computations quickly and accurately. Given their difficulty with providing the correct responses, it is thought that these students would need a longer duration of intervention in order to first master the acquisition stage before being able to demonstrate quicker learning of fluency skills (i.e., the students need time to learn to provide the correct answers for each specific math fact and then additional time to learn to provide the answers fluently).

The grade level worksheets were assumed to be of comparable difficulty within a grade and increasingly difficult with grade increases. However, the worksheets have not been evaluated for accuracy of these assumptions. Additionally, each worksheet presented multiple skills rather than targeting a specific, single skill for remediation which may have shown even greater gains in performance. Also, although a sample size of six students is acceptable in a single subject design, it is relatively small in comparison to the general population. The participants included one male and five females. Three of the females and the only male were African-American and the other two females were Caucasian. One student was repeating the second grade, three students were entering the third grade, one student was entering the fifth grade, and one was student entering the sixth grade. Given the small sample size and variation within the sample, it is with caution that the results can be generalized to other populations or demographics. Future studies should evaluate the effects of Math to Mastery within a larger population amongst groups with homogenous demographics in order to determine populations with which Math to Mastery may be more beneficial or less beneficial. These populations or groups
may include specific grade level students; students who demonstrate more severe
discrepancies between current grade level and instructional level performance; students
who have difficulty with either accuracy, rate of responding, or both; students who have
difficulty with a specified single skill; and with students with and without low
achievement, diagnoses of a specific learning disability, and/or Attention
Deficit/Hyperactivity Disorder.

Participants included in this study were self-referred to the university-based
summer academic clinic and were not identified as at risk or having academic difficulty
apriori. Also, given that the clinic is held mid-summer, the students have not likely been
practicing mathematics. The Math to Mastery intervention package should be evaluated
in the school setting during the school year. As mandated by the Mississippi State
Department of Education, Tier III interventions are to be implemented for eight weeks,
performance is then evaluated, and the intervention is implemented for an additional
eight weeks. Furthermore, Tier III interventions must also be implemented five days per
week for 30 – 60 minutes across each eight week evaluation period (Bounds, 2006). The
efficacy of Math to Mastery under this paradigm needs to be evaluated to assess its merit
as an effective, empirically-based intervention. It would also be interesting to see if
differences in gains in math fluency occur for students receiving intervention in the first
half of the school year versus those receiving intervention later in the academic year.

Third, the participant sample was selected from students attending a remedial
summer clinic for students with academic difficulties. The highly structured environment
of summer academic clinic held by trained graduate students in school psychology
provides high internal validity in that the change in the dependent variables (i.e., DCPM)
can be attributed to the independent variables (i.e., immediate corrective feedback, *Math to Mastery*). The clinic setting is structured so that behavioral and academic expectations are clearly stated, the format of the clinic (i.e., 4 hours per day for 4 weeks during mid-summer) is relatively brief, and the ratio of staff to participant is relatively high (i.e., 1 to 1 in this study). While this environment is similar, it is not truly representative of the school setting (e.g., differences in time of year, facilities, novel environment, interventionists level of training) where effects of the intervention may differ from these results. However, some external validity was established as one of the interventionists was a certified elementary teacher, who had not had previous training in school psychology or mathematics remediation. The teacher was able to implement and accurately measure baseline, *Math to Mastery*, and immediate corrective feedback interventions with less than 1 hour of training. Although, treatment integrity measures revealed acceptable levels of implementation some procedural problems did occur. For example, the pre-treatment assessment for instructional level determination was discontinued prematurely for two students (e.g., April and Edward). April started at a level that was too low given that she should have begun with third grade material. She demonstrated mastery of second grade material during baseline and was subsequently promoted to third grade material for additional baseline and intervention phases. Edward started at a level that was too high given that he was still performing at a frustrational level for his age on third grade material. However, gains were still noted in the *Math to Mastery* phase over the immediate corrective feedback and baseline phase for both students.
Lastly, despite improvement in DCPM for all students, the improvement was not maintained for even one session of the following intervention for the five students receiving Math to Mastery and then immediate corrective feedback. While four of the students appeared to have achieved or nearly achieved the mastery level for DCPM for the particular benchmark on which he or she was working, they did not appear to have maintained the skill of doing so fluently. That is to say that the students have not yet learned to fluently (i.e., quickly) provide responses to basic math computation. The students appear to be at the skill acquisition stage of learning to provide fluent responses to addition and subtraction problems. This is thought to be due to the limited duration of the summer academic skills clinic (i.e., four weeks). The actual number of days of intervention ranged from five to ten (i.e., one to two weeks). It is hypothesized that a longer duration of the intervention would allow time for the students to first acquire fluency skills with the basic math facts and then second, to learn to be fluent with their fluency skills. Again, as previously noted, the Mississippi State Department of Education requires for Tier III interventions be implemented for 8 weeks, performance evaluated, and continued for an additional 8 weeks of intervention (Bounds, 2006). A better understanding of the maintenance of the effects of the Math to Mastery intervention would be available when given ample time for the students to acquire and become fluent with the demonstration of fluent addition and subtraction skills.
Future Research

Components, Procedures, and Forms of Delivery

The individual components used in the *Math to Mastery* intervention package have been found to be effective by other researchers, but have not been evaluated in the context of the *Math to Mastery* collection of interventions. Therefore, there is a need to extend the current research in an effort to determine the most effective combination of components for mathematics remediation. In an effort to further streamline the package, future research may evaluate the package to determine which components are critical and which components are not needed. Previous studies have shown a previewing component to be influential in improving gains in the area of reading (e.g., Tingstrom et al., 1995). Theoretically, the previewing component of *Math to Mastery* should be a necessary element, which needs to be evaluated by future studies. In the *Math to Mastery* package, it appeared that repeated practice was one of the most influential elements to improving DCPM. Also, the use of immediate corrective feedback versus providing delayed feedback at the end of one minute has not been evaluated. Theoretically, immediate corrective feedback should produce better outcomes due to decreasing practice of errors and the punishing effect of reducing available time for correct responding which are not effects of delayed feedback. Graphing alone is a reinforcement procedure as it theoretically increases intrinsic motivation and then provides visual feedback for gains in performance. Different forms of external reinforcement (e.g., social reinforcement from adults or peers, tangible reinforcers such as stickers, food, and access to preferred activities). Along the same line, it may be beneficial to determine the effects of
conducting longer or shorter sessions or allowing for more or less daily trials. Another option to evaluate would be making the *Math to Mastery* intervention computer-based. It would be interesting to determine the effects of computer interaction versus human interaction, level of treatment integrity, and student preferences for presentation of the intervention.

*Length, Duration, and Intensity of Intervention*

Given the short duration of the summer clinic, *Math to Mastery* was only implemented for one or two weeks. The RTI literature suggests a maximum of six to eight weeks of intense intervention. Future research should examine the effects of using *Math to Mastery* for a six or eight week period to determine how responsive a student is to the intervention. Additionally, current research suggests that the interventions should be delivered every day for 30-60 minutes per day. However, these are guidelines that have yet to be empirically validated. Furthermore, the length, frequency and intensity of intervention that each of the types of learners based on Haring and colleagues’ hierarchy (1978) would need has yet to be established and requires further research. At present, *Math to Mastery* appears to assist students in developing fluency skills with basic math facts. However, no data are currently available on the usefulness of the package for developing acquisition, generalization, or maintenance skills. As a result, further investigation of the package is needed to address the aforementioned concerns.

*Comparison to Other Packages*

In this study, *Math to Mastery* was compared to an individual component intervention. It would be relevant to compare it to other packaged math interventions
such as *Cover, Copy, and Compare* (Skinner, Turco, Beatty, & Rasavage, 1989). The *Cover, Copy, and Compare* is a CBM-based program designed to address fluency. The procedure uses a sheet of paper folded in half lengthwise. Ten problems and answers are written on the left half and the right half is used by the student to write from memory the problem and answer. The student is instructed to silently read the problem and answer on the left side of the paper, cover the left side with an index card, write the problem and answer from memory on the right side of the paper, and compare the problems. An incorrect response requires that the student attempt the problem again, with a successful response necessary before moving to next problem. The *Cover, Copy, and Compare* intervention has been proven effective for increasing spelling accuracy, multiplication rates, division rates, and increasing the accuracy of identification of the individual U.S. states (Hansen, 1978; Skinner et al., 1993; Skinner, Belfiore, & Pierce, 1992; Skinner, Ford, & Yunker, 1991; Skinner et al., 1989).

Overall, the *Cover, Copy, and Compare* and *Math to Mastery* interventions include modeling, practice, immediate corrective feedback, and reinforcement components. However, actual implementation of each of these intervention elements is quite different between the two interventions. The modeling of the correct answer in *Cover, Copy, and Compare* is delivered via the worksheet; whereas, in *Math to Mastery* the correct answers are modeled by the interventionist. Both interventions provide corrective feedback for incorrect responses; however *Math to Mastery* provides feedback for each digit discontinuing incorrect practice sooner than does *Cover, Copy, and Compare* which allows for the completion of a complete problem before providing feedback. Also feedback is provided from the interventionist with *Math to Mastery* and
Cover, Copy, and Compare provides feedback in the form of the written answer with which to compare. Both interventions also provide repeated practice. The Cover, Copy, and Compare intervention only requires additional practice for incorrect responses whereas Math to Mastery requires additional practice for incorrect and/or slow responses. Both interventions also provide reinforcement, but Cover, Copy, and Compare does not provide external social reinforcement that is provided by the interventionist in Math to Mastery. Despite similar core components, the variations in method of delivery of each strategy (e.g., modeling, practice, immediate corrective feedback, and reinforcement) may likely cause different effects in math performance.

Settings and Interventionists

A school psychology graduate student and a certified elementary school teacher were able to be trained by the lead researcher to conduct baseline and Math to Mastery and immediate corrective feedback interventions in less than 60 minutes. The program would likely also take little time to adequately train school personnel such as teacher assistants or teacher tutors how to implement the intervention as designed. However, future researchers would need to investigate if school-based personnel could implement the Math to Mastery package with good treatment integrity initially and also maintain adequate levels of integrity over the school year. Some guidance from the Reading to Read literature is encouraging as Bailey (1999) found that teacher assistants could implement the academic intervention for reading skill deficits with good compliance and treatment integrity.
Outcome Measures

In this study, DCPM were used to assess the effects of Math to Mastery. Other dependent variables could be included in future studies to determine the effects of Math to Mastery on other areas of student performance (e.g., grade level, annual achievement tests, reduction in social behavior problems, etc.). As a student progresses through increasingly difficult instructional level worksheets and eventually on to higher grade level worksheets, assessment of the student’s performance on his or her grade level may improve as his or her abilities begin to approximate appropriate grade level skills. At this point it is hypothesized that the effects would generalize to the classroom setting and perhaps to annual achievement testing. The desired effect is for the Math to Mastery program to effect change (i.e., cause learning) that can be maintained and generalized to the general math setting. Additionally, as a student becomes more adept with math skills, it is plausible to expect a reduction of off-task and disruptive behaviors as the demonstration of the acquired skills continue to be internally and externally reinforced.

Group Designs

This study examined the effects of Math to Mastery with a single-subject design to better understand the idiosyncratic responses to the intervention. Now that the intervention has been found to be effective in increasing fluency with basic computational math facts in the areas of addition and subtraction, it would be appropriate to study the intervention effects in larger populations with a group design study (e.g.,
Math to Mastery versus control; Math to Mastery versus school-based tutoring) to evaluate the overall effectiveness of the intervention within a class, grade, or school.

Conclusion

In summary, the Math to Mastery intervention package shows potential for use as an effective and efficient strategy for use with elementary school students who demonstrate dysfluency with addition and subtraction computation. The package includes several effective, empirically-based components that have been shown to be effective individually, but may be even more effective collectively. As such, this research project provided an initial evaluation of the use of the Math to Mastery intervention package. Now, researchers need to address the aforementioned concerns and limitations in order to further evaluate the efficacy of the intervention package as a Tier III empirically-based intervention.
REFERENCES


Bounds, M. (2006.) Draft policies regarding the children with disabilities under the individuals with disabilities education improvement act amendments of 2004 (IDEIA, 2004). Jackson, MS: Mississippi Department of Education.


APPENDIX A

TREATMENT INTEGRITY CHECKLISTS FOR PRE-TREATMENT ASSESSMENT, BASELINE, MATH TO MASTERY, AND IMMEDIATE CORRECTIVE FEEDBACK
Math PreTx Assessment Integrity Checklist

Date:__________  Examiner:_________

Materials: 3 grade level math worksheets, 3 below grade level math worksheets, and 3 two grades below grade level math worksheets.

Please indicate with a mark (✓) if the following step was completed:

1. _____ Sit beside the student and provide the grade level math worksheet.

2. _____ “Begin working right here (point to the first problem) and work across this row and then go to the next row. Write each answer quickly and clearly enough so that I can read it. I will say stop after 1 minute. Ready. Begin.”

3. _____ Time the student for 1 minute, but do not provide assistance. “Stop” after 1 minute.

4. _____ Count the number of DCPM.
   If completed in less than 1 minute or if allowed to go longer than 1 minute calculate the number of digits correct per minute using
   \[ \frac{\text{# digits written correctly}}{\text{# seconds working}} \times 60. \]

5. _____ Get the next worksheet based upon the previous score. For example, if the child is entering the 3rd grade and wrote 50 DCPM with less than 2 errors move up a grade or two. If the child wrote 15 DCPM with 5 errors stay on that grade level and get the MIDDLE passage. If the child wrote 7 DCPM or more than 7 errors move down a grade or two. If a child is entering the upper grades (4th – 6th) but is being assessed at the lower grades (1st – 3rd) instructional level, use the criteria from the upper grade levels (i.e., Frustration = 0 – 19, Instructional = 20 – 39, Mastery = 40+).

6. _____ Repeat to get 3 stable Instructional Level probes & determine Mastery, and Frustration Levels, as well.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Level</th>
<th>Digits correct per minute</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-3</td>
<td>Frustration</td>
<td>0-9</td>
</tr>
<tr>
<td></td>
<td>Instruction</td>
<td>10-19</td>
</tr>
<tr>
<td></td>
<td>Mastery</td>
<td>20+</td>
</tr>
<tr>
<td>4+</td>
<td>Frustration</td>
<td>0-19</td>
</tr>
<tr>
<td></td>
<td>Instruction</td>
<td>20-39</td>
</tr>
<tr>
<td></td>
<td>Mastery</td>
<td>40+</td>
</tr>
</tbody>
</table>

CBM NORMS (DENO & MIRKIN, 1977)

Is the child on grade level?  YES  NO  What math level is the child on? _______
Please indicate with a mark (✓) if the following step was completed:

1. _____ Sit beside the student and provide the worksheet.

2. _____ “Begin working right here (point to the first problem) and work across this row and then go to the next row. Write each answer quickly and clearly enough so that I can read it. I will say stop after 1 minute. Ready. Begin.”

3. _____ Time the student for 1 minute, but do not provide assistance. “Stop” after 1 minute.

4. _____ Count with the student the number of DCPM. If completed in less than 1 minute or if allowed to go longer than 1 minute calculate the number of digits correct per minute using
   \[ \frac{\text{# digits written correctly}}{\text{# seconds working}} \times 60. \]

5. _____ Give student graph paper and have them draw a dot at the corresponding correct digits per minute for each session of the day.
Date: __________ Math to Mastery Integrity Checklist Examiner:_________________

Please indicate with a mark (✓) if the following step was completed:

1. _____ Sit beside the student and provide the worksheet.

2. _____ “Begin working right here (point to the first problem) and work across this row and then go to the next row. Write each answer quickly and clearly enough so that I can read it. I will say stop after 1 minute. Ready. Begin.”

3. _____ Time the student for 1 minute, but do not provide assistance. “Stop” after 1 minute.

4. _____ Count with the student the number of DCPM. If completed in less than 1 minute or if allowed to go longer than 1 minute calculate the number of digits correct per minute using

\[
\frac{\text{# digits written correctly}}{\text{# seconds working}} \times 60.
\]

5. _____ Give student graph paper and have them draw a dot at the corresponding correct digits per minute for each session of the day.

6. _____ Read/demonstrate the correct work for incorrect problems and problems needed to be worked in order to reach the mastery level.

7. _____ “We are going to do it again. If you make a mistake I will tell you ‘that’s not quite right’ and you can try the problem again. If you make a mistake on the same problem I will give you the correct answer which you should copy over and continue working. Put your pencil down when I say stop. Begin.”

8. _____ Immediately correct mistakes.

9. _____ “Stop” after 1 minute.

10. _____ Repeat Steps 4 – 10 until EITHER:

- Student reaches mastery criteria DCPM,
- Repeated the passage 10 times,
- 30 minutes has passed.
Please indicate with a mark (✓) if the following step was completed:

1. _____ Sit beside the student and provide the worksheet.

2. _____ “When I say ‘begin,’ start working the problems. Begin with the first problem and work across the page then go to the next row. If you make a mistake I’ll tell you ‘that’s not quite right’ and you can try the problem again. If you make a mistake on the same problem I will give you the correct answer which you should copy over and continue working. Put your pencil down when I say stop. Ready. Begin.”

3. _____ Time the student for 1 minute, providing corrective feedback for errors.

   Corrective feedback includes:
   
   a. If response was correct, say “That’s right.”
   
   b. If response was incorrect, say “That’s not quite right, try again.”
   
   c. If after trying again, the response is still incorrect, say “That’s not right, (repeat the problem giving the correct response).”

4. _____ Say “Stop” after 1 minute.

5. _____ Count with the student the number of DCPM.

   If completed in less than 1 minute or if allowed to go longer than 1 minute calculate the number of digits correct per minute using

   \[
   \frac{\text{# digits written correctly}}{\text{# seconds working}} \times 60.
   \]

6. _____ Give student graph paper and have them draw a dot at the corresponding correct digits per minute for each session of the day.
APPENDIX B

TABLES AND FIGURES
Table B.1.  Student Demographic Information

<table>
<thead>
<tr>
<th>Name</th>
<th>Gender</th>
<th>Ethnicity</th>
<th>Age</th>
<th>Grade</th>
<th>CBM Instructional Level</th>
<th>Special Education Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>April</td>
<td>Female</td>
<td>African American</td>
<td>9</td>
<td>3&lt;sup&gt;rd&lt;/sup&gt;</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt;</td>
<td>None</td>
</tr>
<tr>
<td>Bridgette</td>
<td>Female</td>
<td>African American</td>
<td>9</td>
<td>3&lt;sup&gt;rd&lt;/sup&gt;</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt;</td>
<td>None</td>
</tr>
<tr>
<td>Carley</td>
<td>Female</td>
<td>Caucasian</td>
<td>9</td>
<td>3&lt;sup&gt;rd&lt;/sup&gt;</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt;</td>
<td>None</td>
</tr>
<tr>
<td>Deanna</td>
<td>Female</td>
<td>African American</td>
<td>9</td>
<td>2&lt;sup&gt;nd*&lt;/sup&gt;</td>
<td>&lt;1&lt;sup&gt;st**&lt;/sup&gt;</td>
<td>SLD: Math</td>
</tr>
<tr>
<td>Edward</td>
<td>Male</td>
<td>African American</td>
<td>12</td>
<td>6&lt;sup&gt;th&lt;/sup&gt;</td>
<td>3&lt;sup&gt;rd&lt;/sup&gt;</td>
<td>None</td>
</tr>
<tr>
<td>Frances</td>
<td>Female</td>
<td>Caucasian</td>
<td>10</td>
<td>5&lt;sup&gt;th&lt;/sup&gt;</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt;</td>
<td>None</td>
</tr>
</tbody>
</table>

* Retained
** Frustrational Level Performance at 1<sup>st</sup> Grade level
Table B.2. Median Pre-treatment Assessment and Mean Digits Correct Per Minute and Errors for Each Phase

<table>
<thead>
<tr>
<th>Student</th>
<th>Median Pre-treatment Assessment</th>
<th>Baseline</th>
<th>Immediate Corrective Feedback</th>
<th>Math To Mastery</th>
<th>Mean trials per session</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>DCPM</td>
<td>Errors</td>
<td>DCPM</td>
<td>Errors</td>
</tr>
<tr>
<td>April</td>
<td>26*</td>
<td>10.3</td>
<td>1.1</td>
<td>10.2</td>
<td>0.6</td>
</tr>
<tr>
<td>Bridgette</td>
<td>10</td>
<td>12.0</td>
<td>0.2</td>
<td>11.3</td>
<td>0</td>
</tr>
<tr>
<td>Carley</td>
<td>12</td>
<td>10.3</td>
<td>3.6</td>
<td>13.0</td>
<td>0</td>
</tr>
<tr>
<td>Deanna</td>
<td>1</td>
<td>1.1</td>
<td>7.7</td>
<td>2.8</td>
<td>1.0</td>
</tr>
<tr>
<td>Edward</td>
<td>14**</td>
<td>13.3</td>
<td>1.3</td>
<td>18.6</td>
<td>0</td>
</tr>
<tr>
<td>Frances</td>
<td>36</td>
<td>22.2</td>
<td>1.9</td>
<td>23.0</td>
<td>0.4</td>
</tr>
</tbody>
</table>

* Pre-treatment assessment discontinued prematurely – score was at mastery level rather than instructional level
** Pre-treatment assessment discontinued prematurely – score was at frustrational level rather than instructional level
Figure B.1. Pathway for Identification of LD adapted from the Heartland Area Education Agency model.
<table>
<thead>
<tr>
<th>Student:__________</th>
<th>Date:__________</th>
<th>Running Total</th>
<th>Cumulative Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 + 3</td>
<td>4 - 3</td>
<td>2 + 7</td>
<td>6 - 5</td>
</tr>
<tr>
<td>6 + 2</td>
<td>8 - 5</td>
<td>1 + 4</td>
<td>2 - 1</td>
</tr>
<tr>
<td>5 + 1</td>
<td>8 - 1</td>
<td>6 + 2</td>
<td>7 - 1</td>
</tr>
<tr>
<td>1 + 8</td>
<td>5 - 3</td>
<td>2 + 5</td>
<td>8 - 4</td>
</tr>
<tr>
<td>2 + 5</td>
<td>9 - 8</td>
<td>6 + 2</td>
<td>7 - 1</td>
</tr>
<tr>
<td>6 + 2</td>
<td>5 - 1</td>
<td>4 + 4</td>
<td>6 - 2</td>
</tr>
</tbody>
</table>

Figure B.2. Sample worksheet of first grade material.
Figure B.3. Sample session graph.
Figure B. 4. Multiple Baseline Graph of Digits Correct Per Minute and Errors in baseline, Math to Mastery, and Immediate Corrective Feedback for all six students.
APPENDIX C

VITA
### EDUCATION

<table>
<thead>
<tr>
<th>Year</th>
<th>Degree</th>
<th>Institution</th>
<th>Major Area</th>
<th>Minor Area</th>
<th>Dissertation Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>Ph.D. Candidate</td>
<td>Mississippi State University</td>
<td>School Psychology</td>
<td>Clinical Psychology</td>
<td>Evaluation of the Effects of a Curriculum Based Math Intervention Package with Elementary School Age Students in a Summer Academic Clinic</td>
</tr>
<tr>
<td>2003</td>
<td>M.S.</td>
<td>Mississippi State University</td>
<td>School Psychology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>B.A.</td>
<td>Mississippi State University</td>
<td>Psychology</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### CLINICAL EXPERIENCE

**9/05 – 8/06**

**PEDIATRIC PSYCHOLOGY RESIDENT**
Columbus Children’s Hospital, Columbus, OH

- **Psychology Inpatient Feeding Disorders Program**: 9/05 – 5/06  
  Supervisor: Tom Linscheid, Ph.D.  
  Duties: Provide direct patient care for children with a variety of feeding problems including developing and implementing a behavioral feeding plan, educating and training parents to implement the plan, and providing follow-up phone calls and support for maintenance and generalization.

- **Outpatient Child Clinical Psychology Service**: 9/05 – 8/06  
  Supervisor: David Michalec, Ph.D.  
  Duties: Provide outpatient therapy services including behavioral parent training and education for low-income families. 3 hours per week.

- **Emergency On-Call Suicidal Assessment**: 9/05 – 8/06  
  Supervisors: Tammi Young-Saleme, Ph.D., Jim Mulick, Ph.D., Kevin Smith, Ph.D., Kathy Vannatta, Ph.D., Cathy Butz, Ph.D., John Beetar, Ph.D., Jennifer Cass, Ph.D., Keith Yeates, Ph.D., Cindy Gerhardt, Ph.D., Kathy Lemanek, Ph.D.  
  Duties: Provide assessment of suicidal ideation and ability of the patient’s family to provide constant supervision and a safe environment in order to determine whether to discharge the patient to his/her parents or to recommend placement to inpatient psychiatric unit. On call Friday through Friday every 4th week.

- **Psychological Assessment**:  
  Supervisors: Kevin Smith, Ph.D., Laura Mackner, Ph.D., Kathy Lemanek, Ph.D.  
  Duties: Provide comprehensive psychological assessment for a variety of referral problems including ADHD, learning disabilities, depression, and anxiety disorders in children ages 3 to 21. Responsible for 2 assessments per month.
• **Inpatient Consultation and Liaison Services and Outpatient Therapy 9/05 – 1/06**  
  Supervisors: Anthony Alioto Ph.D., Tom Linscheid, Ph.D., Laura Mackner, Ph.D.

  Duties: Provide consultation to gastroenterology physicians and medical staff for children with encopresis, intractable vomiting, self-gagging, chronic abdominal pain, Crohn’s disease, anorexia, and bulimia. Provide outpatient therapy services such as developing behavioral interventions to increase compliance with medical regimens and providing parent education.

• **Inpatient Consultation and Liaison Services and Outpatient Therapy 1/06 – 5/06**  
  Supervisors: Cathy Butz, Ph.D., Kathy Lemanek, Ph.D.

  Duties: Provide consultation to pulmonology, sickle cell, surgery, PICU, and neurology physicians and medical staff for children with cystic fibrosis, sickle cell disease, burns, and headaches. Provide outpatient therapy services to this population as well.

• **Inpatient Consultation and Liaison Services and Outpatient Therapy 5/06 – 8/06**  
  Supervisors: John Beetar, Ph.D., Tammi Young-Saleme, Ph.D.

  Duties: Provide consultation to hematology/oncology and rehabilitation medicine physicians and medical staff for children with cancer, hematological disorders, TBI, and spinal cord injuries.

  **7/04 – 5/05**  
  **PEDIATRIC PSYCHOLOGY EXTERN**  
  Supervisor: Susan Jackson-Walker, Ph.D.

  • **A.I. duPont Hospital for Children, Wilmington, DE**

    Duties: Provide individual and family therapy, comprehensive psychological evaluations, and inpatient consultation/liaison for new diagnoses of diabetes and gastrointestinal disorders.

  • **Wilmington Hospital – First State School, Wilmington, DE**

    Duties: Provide individual, family, and group therapy for children with complex medical conditions including diabetes, HIV/AIDS, and asthma; design and implement strategies to increase compliance with medical treatment; and assist medical staff and teaching staff to design and implement strategies to address academic, medical, and behavioral concerns in class.

  **1/04 – 5/04**  
  **SCHOOL CONSULTATION PRACTICA**  
  Starkville Public Schools, Oktibbeha County Public Schools  
  Supervisor: Tony Doggett, Ph.D.

    Duties: Perform functional behavioral assessments and consult with teachers and principals in development and implementation of positive behavior support plans for students in grades 1 – 12. 20 hours per week

  **8/03 – 5/04**  
  **BEHAVIORAL CONSULTANT**  
  Behavioral Research Assessment and Training Services

4/03

PSYCHOMETRY CONSULTANT
Carroll County Public Schools
Supervisor: Carlen Henington, Ph.D.

Duties: Administer and score intelligence tests and achievement tests in order to determine eligibility for special education services. 15 hours of services.

1/03 – 5/03

BEHAVIORAL SPECIALIST
Starkville Public Schools
Supervisor: Tony Doggett, Ph.D.

Duties: Perform functional behavioral assessments and consult with teachers and principals in development and implementation of positive behavior support plans for students in grades 1 – 5. 5 hours per week

1/03 – 5/03

ASSESSMENT PRACTICA
Starkville Public Schools
Supervisor: Cathy Lindsey, M.S.

Duties: Administer and score intelligence tests, achievement tests, adaptive behavior measures, and behavior rating scales to determine eligibility for special education placement. Conduct behavioral observations and curriculum-based assessments to develop intervention recommendations. Attend I.E.P. meetings to provide diagnostic information and feedback to families and school personnel. Write comprehensive evaluation reports to be submitted to Starkville Public School District and to the Mississippi State Department of Education. 20 hours per week in schools.

9/02 – 12/02

BEHAVIORAL CONSULTANT
Project Impact, T.K. Martin Center for Disabilities, Mississippi State University.
Supervisor: Denise Perkerson, M.S.

Duties: Assist teacher with behavior management of eight two-year-old children in the Early Intervention program for children with disabilities. Assist teacher with daily activities to help children meet their IEP goals. Program designed to meet Individualized Education Program goals for children ages 1 – 3 years old. 6 hours per week.

8/02 – 5/03

CLINIC & SCHOOL-BASED PRACTICUM
Department of Counselor Education, Educational Psychology, & Special Education, Mississippi State University.
Supervisor: Tony Doggett, Ph.D.

Duties: Assist in conducting parent, teacher, and child interviews. Administer and evaluate behavioral rating scales, intelligence tests, and achievement tests. Conducted clinic and school-based functional behavioral assessments including interviews,
antecedent-behavior-consequence assessments, and functional analysis conditions. Assisted in providing parent management training based on Parent-Child Interaction Therapy (PCIT) model. Conducted curriculum-based assessments and implemented empirically-based academic interventions. Clients ranged in age from preschool to high school. Diagnoses included ADHD, ODD, LD, RAD, enuresis, encopresis, and sleep disorders. 3 hours per week.

8/02 – 5/03

ADHD CLINIC
Department of Counselor Education, Educational Psychology, & Special Education, Mississippi State University.
Supervisor:  T. Steuart Watson, Ph.D. & Tony Doggett, Ph.D.

Duties: Work with team to evaluate and develop interventions for children with Attention-Deficit/Hyperactivity Disorder. Child and parent interviews, standardized intelligence and achievement testing, curriculum based assessments, direct observations, and parent-child interaction therapy. 1 hour per week.

6/02 – 9/02

EARY INTERVENTION ASSESSMENT ASSISTANT
Child Development Center, Mississippi State University
Supervisor: Carlen Henington, Ph.D.

Duties: Prepare materials for play-based assessment of children ages 0 – 3 years for determination of eligibility of early interventions services. Observed team assessment procedures and provision of information to families to learn multidisciplinary evaluation. Team consisted of two school psychologists, speech language pathologist, early childhood specialist, physical therapist, and evaluated the following areas: Self-help, Social-emotional, Fine and gross motor movement, Speech and language, and Psychological development. 3 hours per week.

RESEARCH EXPERIENCE

6/03 – 8/03

ACADEMIC CLINIC DIRECTOR, RESEARCHER, & INTERVENTIONIST
Department of Counselor Education & Educational Psychology
Supervisor: Carlen Henington, Ph.D.

Duties: Supervise graduate students, undergraduate students, and high school students with research design for academic skill remediation projects, design and implement reading, writing, and mathematics interventions for children age 7 - 10. Oversee general daily activities including outdoor activities and sports, snacks, and pickup and of all the children. 20 hours per week in clinic. 2.5 hours of supervision provided per week.

7/02 – 8/02

ACADEMIC CLINIC RESEARCHER & INTERVENTIONIST
Department of Counselor Education & Educational Psychology
Supervisor: Carlen Henington, Ph.D.

Duties: Design and implement research project on writing skills. Assess writing abilities, develop writing interventions, teach writing skills, evaluate progress, and lead outdoor activities of children grades 2-6. 20 hours per week in clinic.

8/01 – 12/01

GRADUATE RESEARCH ASSISTANTSHIP
Department of Curriculum and Instruction, Mississippi State University
Supervisor: Lynne Arnault, Ph.D.
Awarded Research Assistantship. Duties: Research material for publications. (e.g., alternate route teacher certification, Council for Exceptional Children ethics). 10 hours per week.

8/00 – 12/00

GRADUATE RESEARCH ASSISTANTSHIP
Psychology Department, Mississippi State University.
Supervisor: Duane Miller, Ph.D.

Awarded Research Assistantship. Duties: Recruit and administer surveys to participants for study on school bullying. Enter data into SPSS-8 for analysis. 5 hours per week.

TEACHING EXPERIENCE

8/03 – 12/03

GRADUATE TEACHING ASSISTANT
Department of Counseling, Educational Psychology, & Special Education, Mississippi State University.
Supervisor: Lynne Arnault, Ph.D.

Awarded Teaching Assistantship. Duties: Observe and evaluate undergraduate special education students in pre-practicum at Sudduth Elementary School. Evaluate lesson plans and performance in special education classroom and grade class work. 6 hours per week in classrooms.

6/03 – 8/03

GRADUATE TEACHING ASSISTANT
Department of Counselor Education & Educational Psychology
Supervisor: Carlen Henington, Ph.D.

Duties: Determine needed materials for Pediatric Clinic and Academic Clinic including computers, personal digital assistants, observation software, play-based assessment materials, toys, stickers, snacks, and school supplies. Create a homepage for the school psychology program on the Mississippi State University website. Also, assist with grant proposal for the Mississippi State Department of Education. 10 hours per week.

1/03 – 5/03

GRADUATE TEACHING ASSISTANT
Department of Counselor Education, Educational Psychology, & Special Education, Mississippi State University.
Supervisor: Frank Elrod, Ph.D.

Awarded Teaching Assistantship. Duties: Observe and evaluate undergraduate special education students in practicum at Starkville High School and Millsaps Vocational Center. Evaluate lesson plans, teaching of lessons, behavior management, and professionalism. 4 hours per week in classrooms.

1/03 – 5/03

GRADUATE TEACHING ASSISTANT
Department of Counselor Education, Educational Psychology, & Special Education, Mississippi State University.
Supervisor: Kathy McComb, M.S.

Awarded Teaching Assistantship. Duties: Observe and evaluate undergraduate special education students in practicum at Sudduth Elementary School and Ward-
Stewart Elementary School. Evaluate lesson plans, teaching of lessons, behavior management, and professionalism. 6 hours per week in classrooms.

8/02 – 12/02  
**GRADUATE TEACHING ASSISTANT**  
Department of Counselor Education, Educational Psychology, & Special Education, Mississippi State University.  
Supervisor: Lynne Arnault, Ph.D.

Awarded Teaching Assistantship. Duties: Observe and evaluate undergraduate special education students in pre-practicum at Sudduth Elementary School. Evaluate lesson plans and performance in special education classroom and grade class work. 6 hours per week in classrooms.

1/01 – 5/01  
**GRADUATE TEACHING ASSISTANTSHIP**  
Department of Curriculum and Instruction, Mississippi State University  
Supervisor: Lynne Arnault, Ph.D.

Awarded Teaching Assistantship. Duties: Observe and evaluate undergraduate special education students on practicum at Armstrong Middle School. Evaluate lesson plans, teaching of lessons, behavior management, and professionalism. 10 hours per week in classrooms.

1/02 – 5/02  
**GRADUATE TEACHING ASSISTANT**  
Department of Curriculum and Instruction, Mississippi State University  
Supervisor: Kent Coffey, Ph.D.

Awarded Teaching Assistantship. Duties: Observe and evaluate undergraduate special education students in practicum at Sudduth Elementary School and Ward-Stewart Elementary School. Evaluate lesson plans, teaching of lessons, behavior management, and professionalism. 6 hours per week in classrooms.

1/02 – 5/02  
**GRADUATE TEACHING ASSISTANTSHIP**  
Department of Curriculum and Instruction, Mississippi State University  
Supervisor: Frank Elrod, Ph.D.

Awarded Teaching Assistantship. Duties: Observe and evaluate undergraduate special education students in practicum at Starkville High School and Millsaps Vocational Center. Evaluate lesson plans, teaching of lessons, behavior management, and professionalism. 4 hours per week in classrooms.

**PUBLICATIONS**

**Articles Published in Refereed Journals**


Book Chapters


Works in Progress

Baylot, L., Hoda, N.E., & Henington, C, Doggett, R.A. Progressive writing strategies for increasing written words per minute. Manuscript in preparation to be submitted to *Psychology in the Schools*.


PRESENTATIONS & WORKSHOPS

Hoda, N.E. (2004, November). *Positive Behavior Support in a Hospital-Based School for Children with Chronic Medical Illnesses*. Presentation to faculty and staff at the First State School, Wilmington Hospital, Wilmington, DE.


**AWARDS**

5/2004 *Thomas McKnight Research Award*  
Awarded for actively pursuing research opportunities and disseminating the research at local, regional, and national conferences.