Use of an Interspersal Technique to Enhance Work Completion Rates, On-Task Behavior and Accuracy on Independent Math Assignments

by

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A dissertation submitted to the Graduate Faculty in Educational Psychology
in partial fulfillment of the requirements for the degree of
Doctor of Philosophy, The City University of New York

2011

This manuscript has been read and accepted for the
Graduate Faculty in Educational Psychology in satisfaction of the
dissertation requirement for the degree of Doctor of Philosophy.

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Abstract

USE OF AN INTERSPERSAL TECHNIQUE TO ENHANCE WORK COMPLETION RATES, ON-TASK BEHAVIOR AND ACCURACY ON INDEPENDENT MATH ASSIGNMENTS

by

Teresa A. Hatfield

Adviser: Dr. Georgiana Tryon

Previous research supports the positive educational effects for students when briefer, easier problems are interspersed into independent mathematics worksheets (Skinner, 2002). A concern with the previous research is whether the positive effects would generalize when implemented with large classroom groups over a prolonged period of time. The current study sought to extend this research and determine whether the interspersal procedure would increase accuracy rates, problem completion rates, and on-task behavior rates for a diverse elementary school student population (73% non-Caucasian) in the Northeast United States over a period of 16 days. The participants (*n* = 66) were randomly assigned either a traditional worksheet or an interspersal worksheet on a daily basis after an acclimation period of 3 days. Research assistants recorded accuracy rates, problem completion rates, and on-task behavior rates while students worked until completion on the teacher chosen target problems. On-task behaviors were disaggregated into three behavior types: verbal (e.g., any time that a student made an

utterance to oneself, a peer, or called out to the teacher), visual (e.g., any time that a student broke eye contact from his or her paper while expected to be completing the assignment), and kinesthetic (e.g., any time that a student broke contact with his or her seat to move around or walk around; accompanied by not working on the assignment) during the observations. Students completed a 4-point Likert scale survey to assess preferences for assignment type. Mathematical content varied frequently from session to session, as the study was completed at the end of the school year. Visual on-task behavior levels were found to be significantly higher when students were working on the interspersal assignments. Students did not perform significantly better on the interspersal assignments on the dependent measures of accuracy, problem completion rates, and the other on-task behavior areas (i.e., verbal and kinesthetic). Students did not indicate a preference for the interspersal assignments over the control assignments on the student survey. The current study data support the results of previous studies using the interspersal procedure in that student visual on-task behaviors were improved.

Foreword

Working as a special education teacher and school psychologist for the last 16 years, I have had my share of successes and failures with the students I have attempted to help. Within the past several years, the number of students referred to me due to mathematics anxiety and mathematics performance that is "below average" has risen substantially. Although my husband teaches high school mathematics, I found that many of his suggestions were not appropriate to assist the diverse group of elementary-age students with whom I work. My colleagues and I were at a loss when it came to implementing efficient, research-based interventions for students with these difficulties. To further complicate matters, nearly 15% of my elementary school population has been identified as having Attention Deficit Hyperactivity Disorder. The majority of these students are not receiving any interventions for their disorder, aside from in-school counseling and occasional modifications, as afforded by a 504 Accommodation Plan. When I came across the research on the additive interspersal procedure and mathematics, I was very excited to try out this method during independent work time in the classrooms at my school. Unfortunately, this excitement led to frustration when I realized that this procedure had only been studied on narrow populations and, therefore, may not generalize well into my specific setting. Dr. Tryon encouraged me to stick with this line of study when it came to beginning my dissertation research. I was hoping that additional information regarding the additive interspersal procedure would be found through this study. I also hoped that the results could be firmly interpreted by other educators in the future who may have diverse populations such as the one that I am fortunate enough to work with at my school.

ACKNOWLEDGEMENTS

I would never have been able to finish my dissertation without the assistance and support of my committee members, help from my research assistants and co-workers, and support from my immediate and extended family.

First and foremost, I would like to express my appreciation to my adviser, Dr. Georgiana Tryon, for her guidance and excessive patience during this prolonged endeavor. Despite my being in my "n^{th}" year of the program, she always made time for my project. I would like to also thank Dr. Mary Kopala for her excellent editing skills and Dr. David Rindskopf for his statistical guidance and good sense of humor.

I would like to express my thanks to Dr. Mario Kelly and Dr. Sarah Bonner for stepping in at the last minute to serve as my outside readers. Their comments and ideas at the defense helped me to form a stronger discussion section.

I would like to thank my extraordinary "daily" research assistants, Kathy Mansfield and Barbara Sherman. The tireless effort they put in "after hours", along with the constructive comments they shared, enabled this project to come to fruition. In addition, Cassie Sullivan (with her extremely efficient organizational strategies), Kimberly Hatfield (with her unending dedication) and Kristan Maher were invaluable during this process. In addition, special thanks goes to Barbara Bergin, Jennifer Fitzgerald, Lisa Lesczynski, Lisa Grainger, Donna Griffenkranz, Beckey Patel, Cindy Coleman, Canaan Bump and their students for allowing me to enter their world and make a mess of it during this month-long study.

My deepest gratitude goes to Dr. Greg Zarow, consultant extraordinaire, for the countless hours on the phone and via computer discussing this project. He "talked me off the ledge" more than one time with his humor and solid advice. God bless!

Thank you to my current principal, Donna Geidel, for her unending cheerful attitude, advice and hugs when things were not going so well. Also, thank you to my previous principal, Loretta Richner, for allowing me to rearrange my schedule so that I could complete my graduate studies.

I would like to thank my special "support team" members, including Linda and Frank Kowalczyk, Donna Griffenkranz, my parents, Terry and Lorrie Dockerty, my "other Dad", Roy Hatfield, and my children, Kimberly, Joshua, and Katie. For much of the past 10 years, I have been absent or distracted much of the time, yet you all stood by my efforts to finish this project.

Finally, I would like to thank my loving husband of 18 years, Scott Hatfield. Although I won the bet, his support and encouragement during this process were always honest and appreciated and I will never forget this.

DEDICATION

This dissertation is dedicated to the memory of Joan K. Hatfield,
my mother-in-law and trusted friend.

I would also like to honor my loving parents,
Dr. Terry Dockerty, Lorrie Dockerty, and Roy Hatfield.

Without you all, none of this would have been possible.

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CHAPTER I

Introduction

In January 2002, President George W. Bush enacted Public Law 107-110. This law, also known as the "No Child Left Behind" (NCLB) Act, sought to ensure that students in the Kindergarten through twelfth grades in the United States showed continuing improvement in academics (e.g., reading and mathematics). Specifically, this law established accountability from schools using measures of student performance to judge each school's effectiveness (NCLB). In order for schools to continue receiving federal funding, they must ensure that they conduct annual assessments and that students show "proficiency" (defined by the authors of the NCLB act as achieving "grade level" mastery) in reading and mathematics for grades 3-8. The results of these assessments are made public so that the consumers of the educational system (i.e., the taxpayers, parents, and students) may examine them. Specifically, in the area of mathematics, NCLB indicated that "America's schools are not producing the math excellence required for global economic leadership and homeland security in the 21st century" (NCLB, p.16). At the time of the law's enactment, "only a quarter of our fourth- and eighth-graders [were] performing at proficient levels in math" (p. 16).

Annually, the Institute of Education Sciences and National Center for Education Statistics publishes *The Nation's Report Card*. This publication documents the testing data from the National Assessment of Educational Progress (NAEP) on reading and mathematics scores for the nation overall and each individual state. Currently, *The Nation's Report Card: Mathematics 2009* (National Center for Education Statistics, 2009)

suggests that although the nation's fourth grade students' scores have shown fairly steady increases in mathematics proficiency since 1990, 18% of students are scoring in the "Below Basic" range. These scores imply that these fourth grade students are not achieving "Proficient" range standings as required by NCLB. Furthermore, when these statistics are disaggregated, there are alarming gaps between Caucasian students and other ethnicities. For instance, only 9% of Caucasian students fell within the "Below Basic" range as compared to 36% of African American students and 29% of Hispanic students (National Center for Education Statistics, 2009). The analysis also suggests that 41% of students with disabilities fall below the "Proficient" range nationwide on the standardized mathematics test. The result of this report is mandates that teachers in every classroom must attempt to use "only research-based teaching methods", as directed by NCLB (p.16).

In addition to the changes brought about by the implementation of the NCLB act, the updating of the Individuals with Disabilities Education Improvement Act (IDEA) in 2004 brought about further educational system changes. IDEA 2004 requires school districts to use either the traditional aptitude-achievement discrepancy formula or a response-to-treatment intervention (RTI) approach to identify a student as having a disability. Specifically, the IDEA 2004, Sec 614(b)(6)(B) states that, "In determining whether a child has a specific learning disability, a local education agency may use a process that determines if the child responds to scientific, research-based intervention as part of the evaluation procedures...."

Within this RTI framework, school psychologists need to identify and implement research-based instructional strategies that help students in each of the following three tiers or phases within the RTI approach. During the first tier, one needs to find out if effectual

instructional methods are already in place (Kovaleski & Prasse, 2004). Therefore, even if students are not struggling, effective academic practices must be in place for all students. Next, RTI users should design specific strategies for the student in need and provide continuous monitoring on how well the strategies are working (i.e., second tier). In this second tier, school personnel rely on state assessment results to identify those students in need of specific learning strategies. Lastly, for the third phase or tier, Kovaleski and Prasse recommend that school staff further refer those students for whom the specific targeted interventions were not effective for additional assessment (i.e., psychoeducational testing to ascertain IQ level).

Inevitably, educators and school psychologists are called upon to participate in each of these stages of RTI. It is up to them to determine which interventions meet the National Joint Committee on Learning Disabilities (2005) suggestions that incorporate the "(1) application of scientific, research-based interventions in general education; (2) measurement of a student's response to those interventions; and (3) use of the RTI data to inform instruction" (p. 1). How should education professionals determine which interventions meet the aforementioned conditions? They must rely on the previous practices of others and the research accompanying these practices to the extent that it can be generalized to specific settings and student populations.

In classroom settings, teachers employ several different instructional techniques throughout the school day. In typical elementary level classrooms, teachers lecture, provide cooperative group activities, and give students independent instructional-level classroom assignments (i.e., seatwork). Regrettably, these popular methods of instruction may not meet the needs of all students in a classroom (e.g., IDEA classified students,

students with 504 Accommodation Plans, minorities, students with attentional difficulties). Therefore, it is no surprise that the majority of referrals made to school psychologists center around student academic needs (Shapiro, 1992). School psychologists may be called upon to assist teachers with various interventions in order to help these struggling students. Ysseldyke et al. (1997) asserted that competent school psychologists should be able to develop cognitive and academic skills interventions and be aware of effective instructional techniques.

In a review of interventions within peer-reviewed school psychology journals during the years of 1995 to 2005, Bramlett and Savina (2007) found that "a large gap exists between research and practice" (p. 6). The authors encouraged school psychologists to become more capable in the areas of designing and implementing instructional interventions. McDonald and Ardoin (2007) noted that the "combination of high standards and the frequent failure to employ empirically validated intervention procedures in schools results in frustration for both educators and students" (p. 342).

With regard to mathematics, Chase and Symonds (1992) suggested that "the most effective device that can be applied to learning is to increase the amount of drill or practice" within classrooms (p. 289). Cuvo, Davis, and Gluck (1991) agree with this statement and suggest "self-paced instruction allows students to proceed at their own rate and do so independently of other students" (p. 335). Traditionally, teachers give drill and practice assignments as seatwork for students to complete independently, while they help small groups of students or walk around to help individuals who may be having difficulties. The popularity of the drill and practice technique may be partially due to the benefits to the teacher (including the independent nature of such assignments for students who do not

require a teacher‘s direct guidance). MacQuarrie, Tucker, Burns, and Hartman (2002) suggested that school psychologists need to be familiar with the many different models used for drill and practice in order to assist educators.

Wu (1999) stressed the importance of students understanding basic skills prior to taking on more conceptual, abstract mathematical concepts. Computational skills are an essential element of mathematics (Boerst & Schielack, 2003). Wu (1999) noted “it is the *fluency* in executing a basic skill that is essential for further progress in the course of one’s mathematics education” (p. 2). The National Council of Teachers of Mathematics (2000) suggests that, similar to the reading process, if poorly executed basic skills delay students, further learning is hindered. Carson and Eckert (2003) noted “the importance of basic mathematics skills establishes the need for school-based interventions that promote mastery for at-risk students in general education classrooms” (p. 38).

Unfortunately, the nature of drill and practice assignments requires students to remain engaged with the assigned work or else little learning can occur. Student engagement with independent assignments is essential in order for skill development to increase (Binder, 1996). Fisher et al. (1978) found in their Beginning Teacher Evaluation Study (BTES) that effective “Academic Learning Time” (ALT) consists of the opportunity for students to spend time engaged in a task, along with experiencing success with that task. Murphy (1992) suggested that ALT “is a direct correlate to student achievement” (p. 19). Neef, Shade, and Miller (1994) found that students were more likely to engage in tasks that they found reinforcing. Chase and Symonds (1992) asserted that if educators can enhance and continue a student’s motivation, more practice can ensue. Unfortunately, a

longitudinal study by Fisher et al. found that as the length of independent assignments grew, students' willingness to engage with assignments decreased.

Theoretical Considerations

Matching law.

The matching law (Herrnstein, 1961) suggests that when reinforcement strength approximates the effort required for a task, consistent task behavior occurs over time. In experiments with pigeons, Herrnstein demonstrated that the pecking response of the pigeons to a specific key was directly related to the amount of reinforcement provided on that key. In experiments with humans, researchers have used this theory to ascertain how different levels of reinforcement affect student responses (Billington & DiTomasso, 2003). Therefore, it follows that during mathematics drill and practice assignments, independent work completion is enhanced if reinforcement rates are equivalent to the amount of effort required for the task.

Discrete task completion hypothesis.

Following the premise of this matching law theory, Skinner (2002) proposed that the discrete task completion hypothesis (DTCH) further explains student success on mathematics independent drill and practice assignments. In a meta-analysis of these types of assignments, Skinner found that problem completion becomes a conditioned reinforcer in itself for students. Based on the DTCH, it stands to reason that if a teacher were to increase the opportunities for students to complete more problems, there would be increased reinforcement for students and students' completion would be enhanced (Billington & DiTommasso, 2003).

Behavioral momentum.

Another theory in alignment with the matching law and DTCH is the theory of behavioral momentum proposed by Nevin (1974). This theory suggests that once students are involved in a task that has a high probability of being successfully accomplished, increased compliance follows (Nevin, 1996). Mace et al. (1988) stated that, "Behavioral momentum refers to the tendency for behavior to persist following a change in environmental conditions. The greater the rate of reinforcement, the greater the behavioral momentum" (p. 123). In other words, the more problems a student completes, the more problems he or she is likely to complete subsequently. Burns et al. (2009) explained that

> by structuring a set of tasks so that less effortful responses occur first, students are more likely to contact the conditioned reinforcing properties early on, which in turn increases the probability that they will engage in the more challenging and less preferred tasks that follow. (p. 429)

The majority of studies testing this theory have involved students with autistic spectrum disorders who were educated using a specific behavioral method called Applied Behavioral Analysis (ABA) that helps students learn by having them complete repeated trials of learning tasks until they reach mastery. During most of these studies (as described in the Literature Review), researchers presented easier tasks alongside more difficult learning tasks in repeated trials. The studies found that students would continue to persist with the more difficult tasks when tasks with a high probability of completion (high-*p* tasks) were interspersed among the more difficult tasks (Mace et al.). The implication of behavioral momentum theory is that if teachers configure independent mathematics drill

and practice activities to include tasks that are likely to influence students' continuation with these tasks, students complete more work.

Interspersal Procedure

Consistent with the matching law, DTCH, and behavioral momentum theory, investigators have used an instructional technique called the interspersal procedure to increase the level of reinforcement that students receive during independent assignments without the need for teachers to provide additional social and/or tangible reinforcement (Skinner, Robinson, Johns, Logan, & Belfiore, 1996). This technique allows students to complete briefer and/or easier items (i.e., high-*p* tasks) that are inserted among instructional-level items (Skinner, 2002). There are two types of interspersal procedures. Substitutive interspersal (i.e., exchanging difficult tasks with easier tasks and/or shortening an assignment's length) substitutes items for some instructional-level items (Cates, 2005). Additive interspersal adds items to the number of instructional-level items (Cates). Thus, the additive interspersal procedure results in teachers giving students more items to complete than does the substitutive interspersal procedure. Researchers, including Berliner (1984), suggested that substitutive interspersal diminishes student learning rates. Therefore, during drill and practice techniques, teachers are more likely to use an additive interspersal method rather than a substitutive interspersal method.

Interspersal examples.

Researchers have investigated several aspects of additive interspersal procedures. These variables include the type of populations that respond to this procedure (e.g., Skinner, Hurst, Teeple, & Meadows, 2002; Teeple & Skinner, 2004), the academic subjects with which the procedure can be used (e.g., Knight, Ross, Taylor, & Ramasamy,

2003; Meadows & Skinner, 2005; Montarello & Martens, 2005), and the rates at which interspersed items should occur (e.g., Billington, Skinner, Hutchins, & Malone, 2004; Cates & Skinner, 2000; Hawkins, 2005). In addition, others (Joseph & Nist, 2006) have researched student preferences, time engaged in the assignment, and the attainment of skills. Many studies have used locations other than classrooms for their inquiries, possibly making generalizability difficult (e.g., Joseph & Nist, 2006). One area in which authors (e.g., Billington & Skinner, 2006) have used the additive interspersal technique successfully is independent drill and practice mathematics assignments.

Generalizability of interspersal procedure.

Unfortunately, the studies of interspersal procedures cited above were analogues, single-case studies, or studies using small numbers of students with extensive disabilities. The studies did not use typical students experiencing academic difficulties or assignments reflecting authentic classroom tasks. Researchers also exposed participants to experimental and control conditions only briefly. Before teachers adopt interspersal procedures, researchers must demonstrate the effectiveness of these procedures in real classroom situations with diverse students. Citing drawbacks of analog studies of the interspersal technique, McCurdy, Skinner, Grantham, Watson, and Hindman (2001), Montarello (2007) and McDonald (2007) conducted studies that attempted to address the limitations within previously cited studies. However, even these more current studies included notable limitations that reduced their generalizability.

Statement of Purpose

The purpose of this study is to expand the knowledge base for the additive interspersal technique to a diverse population. This study examined whether the additive

interspersal procedures such as those used in the above mentioned studies were effective with a larger, heterogenous set of students (including students classified under IDEA, students with ADHD diagnoses, and minority students). This study also sought to determine whether there would be an increase in the on-task behavior rates, mathematics problem accuracy rates and problem completion rates of these students. This study addressed limitations within the above studies (i.e., small, specific populations, predictable presentation of interspersal condition, ability to assess the accuracy of the assignments, and the short duration of the experiments).

The information gleaned from this study will assist educators and school psychologists by answering the following questions: (a) Will the on-task behavior of a diverse group of elementary school students be enhanced when the additive interspersal procedure is applied to independent mathematics assignment? (b) Will the problem accuracy on independent mathematics assignments for this same group of students be enhanced when the additive interspersal procedure is employed? (c) Will the problem completion rates for this group of students increase when the additive interspersal technique is used as compared to traditional work sessions (when this procedure is not applied)? (d) Will students rate the additive interspersal technique as easier and more preferred than the traditional method? (e) Will teachers rate the additive interspersal technique as useful and effective for this diverse group of students?

CHAPTER II

Literature Review

This chapter describes the drill and practice technique, three theories that explain the additive interspersal technique, and presents analogue and empirical studies that investigated the additive interspersal technique, particularly the variables inherent to the success of this technique. Finally, the study rationale and hypotheses are presented.

Drill and Practice and Its Use During Math Acquisition

The current state of mathematics instruction and the increasing demands placed on teachers and students at the elementary school level has led to frustration among education professionals. The lack of empirically-based strategies within the field of elementary school mathematics adds much to this frustration level, as teachers try to help students and meet the legal requirements specified by No Child Left Behind (NCLB) and Individuals with Disabilities Education Act (IDEA) of 2004. The National Mathematics Advisory Panel was created with the intention of examining research-based approaches to determine the best course of action for teachers of mathematics (Packard, 2008). This committee is currently surveying over 16,000 studies and reviewing public testimony in an effort to identify best practices in mathematics to share with educators.

Teachers use drill and practice techniques frequently in elementary-level classrooms after group mathematics lessons. Drill and practice techniques typically employ a worksheet or book assignment where students complete repetitions of a specific mathematics procedure in an independent fashion. Chase and Symonds (1992) suggest that "the most effective device that can be applied to learning is to increase the amount of drill or practice" within classrooms (p. 289). Cuvo, Davis, and Gluck (1991) suggest that

"self-paced instruction allows students to proceed at their own rate and do so independently of other students" (p. 335).

Wu (1999) stressed the importance of students understanding basic skills prior to taking on more conceptual, abstract mathematical concepts. Basic computational skills (such as addition, subtraction, multiplication, and division) are essential elements of mathematics (Boerst & Schielack, 2003). Wu (1999) noted, "it is the *fluency* in executing a basic skill that is essential for further progress in the course of one's mathematics education" (p. 2). The National Council of Teachers of Mathematics (2000) suggested that, similar to the reading process, poorly executed basic skills will hinder further student learning. Due to the importance of this issue, Carson and Eckert (2003) noted that, "the importance of basic mathematics skills establishes the need for school-based interventions that promote mastery for at-risk students in general education classrooms" (p. 38).

Gickling and Thompson (1985) suggested that drill and practice tasks are most effective when used at the initial practice stages. In agreement with this suggestion, Haring and Eaton (1978) suggested that learning takes place over four phases. The first two phases, acquisition and fluency, require students to practice their responses repetitively, making drill and practice the obvious instructional technique choice at these stages. Students achieve acquisition when they are able to consistently produce correct responses to given questions. Students attain fluency when they can produce a given response accurately and quickly, without further instruction (Haring & Eaton, 1978).

Cooke, Guzaukas, Pressley, and Kerr (1993) implied that drill and practice activities offer opportunity to rehearse a skill repeatedly until the skill becomes more habitual to the students. Offering more drill and practice opportunities leads to improved

acquisition and fluency of the skill (Skinner, Logan, Robinson, & Robinson, 1997). In the neuropsychological literature, Augustyniak, Murphy, and Phillips (2005) found that well-ordered neural networks encourage the exact retrieval of facts and procedural steps. In order to form these desired neural connections, one requires correct repetitive practice. Burns (2004) asserts that "drill tasks can serve an important role in academic remediation in that children who lack prerequisite skills are not capable of performing higher order tasks and must first master the basic information in order to move to that level" (p. 168). This finding is in agreement with the neuropsychological point of view regarding drill and practice of a skill.

Acceptance of the drill and practice assignments may lie in the fact that teachers have used it as an instructional technique for decades (Fisher et al., 1978; Rosenshine, 1971). The popularity of the drill and practice technique may be partially due to the benefits to the teacher, including the independent nature of such assignments for students, without the need for a teacher's direct guidance. Traditionally, teachers give drill and practice assignments as seatwork for students to complete independently while they help small groups of students or walk around to help individuals who may be having difficulties with the assignments.

On the other hand, several scholars find fault with this technique. Binder (1996) implies that the typical teacher may consider customary drill and practice activities as old-fashioned, dull, and fruitless because this strategy does not teach real-life problem-solving techniques. Hasselbring, Goin, and Bransford (1988) conducted a study in which drill and practice techniques were not effective with students with learning disabilities. The authors gave 160 students between the ages of 7 and 14 years old

mathematics drill and practice activities via a computer program. Typical students served as a comparison group to the students with learning disabilities. The authors found that computerized drill and practice was relatively ineffective for students with learning disabilities. Specifically, Hasselbring et al. found that even after approximately 70 sessions on the computer, students who had not originally come into the intervention with "declarative knowledge networks [i.e., established facts and experience] between problems and answers" (p. 3) were unable to develop facility with the computerized mathematics problems. From this study, the authors summarized that unless learning disabled students are able to move from procedural mathematical knowledge (e.g., finger counting strategies, using manipulatives) to declarative knowledge (e.g., knowing fact families), their attempts at fluency using any drill and practice method will have limited success. Also, Augustyniak et al. (2005) imply that if students make errors during the acquisition stage of facts or procedures, these mistakes will forge incorrect neural connections into the memory stores of the brain. If students learn a mathematical procedure incorrectly, the incorrect procedure is what will be recalled.

In addition, the nature of drill and practice assignments require students to remain engaged with the assigned work or little learning can occur. Student engagement with independent assignments is essential in order for skill development to increase (Binder,1996). Fisher et al. (1978) found in their Beginning Teacher Evaluation Study (BTES) with teachers of second and fifth grade students that effective "Academic Learning Time" (ALT) consists of the opportunity for students to spend time engaged in a task, along with experiencing success with that task. Murphy (1992) suggests that ALT "is a direct correlate to student achievement." (p. 19). Neef, Shade, and Miller (1994) found that

students were more likely to engage in tasks that they experienced as reinforcing. Chase and Symonds (1992) assert that if educators can enhance and continue a student's motivation, more practice can ensue. However, Fisher et al. (1978) found in their six-year study of teachers and their classrooms that, as the length of independent assignments grew, the students' willingness to engage with assignments decreased.

In summary, while the drill and practice technique can assist student acquisition of basic mathematics skills (Chase & Symonds, 1992; Cooke et al., 1993; Cuvo et al., 1991), drill and practice are not effective for all types of students (Hasselbring et al., 1988). In order for drill and practice to be effective, students must remain engaged with the independent assignment (Binder, 1996; Fisher et al., 1978; Murphy, 1992). Student engagement is facilitated by reinforcing tasks (Neef et al., 1994). One technique, the additive interspersal procedure, may be added to drill and practice to facilitate skill acquisition by interspersing previously acquired tasks among tasks that students are just learning (Cates et al., 2003). Skinner (2002) believes that this method facilitates student engagement with the drill and practice assignment through the student's completion of the work, rather than teacher presentation of tangible and/or social reinforcement.

Theoretical Contributions Applicable to the Interspersal Procedure

Early on, researchers recognized that a subject's choice behavior could be influenced by reinforcement schedules (Herrnstein, 1961). Later studies tested this tenet with students in classroom environments (Martens & Houk, 1989; Myerson & Hale, 1994). From these earlier studies, a series of investigations ascertained features within student choice behavior that could help students succeed in classroom settings. Recently, Billington and Skinner (2006) reviewed several analogue studies that showed that students

complete more mathematics problems when experimenters intersperse familiar problems with recently learned problems. After completing drills and practices with interspersed familiar problems, students chose these longer assignments to complete as homework in preference to traditional homework problems that present newly learned mathematics problems only. Some theories have attempted to explain why students prefer this technique including (a) matching law, (b) discrete task completion hypothesis, and (c) behavioral momentum.

Matching law. The earliest theory proposed to explain the success of the interspersal technique is the matching law (Herrnstein, 1961). Researchers found that when they gave animals in laboratory settings a choice between two behaviors when they held all else constant (e.g., reinforcement rate), the animals were more likely to choose the behavior that requires less effort (Aparicio, 2001; Hernnstein, 1961; Sumpter, Foster, & Temple, 1995).

Herrnstein (1961) punished pigeons by imposing a 1.5 second delay in reinforcement if they chose an alternate key after choosing the correct key. Eventually, the pigeons began to equate the correct pecking of the specified correct key with reinforcement. Herrnstein suggested that this pattern demonstrated that "the relative frequency of responding on a given key closely approximated the relative frequency of reinforcement on that key" (p. 272). Herrnstein (1961) developed a mathematical formula that he believed explained this "matching" phenomenon of response frequency with reinforcement frequency. An interpretation of this formula by Billington and DiTommasso (2003) suggests that the subject's goal response is equal to the maximum amount of responding that can happen within a specific amount of time multiplied by the known rate

of reinforcement for the goal response divided by known rate of reinforcement plus the reinforcement rate for all other behaviors that have the possibility of occurring. Cates and Dalenberg (2005) suggested that this formula may assist researchers in predicting how the level of behavioral choice will increase as the schedule of reinforcement is increased.

In a study using six hens, Sumpter et al. (1995) used fixed ratio *vs.* variable interval schedules to examine choice behaviors with the hens in an experimental chamber. The researchers wanted to find out if the matching law theory might be confounded by the effect of equipment or attributes of the subject. Despite these aspects of variability, they found that matching predictions were supported for different types of reinforcers. Overall, Sumpter et al. found that this "generalized matching law can be extended to describe and predict the relative preference values of several different response forms" (p. 158).

The implication from these animal studies is that one can generalize the matching law to human behavior as well. Researchers hypothesized that the behavioral processes responsible for the matching law phenomenon may be supported through the use of the additive interspersal technique (e.g., Billington, 2004; Skinner, 2002). Fuqua (1984) reminds researchers, however, that rarely are experiments conducted in applied settings able to control reinforcement as well as studies conducted in laboratory environments. This observation has implications for applying the matching law and its corresponding formula to settings where reinforcement cannot be entirely controlled, such as in a school classroom (Johns, 1998). Baum (1974) cautions that undermatching (i.e., subjects not responding as predicted to the amount of reinforcement) may occur if researchers are not cognizant of the factors within a setting that cannot be easily controlled. Likewise, Sumpter et al. (1995) advise investigators that bias (i.e., a consistent preference of a subject for a

specific response, due to unavoidable factors such as equipment and/or individual characteristics) may occur when utilizing the matching law.

With human subjects, investigators have used the response-reinforcement matching law formula in analogue studies to examine interventions to help teachers increase the likelihood of students' completion of assigned work. These analogue studies allowed for greater control of reinforcement conditions than would studies done in actual classrooms.

Billington and Skinner (2002) conducted a study with 35 college students to examine the matching law's utility in explaining the success of the additive interspersal procedure. They wanted to determine whether participants would choose longer assignments if the assignments included interspersed briefer, easier items. The researchers proposed that student completion of the easier items interspersed with the more difficult items would provide them additional reinforcement in the form of a higher number of completed problems and would result in students choosing the additive interspersal assignment for homework over choosing homework that included only more difficult items. They gave college students pairs of assignments. The first assignment included fifteen 3-digit by 2-digit multiplication problems. The second assignment consisted of eighteen 3-digit x 2-digit multiplication problems plus 6 interspersed 1-digit by 1-digit multiplication problems. Students had to complete the first assignment in five minutes, but had no time limit in which to complete the second assignment.

Following exposure to each assignment, Billington and Skinner (2002) asked the participants which assignment they would prefer to complete for homework. They did not expect students to complete homework; however, the students did not know this.

Overwhelmingly, the college students chose the experimental (i.e., interspersal) assignment over the typical assignment for homework (Billington & Skinner). Also, students identified the experimental assignment as requiring less effort than the control assignment. The study results suggest that "when assignments require the same amount of time and effort, choice should be influenced by rates of reinforcement" (p. 113). Although the study supported the matching law theory, Billington and Skinner described many limitations, including the study's length (i.e., only one day) and the inappropriate level of the assignments (i.e., well below a college level). Also, the authors noted that they did not counterbalance the assignments. This oversight may have caused sequence effects (i.e., influence of one condition over the other), hence limiting the generalization of the results as well.

A study by Cates and Dalenberg (2005) also found support for the matching law when they examined three different rates of reinforcement during a math task with undergraduate college students. They predicted that the 60 college students, when presented with four separate assignment pairs would choose to complete the interspersal assignment for homework. The assignment pairs each consisted of a 3-digit x 2-digit multiplication assignment with 15 problems and an interspersal assignment with fifteen 3-digit x 2-digit multiplication problems plus a varying number of interspersed 1-digit x 1-digit multiplication problems. Cates and Dalenberg manipulated the ratios of the interspersal problems on the experimental assignments (i.e., interspersed items placed after every other target problem, after every third target problem, and after every fifth target problem). Students had three minutes to complete each of the four assignment pairs. After they completed each assignment pair, students chose which of the assignment types they

would like to complete for a homework assignment. Students did not know that the authors did not expect them to complete the homework assignment. Based on the matching law, Cates and Dalenberg expected that the participants would choose the assignment with the heavier interspersal rate, and the results confirmed this prediction. The college students more frequently chose the experimental assignment with easier, briefer items interspersed after every target problem.

Despite the support for the matching law theory, as with the study by Billington and Skinner (2002), Cates and Dalenberg's (2005) study contains limitations that reduce its generalizability. The students were not expected to complete the assignments (as there was a time limit) and the tasks were not appropriate for the college students' educational level. Thus, the study was an analogue and not representative of real classroom assignment conditions.

Martens and Houk (1989) conducted a study with one 18-year-old female student with moderate mental retardation to assess whether she would benefit from the matching law in a classroom setting to decrease several inappropriate behaviors. The investigators observed the student in her class over thirteen 18- to 30-minute sessions, recording behaviors such as on-task occurrences, disruptions, etc. Martens and Houk identified teacher one-to-one instruction, praise, and proximity as the student's natural reinforcers. They used Herrnstein's matching law equation to determine whether a correlation existed between the student's behavior and the identified reinforcers. Their results suggest that the matching law can explain the correlation between reinforcing teacher attention and classroom behavior. Martens and Houk found that the matching law equation explained 83% of the variance in troublesome behavior and 44% of the variance in on-task behavior.

Again, this study had several limitations including the observation of only one student to ascertain the correlational relationship. As this study was correlational, other variables within the study setting or the participant may have produced the results.

Banda, McAfee, Lee, and Kubina (2007) completed a study to explore the matching law with five middle-school students diagnosed with Asperger's Disorder. The students were part of a general education classroom, yet received specialized assistance in a resource room designed for students with autistic spectrum disorders. The study took place in the resource room at the students' school. Initially, Banda et al. conducted mastery trials to determine educational levels of the students (i.e., they defined "mastery" of a task equal to or greater than 90% problem accuracy) and preference trials to determine the students' partiality for specific mathematical tasks (i.e., they defined "preference" for tasks if students demonstrated 60% or higher choice for a specific math task). Based on the matching law, the authors asserted that, "completing brief math problems may enhance reinforcement rates in children because they are more likely to result in correct responses that produce more opportunities for reinforcement" (p. 223).

Banda et al. (2007) created six academic presentations using mixtures of mastered tasks *vs.* non-mastered tasks and mathematical word problems *vs.* computation problems. They presented students with two formats at the same time and used a forced choice method, requiring participants to choose their preferred format. The authors found that the students demonstrated mixed preferences that did not consistently relate to their mastery of tasks. This study was limited in that Banda et al. did not administer all mixtures of presentation formats to all students. The authors note that, "group comparison of [all] six formats was not possible due to limited selection of task difficulty levels" (p. 221).

In summary, Herrnstein (1961) proposed that the matching law formula predicts behaviors based on the match between the level of reinforcement offered to participants and the effort required of participants to complete tasks. Originally, researchers studied matching law using animal subjects (Herrnstein; Sumpter et al., 1995). More recent studies used human participants, including college students and middle- and high school students (Banda et al., 2007; Billington & Skinner, 2002; Cates & Dalenberg, 2005; Martens & Houk, 1989). Unfortunately, these were analogue or single-case studies with limitations that reduce the generalizability of results supporting the matching law to other settings and participants. Among these limitations are the lack of grade appropriate educational assignments, short length of assignments, and lack of student completion of the assignments.

Discrete task completion hypothesis. During a series of experiments using drill and practice techniques (e.g., Skinner, Fletcher, Wildmon, &Belfiore, 1996; Skinner et al., 1999), Skinner (2002) developed a similar theory to the matching law to explain student behavior during interspersal assignments. Skinner theorized that a possible causal mechanism for the success of the interspersal procedure in keeping students engaged in drill and practice assignments follows the "discrete task completion hypothesis" or DTCH (p. 347). The DTCH asserts that during the completion of a multiple-problem assignment the actual completion of each discrete item may act as a reinforcing event and eventually become a conditioned reinforcer for the student (Skinner). The implication of this hypothesis is that if one can increase the completion of individual tasks, reinforcement rates will increase also (Billington & DiTommasso, 2003). Cates and Lee (2005) asserted that the interspersed items act as conditioned reinforcers. Wildmon, Skinner, and McDade

(1998) suggested that the success of the additive interspersal technique may lie in the fact that teachers have previously reinforced students for task completion, thereby setting up the act of task completion as a reinforcing situation that encourages similar behaviors. The DTCH is similar to Herrnstein's (1961) matching law in that the level of reinforcement in relation to the difficulty of the task appears to predict the students' subsequent responses.

Two analogue studies by Billington (2004) sought to determine whether various students (i.e., 51 undergraduate college students in Study 1 and 44 sixth-grade students in Study 2) would choose to complete homework assignments that were traditional drill and practice or drill and practice with brief, easier interspersed items. During Study 1, Billington presented students with a packet comprised of a traditional 3-digit x 2-digit multiplication assignment and an experimental assignment with the same number of 3-digit x 2-digit multiplication problems, plus 1-digit x 1-digit interspersed multiplication problems. The students had a time limit in which to work on the assignments. After Billington told the students that time was up, he asked them to indicate which type of assignment they would prefer to complete for homework. Billington did not expect the students to complete the assignment, but the students were not aware of this. The study (Study 1) with the college students lasted one class period. Billington conducted the middle school study (Study 2) in precisely the same manner, yet over two school days for 15 minutes each day. The results from both experiments showed that significantly more students chose the interspersal homework, rather than the traditional drill and practice homework assignment.

During the study, Billington (2004) noted choice behaviors similar to those predicted by both the matching law and the DTCH. Further studies of choice behavior have

supported the concept that student choice will migrate toward tasks that require less effort, as seen in this study (Horner & Day, 1991; Sumpter et al., 1995). Billington and Skinner (2002) suggest, "When assignments require the same amount of time and effort, choice should be influenced by rates of reinforcement" (p. 113). However, the Billington study has limitations that prevent the generalization of the study results to other settings. These include the lack of social validity of the study due to the educational levels of the assignments. Also, the students did not complete the assignments, reducing the study result's applicability to classrooms where students must complete assignments.

In 2002, Skinner completed a meta-analysis to help determine the support for the DTCH. The analysis included 5 studies (i.e., Logan & Skinner, 1998; Skinner et al., 1996; Skinner et al., 1999; Wildmon, Skinner, McCurdy, & Sims, 1999; Wildmon, Skinner, & McDade, 1998) that examined student choice behavior and interspersal math assignments. The age range of the participants in the studies was between sixth grade students (i.e., approximately 12 years old) to college-aged students (i.e., approximately 18-24 years old). All of the studies included relative problem completion rates (RPCR). RPCR are "problem completion rates on interspersal assignment[s] divided by problem completion rates on control assignments" (p. 353). Each of the studies employed similar methodologies in which researchers presented students with an assignment packet containing a traditional drill and practice assignment (e.g., fifteeen 3-digit x 2-digit multiplication problems) and an experimental assignment (e.g., fifteen 3-digit x 2-digit multiplication problems, plus 1-digit x 1-digit interspersed multiplication problems after every three target problems). Within the studies, investigators gave students the same time limits to complete each assignment (although the time limits varied across experiments). Similar to previously

cited additive interspersal experiments, the investigators asked participants to choose a hypothetical homework that they would prefer to complete.

Limitations within these studies were similar to those in previously cited studies (Skinner, 2002). All of the studies used poorly matched educational assignments (i.e., tasks that were much easier than would be expected for students in their specific grades). Three of the studies included college students, while one employed 28 middle-school students, and one used a mixture of ninth-, tenth-, eleventh-, and twelfth-grade students in a high school. Results of studies are difficult to generalize to other settings, especially to an elementary school population. Also, a large majority of studies only required participants to have experience with the additive interspersal technique for just a part of one day. The findings of this meta-analysis suggest that even though some of the circumstances in the studies may have reduced the probability of exact "matching" of the task and reinforcement, there was a robust direct relationship between the easier interspersal assignment and the preference of the participants for interspersal procedure homework (Skinner).

At least one study challenges the DTCH theory, indicating that it may not fully explain the interspersal technique. Clark and Rhymer (2003) examined 19 Midwestern college students' choice behavior when the authors gave them two assignments each of the additive interspersal procedure *vs* an explicitly timed assignment (i.e., Clark and Rhymer gave students an exact, known time limit to complete the mathematics assignment). On Trial 1, students completed twenty-five 3-digit minus 3-digit subtraction problems on the target problem assignment and an experimental task with twenty-five 3-digit minus 3-digit subtraction problems, plus nine 1-digit minus 1-digit interspersed subtraction problems.

After the participants completed the assignments, they chose the assignment that they would prefer to complete for homework. Trial 1 results supported the DTCH, as students both completed more target items and chose the interspersal assignment for homework relative to the explicitly timed procedure. However, during Trial 2 (in which the same students completed identical assignments), Clark and Rhymer found that students completed more target items on the explicit timing assignment and indicated that they preferred the explicit timing assignment more than the interspersal assignment. Limitations of this study included the inappropriate nature of the tasks (i.e., subtraction tasks are easy for college students) and the duration of the study (one day). The authors noted the need for repeated trials in future experiments to ensure that the DTCH is not just "valid during a one trial session with interspersal…" (p. 285).

The analogue studies reviewed generally provide support for the matching law and DTCH explanations concerning students' higher mathematics problem completion rates during drills using the additive interspersal technique, however, limitations exist in each of the studies that reduce the ability to generalize. These limitations include the mismatch of task levels with student academic levels, the lack of completion of assignments, and the extent of time used for the experiments (i.e., the majority lasted just part of one day).

Behavioral momentum. Closely related to the matching law theory and the DTCH theory, behavioral momentum demonstrates a movement toward a continuing response (e.g., completion of an independent math worksheet), as long as the response is carried along by the lack of an interfering stimulus and/or a decrease in reinforcement. Behavioral momentum is an antecedent intervention, since the modification comes before the expected behavior (Horner & Day, 1991; Kern, Choutka, & Sokol, 2002). Kern et al. assert that,

"variables, or conditions, that occur antecedent or prior to problem behavior are altered in some way so that they are no longer present in a manner that is likely to provoke or set the occasion for problem behavior to occur" (p. 114). Like the matching law, investigators have applied this theory to human behaviors (Banda et al., 2007; Calderhead, 2004; Kern et al.; Mace et al., 1988).

Mace et al. (1988) describe behavioral momentum as "the tendency for behavior to persist following a change in environmental conditions" (p. 123). These authors also suggest that if an instructional method offers considerable reinforcement, this will lead to more behavioral momentum (Mace et al., 1988). High-probability sequencing (i.e., placing tasks that have a high probability of compliance with tasks that have a reduced probability of compliance) and the interspersal procedure fit within this explanation, as they both offer students the opportunity to experience consistent levels of reinforcement as they work through a task. Mace et al. gave a single adult subject with developmental delays a high probability command sequence (e.g., a specific order of commands that have a great chance of being followed) immediately preceding "don't" commands in the first phase. The compliance of the participant to the "don't" command increased from a baseline level to a mean of 87.5% over repeated trials. In the second phase of the study, Mace et al. gave the participant a high probability command sequence immediately before a "do" command. This modification resulted in the participant's mean compliance rate rising to 90.5% over repeated trials. When researchers intersperse high-probability tasks with low probability tasks, the reinforcement experienced by the participant from the high probability (high-*p*) tasks can enhance the completion of the low probability tasks.

Summary. Early research supported a relationship between participant choice behavior and reinforcement strength (e.g., matching law theory proposed by Herrnstein, 1961). This line of thinking was expanded throughout the years and eventually led to analogue studies within educational settings (e.g., Martens & Houk, 1989; Myerson & Hale, 1994). Several investigators have examined the causation between student choice behavior and reinforcement (e.g., behavioral momentum theory proposed by Nevin, 1974; DTCH proposed by Skinner, 2002). Both of these theories imply that completion of assignment tasks is intrinsically rewarding to the student, thereby increasing the students' choice behavior toward completing more tasks. These theories have empirical support and strongly validate a technique called the additive interspersal procedure that offers students the opportunity to experience success on interspersed briefer, easier items while they are working on typical independent mathematics assignments.

Studies Using the Additive Interspersal Technique

During the past several years, investigators have used the interspersal procedure to raise the level of reinforcement that students receive during independent assignments without the need for teachers to provide more traditional reinforcement (Skinner et al., 1996). The interspersal technique allows students to complete briefer and/or easier items inserted into instructional-level items (Skinner, 2002). If investigators substitute the easier items for instructional-level items, the procedure is called substitutive interspersal (Cates, 2005). If researchers add the interspersed items to the number of instructional-level items, the procedure is identified as additive interspersal (Cates, 2005). Originally, investigators attempted to use additive interspersal to supplement other techniques while working with

students with disabilities. When the published studies demonstrated success with this technique, studies using other populations began to emerge (Neef et al., 1977, 1980).

The earliest research literature regarding the use of an additive interspersal technique focused on applied behavioral analysis (ABA) and studies with persons with extensive disabilities. ABA is a specific behavioral technique that helps students to learn via numerous approximations and trials of a distinct behavior. ABA seeks to replace undesirable behavior with more acceptable behavior using a system of consistently applied rewards and/or consequences. Typically, ABA trials include heavy reinforcement until the student acquires a task.

In an early study with six teenagers diagnosed with mental retardation, Neef, Iwata, and Page (1977) looked at the acquisition of spelling and sight words. The authors added previously learned words to the sets of unlearned target words during the acquisition stage of the ABA study. They found that the

> effectiveness of the procedure may possibly be attributed to better maintenance of attending behavior to unknown items as a function of the inclusion of known items which directly increase the amount of reinforcement for correct responses during the early stages of skill acquisition (p. 738).

This early study's results support the matching law, DTCH, and behavioral momentum theories.

Another study by this set of researchers involved three adults (with a mean age of 22 years), including a man with widespread deafness and two other adults with mild mental retardation (Neef, Iwata, & Page, 1980). The authors looked at the effectiveness of the

additive interspersal approach against strong social reinforcement while trying to teach the adults spelling words using the ABA method. Initially, they gave a pretest to establish which spelling words participants knew and did not know. Following the pretest phase, they presented participants with two conditions (i.e., a list of unknown words *vs.* an interspersal list of unknown + known words) daily for 35 to 70 total sessions in a randomized alternating fashion. The authors gave a post-test at the end of the study to see which condition resulted in the higher acquisition rate of the unknown spelling words. In addition, the authors explored the preferences of the adults with regard to the assignment types. Neef et al. discovered that the interspersal method exceeded the social reinforcement condition with regard to both acquisition and retention of the target spelling words. Furthermore, Neef et al. found that the adult participants indicated that they preferred the additive interspersal method over the traditional presentation method when offered a choice of assignment. Both studies by Neef and colleagues (1977, 1980) offered participants numerous trials of the additive interspersal technique.

In a study with five elementary-age children with autistic spectrum disorders, Dunlap (1984) attempted to ascertain whether interspersing "maintenance" tasks within the children's ABA programs would have an educational or affective impact. The study participants ranged in age from 4 to 10 years old. Dunlap presented tasks in three ways: traditional constant ("massed") presentation, target items only presentation, and mixed maintenance and target items. The target tasks varied extensively by participant, yet included sequencing tasks, spelling, and touching picture cards by using receptive language skills. This study produced several major findings. First, the mixed (interspersed) condition was significantly better with regard to acquisition of maintenance tasks. Second,

the efficiency of the additive interspersal condition (i.e., total teaching time divided by the number of presented tasks) was also robust. Finally, the interspersal condition led to more positive ratings of child affect by the observers during the study, while the constant ("massed") condition led to the most negative ratings of affect by the observers. Dunlap asserted that students displayed more problem behaviors when the tasks presented were constant or diverse new tasks. The converse of this finding is that problem behaviors may be reduced if teachers do not present target tasks in an unremitting fashion, yet intersperse them with known or maintenance tasks. Unfortunately, the specific populations and method of overall instruction (i.e., ABA) used in this study and the previous one limit the generalization of the results to other populations and types of instruction.

A study with an 8-year-old child with lasting effects from a stroke examined the rates of acquisition of spelling, word recognition, reading, and memory skills (Koegel & Koegel, 1986). The authors interspersed previously learned skills with the target skills for the student. The dependent variables for the study included the percentage of correct responses, affective ratings of the participant by the speech/language pathologist and another adult observer, and social validation. The results from 64 sessions found that the child gained approximately 75% of the subject material that teachers would cover in an academic year within eight weeks. Koegel and Koegel noted "consistent improvements in motivation and correct responding when maintenance trials were interspersed with acquisition trials" (p. 429).

The implication from these early inquiries is that the interspersal of easier tasks along with target tasks appears to assist in the acquisition, attention to, and preference for the new tasks. Based on these prominent early studies of the interspersal technique, C.H.

Skinner and colleagues implemented a long series of studies that explored several aspects of the interspersal technique with mathematics, including the substitutive interspersal technique (Cates, 2005). Additive interspersal is when investigators add briefer, easier items in addition to instructional-level items (Cates). Many researchers, including Berliner (1984), suggest that exchanging difficult tasks with easier tasks and/or shortening an assignment's length can actually diminish learning rates. Therefore, during drill and practice techniques, teachers are more likely to use an additive interspersal method, than a substitutive interspersal method. This review will briefly focus on the accuracy, on-task behavior, and completion rates of the additive interspersal procedure.

Effects on accuracy. Very few studies of the additive interspersal technique focus on target problem accuracy as a dependent variable. Unfortunately, most of those studies that did include an accuracy assessment (Skinner et al., 1999; Wildmon et al., 1998, Wildmon et al., 1999), neglected to include an acclimation period prior to the study. This oversight may have led to incorrect assumptions regarding the use of the interspersal technique. In addition, a study by McDonald (2005) focused on using the number of correct digits within a problem as a measure of accuracy, rather than the total number of correct problems. The author found that this type of measure is much more sensitive than examining the number of correct problems. McDonald suggested that the discrepancy in measurement procedures may call previous study results into question, as well.

In a recent study, McDonald (2007) sought to determine whether the additive interspersal procedure *vs.* a traditional worksheet presentation would increase the problem accuracy and preference choice of students. She employed 64 second-grade students from the southeast United States as participants. The population was fairly diverse in nature

(55% Caucasian students, 36% African-American students, 5% Hispanic students, and 4% other ethnicities). She placed 28 of the students in an additive interspersal worksheet group and 36 in a traditional worksheet group. Over eight sessions, she gave students in the respective groups a total of five minutes to work on either two additive interspersal worksheets or two traditional worksheets. During the eighth session, McDonald gave both groups a three-page packet of worksheets containing one experimental worksheet and one control worksheet. On the third page, students completed four preference assessment questions. The author found no significant difference between the effectiveness of the additive interspersal procedure with regard to accuracy and problem completion rates (assessed by examining digits correct) when compared to traditional worksheets. Also, the second-grade students did not indicate that they preferred the additive interspersal procedure worksheet to the control worksheet for homework. Limitations within this study include the small sample size and the time limit used during the completion of the worksheets. Again, these drawbacks make it difficult to generalize the study results to classroom settings.

Effect on on-task behavior. Studies show that the completion of tasks on an additive interspersal procedure assignment serves as non-contingent reinforcement for students (Skinner, 2002). Several investigators suggested that if the amount of reinforcement within an assignment can be increased, on-task behavior may also increase (Martens & Houk, 1989; Martens, Lochner, & Kelly, 1992). The matching law (Herrnstein, 1961) suggests that the level of reinforcement interacts with the amount of effort required to predict the subsequent behavior. If the effort required and the levels of reinforcement are roughly equivalent (i.e., a “match”), then the desired behavior (in this

case, on-task behavior) is likely to occur. Furthermore, Skinner suggests that while completing an additive interspersal task, the process of completing tasks may serve as a form of reinforcement for students. The amount of reinforcement is increased as students complete more items overall on these tasks (Skinner et al., 1999). The students' desire to complete the task will most likely increase on-task behavior.

McCurdy, Skinner, Grantham, Watson, and Hindman (2001) conducted a single-subject (n=1) study using a 9-year-old girl from the southeastern United States who displayed off-task behavior and failed to complete math assignments. Their results suggested that the interspersal procedure may assist teachers by enhancing the on-task behavior of a student during independent drill and practice assignments. In their case study, McCurdy et al. gave the student an additive interspersal assignment on one day alternated with a typical drill and practice assignment the next day over a period of 16 days. The authors found that the use of the additive interspersal method enhanced the student's on-task behaviors. The length of the study suggests that the additive interspersal procedure may demonstrate effects over a relatively long period of time. This study was the first to attempt to introduce the additive interspersal procedure over several consecutive days within an authentic classroom setting. However, there were several limitations in this study that reduce its generalizability to classroom settings. First, the study only used one participant. This small sample size limits this study's usefulness to populations other than those precisely similar to this one (i.e., female, 9-years old, from southeast United States). Second, the authors did not randomize the alternating treatment condition. They used the additive interspersal condition only on odd days, possibly causing multiple treatment interference (Barlow & Hersen, 1984). For instance, since they did not employ

counterbalancing, the additive interspersal condition may have influenced the girl's response to the control condition or vice versa. Third, the authors did not ascertain the accuracy of the assignments. This limits the usefulness of this study for educators who are concerned about students increasing their learning of the material in addition to increasing their on-task behavior.

A recent study completed by Montarello (2007) included 5 sixth- and seventh-grade students from the northeastern United States diagnosed with emotional disabilities. The study examined the effects of the additive interspersal procedure, a "momentum" condition (i.e., interspersing groupings of three easy problems into instructional level worksheets), and a tangible reinforcement condition (i.e., administering rewards after a specified number of completed problems) on problem completion rates (assessed by using a digits correct method), on-task behaviors, and accuracy. The study lasted for 25-40 sessions, with the lower session amount reflecting poorer student attendance during the study. Montarello presented each of the conditions in a counterbalanced fashion during every session for a total of 10 minutes per day. The results regarding problem completion (i.e., digits correct) rates showed variability across participants and conditions. Results did not support additive interspersal as a procedure that increases problem completion rates in this study, as all students showed higher problem completion rates during the other two conditions. With regard to on-task behavior, only three out of the five students showed an increase in on-task behavior during the interspersal condition. Finally, the levels of accuracy on mathematics problems remained high for all students across all conditions, despite the students expressing dissatisfaction with the interspersal procedure overall. Limitations for this study include the limited

sample size, time limit for the completion of problems, and the specific population. These factors make generalization to a heterogeneous setting difficult.

Only a few studies included on-task behavior as a dependent variable when exploring the benefits of the interspersal technique (e.g., McCurdy et al., 2001; Montarello, 2007; Skinner, Williams, & Needenreip, 2004; Wildmon, Skinner, McCurdy, & Sims, 1999). Of these studies, only the McCurdy et al. and Montarello studies used a longitudinal approach, continuing the study for more than only a few days with an elementary school population. Unfortunately, these studies produced mixed results, with the McCurdy et al. case study supporting the use of the additive interspersal procedure for increasing on-task behavior and the Montarello study only partially supporting the interspersal procedure. These studies may have limited generalizability to a traditional classroom setting.

Effect on completion rates. In addition to lower rates of on-task behaviors, several theorists speculate that students may have lower rates of problem completion if the tasks are too difficult and/or not reinforcing. The premise is that if assignments are too difficult or not reinforcing enough, students will not choose to engage in the assignments (e.g., Cooke et al., 1993; Horner & Day, 1991). Gickling and Armstrong (1978) found that when they presented students with materials that were appropriate for their academic level (i.e., approximately 70- 85% previously mastered items during a seatwork activity), students completed more tasks. When the tasks were too difficult (i.e., contained less than 70% previously mastered items), students did not complete the tasks in their entirety (Gickling & Armstrong). Mace et al. (1988) suggest that when students complete tasks too slowly, they may not receive adequate reinforcement. Skinner (2002) suggests that task completion can act as an intrinsic reward to students. However, if students work very slowly on an

assignment, the intrinsic reward of completing tasks may not come expeditiously enough to sustain their effort on the assignment. Therefore, a slow completion rate may lead students to put forth even less effort toward completing the assignment.

Several studies attempted to examine problem completion rates and the effect of using an additive interspersal procedure (Billington & Skinner, 2002; Cates & Skinner, 2002; Logan & Skinner, 1998, 1999; Skinner et al., 1999). This series of studies employed college students in their university setting. Each study required the college students to complete packets of independent mathematics assignments - one with easier, briefer items interspersed and one traditional worksheet. After the prescribed time limit (i.e., between 2 minutes, 15 seconds and 8 minutes for the various studies), the college students answered preference questions regarding the assignments. The overall results from these studies supported the use of the additive interspersal procedure to enhance problem completion rates on independent mathematics assignments. Unfortunately, these studies contained many limitations that reduce their generalizability to other settings. Most importantly, these analogue studies employed college students who were expected to complete mathematics assignments that did not match their academic levels (e.g., college students completing multiplication problems). In addition, the studies used time limits, limiting the completion of the mathematics assignments. Finally, the studies did include an acclimation phase to familiarize students with the testing procedures prior to the completion of the mathematics assignments for hypothesis testing.

Student Preference for Interspersal Assignments

Educators would benefit from a procedure that would not only increase student productivity and accuracy, yet would also be acceptable to students. Skinner (2002)

suggested that there was a robust direct relationship between the interspersal assignments and student preference for the assignment. He discussed this relationship when describing the discrete task completion hypothesis (DTCH). The level of reinforcement in relation to task difficulty appears to predict the students' responses to assignments (Herrnstein, 1961; Skinner, 2002). A study involving college students was conducted by Clark and Rhymer (2003) over two trials. After the first trial, the interspersal condition was given alongside the control (traditional) assignment for students to choose for hypothetical homework. The students showed preference for the interspersal assignment. However, Rhymer and Morgan (2005) caution that "When interventions are only examined in relation to control conditions, it is often the case that any intervention is better than no intervention" (p. 287). Clark and Rhymer (2003) then completed a second trial comparing the interspersal condition with an explicit timing intervention. At the end of this trial, students chose the explicit timing intervention over the interspersal procedure. In two studies supervised by Billington (2004), he concluded that both college students and middle school students chose the interspersal assignment over a traditional assignment for hypothetical homework assignments. A meta-analysis conducted by Skinner (2002) suggested that for the studies he reviewed, the discrete task hypothesis accurately predicted student choice for the interspersal assignment. However, Clark and Rhymer (2003) found that the discrete task completion hypothesis (Skinner, 2002) had overestimated the number of students who would prefer the interspersal procedure. Two studies were conducted that did not support the discrete task completion hypothesis. The study implemented by McDonald (2007) with second grade students suggested that the students did not prefer the interspersal assignment over the traditional assignment. The investigator presented students with a packet with

three parts; an interspersal assignment, a traditional assignment, and a student preference survey. Therefore, students were able to refer back to each assignment to see which one they preferred. In a study conducted by Montarello (2007), the investigator suggested that some students expressed dissatisfaction with the interspersal procedure overall.

Previous research has widely supported the interspersal procedures preference over traditional assignments (Billington, 2004; Clark & Rhymer, 2003; Skinner, 2002). However, Clark and Rhymer (2003) found that the discrete task completion hypothesis did not accurately predict student preference for the interspersal assignment over a traditional assignment. In addition, two studies (McDonald, 2007; Montarello, 2007) did not find that students preferred the interspersal assignments over the traditional assignments.

Teacher Acceptance of Interspersal Techniques

Occasionally, school administrators ask teachers to implement practices in school settings that they may not be able or willing to do. Examples of this might include the implementation of a new reading series or a strategy with a student during a classroom lesson. Gresham (1989) argues that teachers may not invest themselves in or correctly conduct an intervention unless they find the strategy is acceptable to them. The acceptability of an intervention to teachers is the first issue that investigators need to examine when beginning a new strategy for learning (Witt & Elliott, 1985). Once the teacher accepts the intervention, the likelihood of the teacher actually using the intervention will increase (Witt & Elliott).

If a teacher strays from a prescribed intervention, the chances of intervention failure may increase. Gresham (1989) suggests six possible reasons why teachers may not follow through correctly with an intervention. These include: the complexity of the

intervention, the amount of time needed to implement an intervention, the necessary means and materials essential to carry out the intervention, the number of people involved in the intervention, the teacher's thoughts on the probable effectiveness of an intervention, and the teacher's motivation level with regard to the intervention. To increase the acceptability of an intervention to teachers, Gresham mentions that a consultant (such as a school psychologist) can suggest implementing interventions that are simple to use, do not require excessive time, limit the needed number of components and resources, and enhance the perceived effectiveness of the intervention. The additive interspersal method may fit all of these requirements. However, investigators have not explicitly examined the additive interspersal technique in light of its acceptability to teachers, as they have the substitutive interspersal technique. Berliner (1984) found that the substitutive interspersal method diminished student learning rates and therefore would not be acceptable to teachers.

Summary of Reviewed Literature

Teachers frequently use a drill and practice procedure with students during independent seatwork to enhance the acquisition and fluency of mathematical skills. However, inherent in such an assignment is the tendency for some students, including those who may have attentional difficulties, to have difficulty engaging with and completing the task. This behavior may lead to poor accuracy and lengthy problem completion rates or lack of completion for tasks. Educational professionals would welcome a technique that appears to be easy to implement and requires a minimum of time that could assist in alleviating these negative aspects of the drill and practice procedure. The additive interspersal procedure is one technique that has research support. However,

many limitations exist within the studies that limit the generalization of their results to diverse and heterogeneous populations within an elementary school.

Overview of the Present Study

The purpose of this dissertation was to examine the effectiveness of the additive interspersal technique's ability to enhance elementary school students' accuracy, on-task behavior, and work completion rates on independent math assignments. The matching law, DTCH, and behavioral momentum theories suggest that students will respond favorably to the use of additive interspersal in independent math assignments. Unfortunately, the review of the additive interspersal literature has revealed many limitations with regard to the populations used, time spent implementing the studies, and social validity of the tasks employed. This study will attempt to correct these limitations in order to determine whether there is support for the use of the additive interspersal procedure compared to traditional mathematics assignments in a suburban elementary school population in the northeastern United States for on-task behavior, relative problem completion rates, and problem solution accuracy.

Hypotheses

The above reviewed literature indicates discrete academic tasks may provide a favorable match between the level of reinforcement and the effort required (Herrnstein, 1961) enhances student work completion as their successful completion of items becomes a reinforcing event (Nevin, 1974; Schunk, 1989; Skinner, 2000). Therefore, this investigator advances the following hypotheses for testing on a heterogeneous population of elementary school students:

HY1: The independent seatwork mathematics relative problem completion rates using additive interspersal will be significantly higher than completion rates using traditional mathematics assignment presentation.

HY2: The mathematics problem accuracy rates using additive interspersal will be significantly higher than accuracy rates using traditional mathematics assignment presentation.

HY3: The on-task behavior rates using additive interspersal will be significantly higher than on-task behavior rates using traditional mathematics assignment presentation.

Studies (e.g., Billington & Skinner, 2002; Cates & Skinner, 2002; Skinner et al., 1999) indicate that the additive interspersal technique may be more acceptable to students. Therefore, this investigator advances the following hypothesis:

HY4: Students will rate the additive interspersal assignments as being significantly easier and more preferred than the traditional mathematics assignments.

CHAPTER III

Method

This chapter presents the specific methodology of the study to explore the effect of the additive interspersal technique on on-task behaviors, accuracy rates, and work completion rates on independent mathematics worksheets in 3rd through 5th grade students over an extended period of four weeks. It begins with a complete description of the participants. The chapter then describes the procedure to be used, the materials, and the dependent measures. The chapter continues with a description of the data analysis techniques to be used. The chapter also addresses issues of acceptability of the additive interspersal procedure to the involved teachers, experimental integrity, and data analysis.

Participants and Selection Procedures

Participants were solicited from a suburban kindergarten through 5th grade elementary school in Orange County, New York that had a population of nearly 550 children. This elementary school had 39% Caucasian students and 61% of students were from other ethnicities (e.g., 24% African American, 27% Hispanic, 6% Asian-Pacific and 4% other). Thirty-five percent of the students were eligible for free and reduced lunches. The potential participant pool consisted of 256 3rd through 5th grade students. In the 3rd grade, there were 80 students. In the 4th grade, there are 100 students and in the 5th grade, 76 students. This group of students was chosen for the current study due to the paucity of additive interspersal studies based in the northeastern United States and the lack of studies involving large groups of diverse students in heterogeneous 3rd through 5th grade classrooms (Skinner, 2002). In addition, the teachers in these particular grades utilized independent seatwork as an instructional method quite frequently (Fisher et al., 1978;

Rosenshine, 1971), whereas students in the kindergarten through second grades do not have independent mathematics seatwork on a regular basis. Therefore, kindergarten through second grade students were not included in the present study.

In the total pool of 3rd through 5th graders during the 2009-2010 school year, 97 (38%) of the students were white, 77 (30%) were Hispanic, 77 (30%) were Black American, and 5 (2%) were Asian-Pacific. Eighteen (7%) members of the total participant pool of students had disability classifications under IDEA and another 13 (5%) had a 504 Accommodation Plan. All of the potential participants were in either integrated co-teaching classes (i.e., one general education teacher plus one special education teacher or teacher's aide in the classroom at all times) or general education classrooms (i.e., one general education teacher only).

As the school district did not have an Institutional Review Board (IRB), the superintendent of the district and the principal of the participating elementary school provided written letters of permission for this investigator to conduct the study (see Appendices A and B).

Selection procedures. Informed consent was secured from 3rd- to 5th -grade teacher volunteers at a short faculty meeting presentation (Appendix C) during which this investigator gave teachers informed consent letters (Appendix D). Since this investigator worked in the school district, research assistants collected consent letters and data to ensure participants' voluntary consent and confidentiality. The investigator did not know which teachers agreed to participate, because research assistants collected the consent forms from teachers after she left the meeting. A total of 5 out of a possible 10 teachers (50%) agreed to

participate. The sample included the classrooms of one 3rd grade teacher, two 4th grade teachers, and two 5th grade teachers.

The research assistants, whom this investigator paid, were two teacher assistants in other district buildings who had a minimum of six college credits in education courses and a master's level graduate student in school psychology.

Following collection of teacher consent forms, research assistants solicited student participants from consenting teachers' classes by sending home to the parents of the potential participants an explanatory cover letter and enclosed permission slip (see Appendices E and F) in students' classroom folders and/or backpacks. The letter of explanation clearly specified that this investigator was the principal investigator for the study, yet she would not have knowledge of the participating teachers or students, as the research assistants collected all data and permissions. Students returned signed consent forms to a box in the front of each classroom.

Research assistants obtained student participants' assent through a short discussion in the classrooms of consenting teachers using a script (Appendix G). After the presentation by the research assistants, the students signed an assent form if they were interested in participating in the study (Appendix H). Only assenting students who also had parental consent participated in the study. If some students assented to participate in the study, but did not have parent consent as well, or if parents gave consent but students did not, the teachers gave these students the traditional classroom mathematics seatwork assignment during each day of the study. In other words, only assenting students with parental consent participated in the study.

Research assistants collected the permission slips and assigned all participating children (i.e., those whose parents consented to the study) in the classrooms of the assenting teachers a code number to hide their identities. Only teachers and research assistants were aware of the identities of the student participants. During the study, research assistants kept the coding sheets and any other identifying information in a locked file cabinet in the nurse's office that others could not access. At the completion of the study, the research assistants placed the coding sheets in a locked box in the investigator's office and I will shred the data after a prescribed period. The American Psychological Association (APA) advocates retention of data "for a minimum of five years after publication of the research" (APA, 2009).

Sample Size

Using the power analysis calculations of Cohen (1992), it was determined that a minimum of 64 participants would be necessary to obtain a significant medium effect at the $p < .05$ level of significance, so 66 participants were enlisted.

Dependent Variables

Mathematics problem completion rate. The assignment completion times were used to calculate problem completion rates by dividing the total amount of time (in seconds) needed to complete an assignment by the number of total problems (i.e., 20 on all control assignments and 26 on all interspersal assignments) that students completed on that assignment (e.g., Logan & Skinner, 1998; Skinner, Fletcher et al., 1996; Skinner, Robinson et al., 1996; Skinner et al., 1999; Wildmon et al., 1998; Wildmon et al., 1999). This formula gave the average time (in seconds) to complete each problem on the assignment.

Mathematics problem accuracy rate. To substantiate the accuracy of each target item on the assignments, the number of correct target items for each assignment type were noted. The students' scores for the traditional mathematics assignments and interspersal mathematics assignments were reflected as a percentage calculated by dividing the total number of target problems completed by the number of correct target problems (20 in both cases) and multiplying by 100%. As with the relative problem completion rate formula, several studies of the interspersal technique have used this formula (e.g., Skinner et al, 1999; Wildmon et al., 1998, Wildmon et al., 1999).

On-task behavior. To examine the incidence of on-task behavior, two research assistants were present in the classroom during each session, and they both tallied the number of times that individual students exhibited verbal, visual, or kinesthetic off-task behaviors during the independent mathematics assignment time. The operational definitions for each of the behaviors were modeled after the structured observation designed by Barkley (1998). Using a large class seating chart, research assistants placed a tally mark by the student's name on a seating chart after the student exhibited the specified behavior on a chart (see Appendix P). The two research assistant observers split each class in half, using the seating chart, to make observations easier and more accurate. The amount of time (in seconds) it took each student to complete the assignment was listed next to the tally of his or her behaviors. Once the student finished the assignment and placed it in the designated box, the behavioral observation ended for that student. The training procedures for the research assistants are described in Appendix U. The research assistants then transcribed the data onto class lists that had students' coded identifiers instead of their names and gave the list to me. The rate of the discrete behaviors observed within the length

of observation time was computed for each student by dividing the number of occurrences of each type of off-task behavior divided by the length of the observation time for the student (Goodman, 1990).

Materials

Mathematics assignments. This study used two types of mathematics independent seatwork assignments: a traditional assignment that the classroom teacher ordinarily used for independent mathematics seatwork (with 20 target problems on white 8 ½ x 11-inch paper) and the interspersal assignment composed of the same 20 teacher-assigned problems as the traditional assignment plus 6 additive interspersed problems (also presented on white 8 ½ x 11-inch paper). The interspersal assignments were constructed in a manner similar to several previously published studies on this topic (e.g., Logan & Skinner, 1998; Rhymer & Morgan, 2005; Skinner et al., 1999).

During each week of the 4-week period of the study, the research assistants provided the investigator with an advance copy of the independent mathematics work that teachers in the participating classes would use. Research assistants asked teachers to provide a total of 20 target seatwork problems per day for students to complete. Because the school district had a prescribed syllabus for each grade level, all grade-level classes covered similar topics and used the same textbooks and workbooks. Topics and assignments presented throughout the duration of the study varied, as the individual classroom teachers chose the daily assignment content. The number of target problems (i.e., problems that teachers in the classes assigned) for each type of assignment (traditional and interspersal), was held constant at 20 for each day of the study to help establish

consistency for future data analysis. Students who were not participating in the study completed the traditional assignment that the teachers constructed.

For the traditional regular assignment condition for participating students, the investigator retyped the 20 mathematics problems that teachers assigned from the textbook or workbook onto a white piece of 8 ½ x 11-inch paper. For the interspersal assignment condition, the same 20 book or workbook mathematics problems were retyped onto a white piece of 8 ½ x 11-inch paper, with the addition of 6 briefer, easier problems inserted after every third problem for a total of 26 problems. The 6 briefer, easier problems were designed after examination of the teachers' original assignments.

For example, if a teacher assigned 20, 2-digit x 1-digit multiplication problems as the target items, six 1-digit x 1-digit multiplication problems were interspersed into the assignment. Previous studies of the interspersal method commonly used this method of choosing easier, briefer items, yet the method was only clearly explained in a few (e.g., McDonald, 2007). The ratio of one interspersed (i.e., briefer, easier) item after every third target problem was chosen because results of previous studies have supported this ratio as most effective when using the interspersal technique (e.g., Cates & Skinner, 2000; Cooke et al., 1993; Hawkins, 2005). There was an equal amount of target items (i.e., 20 instructional-level items) on both the traditional and additive interspersal worksheets from day to day. Both types of assignments presented the problems in rows with no numbering or consistent spacing, to avoid immediate visual detection of the different types of assignments (see Appendix I & J for examples of traditional assignment and an interspersal assignment).

Procedure

Throughout the study, students completed mathematics seatwork worksheets on previously learned problems as they would originally during a typical school day. The only difference was that on some days, the worksheets included 6 interspersed problems along with the 20 problems assigned by teachers for that day. The research assistants established a 3-day acclimation phase level for each participating student (n = 66) by examining each student's traditional mathematics seatwork assignments and recording scores for accuracy of answers to the 20 target problems that teachers assigned each day and recorded work completion times for those problems, as well as incidences of off-task behavior (as described below). A 3-day acclimation phase allowed students to become acclimated to having the research assistants in the classroom and gave the research assistants time to get to know the students' names and seating locations using classroom seating charts provided by the teachers.

After they collected the acclimation phase data, the research assistants presented either the additive interspersal technique assignment or the traditional seatwork assignments for participating students to complete using an alternating treatments design during 16 classroom sessions over 16 consecutive school days in June 2010. An alternating treatments design is used to compare the effects of two treatments. In this case, the interspersal assignments and traditional assignments were alternated in succession over the 16-day period. The type of assignment given to a particular student on a particular day was generated by a list of random numbers, covering all 16 days of the study. The length of the seatwork sessions varied, depending on the amount of time it took students to complete the daily assignments. The alternating treatments design was chosen due to its usefulness when

comparing treatment conditions over short periods of time in natural settings, such as the classroom (Barlow & Hayes, 1979). Also, the alternating treatments design allows two distinct treatments to be compared in the same subject within the same time period, thus controlling significant threats to internal validity. Sixteen sessions were chosen because this represented a substantial increase over the number of sessions employed in most investigations of the interspersal procedure (e.g., Billington & Skinner, 2002; Calderhead, Filter, & Albin, 2006; Skinner et al., 1996), and therefore, this study joins the few studies that employed this procedure for more than just a few sessions.

Each day of the study, research assistants handed out the assignments and read the directions to the participating students (Appendix K). Students began the assignments at the same time, with the start time indicated by the research assistants after they gave assignment directions. The research assistants started a timer when the students turned their papers over to begin. When each student was done with the assignment, he or she brought it up to the teacher's desk and placed it in a designated box. To document the amount of time it took for students to complete the independent mathematics tasks, the research assistants recorded the time indicated on the timer when each student handed in the daily assignment into the designated box. Students had unlimited time to complete the assignments and did not know that the research assistant was timing them. As previously mentioned, research assistants had the opportunity to learn student names and seating locations during the 3-day acclimation phase period.

To record the occurrence of off-task behaviors during the seatwork assignments, two research assistants were observing in the classrooms and using a checklist within a seating chart format to mark the off-task behaviors of each student (Appendix Q). The

research assistants were trained prior to the start of the study as to how to observe the students and complete the checklists. During two classroom periods prior to the start of the study, a second grade teacher not affiliated with the study allowed the research assistants to practice their observation techniques and work out possible difficulties ahead of time. It was determined that using "squares" to designate each student's seating location was the most efficient place to tally off-task behaviors (see example in Appendix Q)

Research assistants looked for the following behaviors during the time period: verbal off-task behavior (e.g., any time that a student made an utterance to oneself, a peer, or called out to the teacher), visual off-task behavior (e.g., any time that a student broke eye contact from his or her paper while expected to be completing the assignment), and kinesthetic off-task behavior (e.g., any time that a student broke contact with his or her seat to move around or walk around; accompanied by not working on the assignment). The two “every day” observing research assistants decided to split each class in half, using the seating chart, to make observations easier and more accurate. Therefore, each observing research assistant was limited to only 6-9 students to observe, rather than 6-18 students per class.

To counterbalance the presentation of the two types of assignments, the research assistants randomly split each large class into four groups (i.e., Group A, Group B, Group C, and Group D), with each group receiving a random assignment type. The students were randomized into four groups by placing all student code numbers into a container and randomly drawing code numbers into groups. One class only had 6 participants and was broken into 2 random groups, rather than four. Teachers chose specific times for the daily seatwork procedures to occur, based on their predetermined classroom schedules.

Classroom periods typically ran for 30 minutes each. While students completed their assignments, research assistants tallied off-task behavior (see below). The research assistants removed the participating students' stickers (with names on them) and replaced them with code numbers for each assignment, after the research assistants had graded the assignment using a provided answer key for correct answers.

Days were chosen for the traditional and interspersal conditions using a computer-generated table of random numbers in a sequence (representing days 1-16) for each group, so that the students experienced the conditions in a truly random fashion (see Appendix L). For example, if the table gave the numbers 14, 5, 4, 2, 15, 7, 8, 11, etc., the first eight random numbers represented the days of the study that students in one group in a classroom received an interspersal assignment and the students in another group received a control (i.e., traditional) assignment.

One drawback of using an alternating treatment design is the possibility of carryover effects (Barlow & Hayes, 1979). Carryover effects are the "influence of one treatment on an adjacent treatment" (p. 204). For instance, the predicted positive influence of the interspersal condition may influence a student's performance during the control condition. Barlow and Hayes suggest three ways to minimize carryover effects and therefore increase external validity. These methods include counterbalancing the order of conditions in an unpredictable way (as described above), only presenting one condition per study session (as described above), and allowing for the discrimination between the two conditions. To enhance the discrimination between the conditions, on control assignments, this investigator typed a 20-font label "C" on the top of the assignments and on interspersal assignments, this investigator typed a 20-font label "I" on the top of the page to help

eliminate carryover effects between the two conditions (see Appendix I & J for an example of a control assignment and an interspersal assignment). The labels indicated to students that there was a difference between the assignments, to minimize carryover effects from one assignment to the next (Barlow & Hersen, 1984). These labels also served to help students identify the two types of assignments in order to give preference ratings for each type (see Appendix P for an example of the preference survey). One time per week, immediately following the completion of the daily assignment, students filled out the preference survey, reflecting their opinion of the week's assignments.

Experimental integrity. The research assistants used a checklist outlining the exact steps for the procedures of the study each day (see Appendix N). Each day, the research assistants turned in the checklist that detailed which procedural steps they followed and which steps they did not follow. As suggested by Gresham (1989), the investigator analyzed the percentage of correctly completed steps for the "occurrence and nonoccurrence of each treatment component" (p. 42), thus leading to the protocol compliance rate (expressed as a percentage) for each step over the 4-week period.

Interscorer agreement of behavioral observations. To assess the interscorer agreement for the daily observations by two of the research assistants, interobserver agreement data was collected on the incidence or lack of incidence of the off-task behaviors of the students. The percent of interobserver agreement was calculated by dividing the number of agreements on behavior occurrences by one observer by the number of agreements on occurrence plus the number of disagreements on occurrence by the second observer multiplied by 100 (Shapiro & Kratochwill, 2002).

Acceptability of the Interspersal Method

Student acceptability measure. To determine the level of the additive interspersal procedure's acceptability to the students involved, research assistants gave a set of preference assessment questions to the students at the end of each week beginning with the first week, asking them to compare the assignments labeled with an "I" to the ones labeled with a "C". The Likert-scale used in the survey had four possible ratings (i.e., "1" as the lowest score, "4" as the highest score), forcing the students to decide whether they found each aspect of the procedure acceptable or not acceptable (see Appendix N). Several researchers have used this measure successfully in past studies (Cates & Dalenberg, 2005; Cates & Lee, 2005; Cates et al., 1999). During these studies, researchers had participants show preference for one type of assignment over another by having the students choose a hypothetical homework assignment, rather than completing a survey.

Teacher acceptability measure. Following the conclusion of the study, participating teachers completed a 6-point Likert-scale survey indicating whether or not they found the intervention to be acceptable (Appendix O). The survey in this study reflected aspects of the teacher acceptability suggestions from Gresham (1989). The survey included questions regarding the complexity of the additive interspersal intervention, the time involved during each day, the resources required, the number of people involved, the perception of the intervention's effectiveness and its actual usefulness and the teachers' motivation to use the intervention on their own (Gresham, 1989). The Likert-scale used in the survey had six possible ratings (i.e., "1" as the lowest score, "6" as the highest score), forcing the teachers to decide whether they found each aspect of the intervention mostly positive or mostly negative. Descriptive statistics are provided in the results chapter.

Data analysis. Problem completion rates, rates of each type of off-task behavior, and accuracy levels of the target items across assignments served as the dependent variables, while the structure of the mathematics assignments (regular or interspersal) served as the independent variable in the data analysis. Two-factor repeated measure ANOVAs were used to examine differences within subjects across performance for each of the dependent variable categories (e.g., assignment type x accuracy, assignment type x relative problem completion rate, assignment type x off-task behaviors). In addition, if differences did appear, interspersal and control conditions were contrasted while accounting for any possible effects of other variables (e.g., gender, grade level, type of classroom, and ethnicity) via analysis of covariance (ANCOVA).

Due to the risk of order effects and multiple-treatment interference problems with within-subject designs (Barlow & Hersen, 1984), randomization and counterbalancing of the assignments occurred throughout the study (Cates et al., 2003). On control assignments, the large label "C" was placed at the top of the assignments and on experimental (interspersal) assignments, the large label "I" was placed at the top of the page to help eliminate carryover effects between the two conditions.

Missing data were inevitable because students sometimes were absent during the 3-day acclimation phase or the 16-day study period and therefore missed an assignment. Because treatments were randomized and because scores were averaged within each treatment condition in preparation for statistical analyses, occasional student absences did not compromise the integrity of the data. For example, if an individual missed one control assignment, the remaining control assignment scores were averaged to find the overall mean of the control assignments for that student. These average performances therefore

represent the best unbiased measure of performance for each student. Appendix T lists the percentages of interspersal assignments, control assignments, and overall student absences during the study.

Compliance with Ethical Considerations. Several safeguards were put into place to protect the rights and identities of both the participating teachers and students in this study. The Institutional Review Board at City University of New York- Graduate Center approved the study procedure, teacher consent form, parent permission slip, and student assent form. Throughout the study, participating student identities were coded immediately after the administration of the assignments to protect anonymity. All consent forms, permission slips, and student assent forms were kept in a binder, locked in a file cabinet in the nurse's office, with access only available to the research assistants. These identifying forms will be kept in this location until 5 years after the publication of this dissertation (APA, 2009), upon which time they will be shredded. Throughout the length of the study, students were reminded that they could withdraw from the study at any time and did not have to complete surveys if they did not want to. Each day of the study, 100% of the student participants who were present completed the daily worksheet. However, several students opted not to complete the surveys on the days they were given. Data collected in this study were inputted into PASW Version 18 by someone blinded to the purpose of the study. Data were checked and double checked. No adverse events needed to be reported to the Institutional Review Board during the length of the study.

CHAPTER IV

Results

This chapter presents the results of the current study which explored the effects of the additive interspersal technique on on-task behaviors, accuracy rates, and relative work completion rates on independent mathematics worksheets in 3rd through 5th grade students. It begins with a discussion of the treatment integrity, then describes recruitment procedures, participant demographics and interobserver agreement data. The four hypotheses of the study are interpreted. Lastly, teacher survey data are discussed.

Treatment Integrity

Each day of the study, the research assistants followed a checklist that described the sequential procedures for each of the classrooms (see Appendix N). Adherence to the prescribed daily procedures checklist was 100% for each classroom. However, research assistants were found to have not always given the students in each classroom the correct assignment for the day (this aspect was not listed on the checklist). For instance, if the random table of numbers dictated that the interspersal assignment was to be given to student D4 on Day 7 of the study, the student would be given the control assignment erroneously. Examination of assignments found that incorrect assignments occurred 13 times out of a possible 1056 times over the course of the study. The resulting 1% error is not large enough to affect the data analysis of the study, as a repeated measures ANOVA compared each student's performance to himself or herself across several sessions of each type of assignment. Therefore, the very few times that any student received an erroneous assignment did not appear to affect the treatment integrity for this study.

Recruitment

The teacher information was presented during a faculty meeting which took place on May 19, 2010. Teachers returned the consent to participate by May 21, 2010. Parental permission slips were given to each student in the classrooms of participating teachers on May 21, 2010. The student assent slips were explained and distributed on May 24, 2010 to all students in the participating classrooms. The acclimation phase portion of the study took place between June 1, 2010 to June 3, 2010. The study itself lasted for 16 consecutive school days, between June 4, 2010 until June 25, 2010. Figure 1 shows the flow of participants through the study.

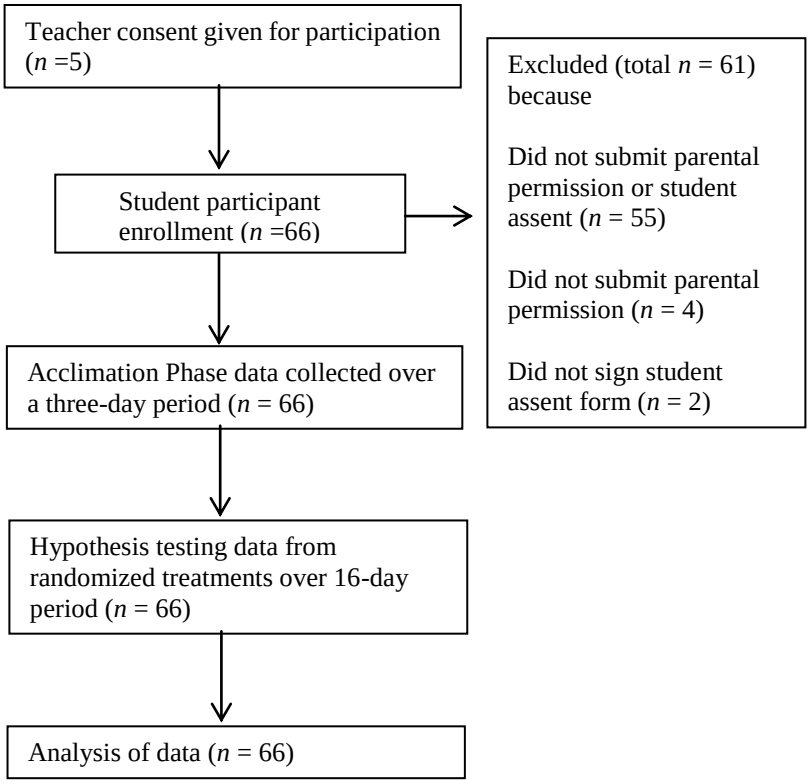


Figure 1. Flow of participants through each stage of present study.

Participant Sample Demographics

A total of 66 students out of a possible 127 students from participating classes (52%) enrolled in the study, having both parental consent and student assent. Figure 1 shows that 55 students supplied neither consent or assent or students gave assent and did not have parental permission and 2 students had parental permission, but did not choose to sign the student assent. These students did not participate in the study. All participating students were involved in the study throughout the acclimation phase and 16 study days.

The demographics of the participating students consisted of 12 students from the 3rd grade (18% of the sample), 18 students from 4th grade (27% of the sample), and 36 students from the 5th grade (55% of the sample). Fifty-five percent of the participants were female and 45% were male. Eighteen of the 66 participants (27%) were Caucasian, 23 were Hispanic (35%), 23 were Black American (35%), and 2 of the 66 participants were Asian (3% of the overall sample). Therefore, 27% were Caucasian and 73% were non-Caucasian within this sample. Parents identified 70% (*n* = 46) of the sample as "typical" students (e.g., not receiving any academic assistance within the school setting), and 30% (*n* = 20) "atypical" students (e.g., students receiving additional academic assistance within the school setting through the Committee on Special Education, a Section 504 Accommodation Plan, or Academic Intervention Services). Parents reported that half (n= 15) of the "atypical" students had been diagnosed with Attention Deficit Hyperactivity Disorder.

Inter-Observer Agreement Data

Two times per week during the study, a third observer was brought in to observe two students in a single class whom research assistants were observing. In other words, the

third observer observed one student that a research assistant also observed at these times. The off-task behavior tallies from this outside observer were compared with the observations of the research assistants who observed the two participating students every day. The percent of interobserver agreement was calculated by dividing the number of agreements on behavior occurrences by one outside observer by the number of agreements on occurrence plus the number of disagreements on occurrence by the research assistant multiplied by 100 (Shapiro & Kratochwill, 2002). Inter-observer agreement for this study was 82%, which was considered adequate reliability to proceed with hypothesis testing.

Acclimation Phase Data

Originally, the first three days of data collection were to serve as a baseline measure using three traditional assignments of 20 problems for completion by students. However, after the students had completed these assignments, the teachers revealed that the assignments they gave during the first three days were substantially easier than the assignments they would ordinarily give and did in fact provide during the 16 study days. This was a decision by the teachers, and they did not inform the investigator until after the fact.

Therefore, these three days served to acclimate the participants to the experimental procedure and the presence of the research assistants. Also, the assignments in this time period determined whether students would “top out” at 100% on each assignment, indicating that the tasks presented were too easy for such students. Despite the acclimation phase assignments being “very easy”, no students posted perfect scores across the acclimation phase assignments and, thus, no participants were removed from the study. Because the acclimation phase assignments were easier than the interspersal and control

assignments for hypothesis testing, it was not prudent to compare the acclimation phase assignments to the interspersal and control assignments because the content difficulty was not matched. Because students achieved a range of scores on these earlier acclimation problems, the investigator was confident that students' scores on the interspersal and control assignments would have sufficient range to allow meaningful statistical comparisons. Table 1 displays acclimation phase descriptives for time to assignment completion (problem completion rate in seconds), score (on a scale of 0- 100%), verbal off-task behaviors (VB), visual off-task behaviors (VS), and kinesthetic off-task behaviors (K), including the mean (*M*), standard deviation (*SD*), minimum (Min), and maximum (Max). The operational definitions for the off-task behaviors were as follows: verbal off-task behavior (e.g., any time that a student made an utterance to oneself, a peer, or called out to the teacher), visual off-task behavior (e.g., any time that a student broke eye contact from his or her paper while expected to be completing the assignment), and kinesthetic off-task behavior (e.g., any time that a student broke contact with his or her seat to move around or walk around; accompanied by not working on the assignment).

Table 1

Acclimation Phase Data for Traditional Assignments Over Three Sessions

Descriptive	*N*	*M*	*SD*	Min	Max
Time	66	21.7415	9.45	7.50	50.80
Score	66	84.2929	13.65	33.33	98.33
VB	66	0.0004	0.00	0.00	0.01
VS	66	0.0048	0.01	0.00	0.03
K	66	0.0003	0.00	0.00	0.01

Note. Time = Problem completion rate (for 20 total problems), Score = average score (based on range of 0-100%), VB = Verbal off-task behavior, VS = Visual off-task behavior, K = Kinesthetic off-task behavior (see behavioral definitions above).

Correlations Between Descriptive Data and Dependent Variables

Table 2 presents the intercorrelations of students' gender, grade level, class type, and ethnicity and their completion times, scores, and off-task behaviors during the interspersal and control assignments in this study. Grade levels were correlations with dependent variables using Pearson product-moment correlations. Point bi-serial correlations were used to examine the relationship of dependent variables and the descriptors of gender, class type (i.e., students in integrated co-teaching classrooms, n = 60 [with a general education teacher and a special education teacher and/or teacher's assistant in the room the entire day, students may or may not receive extra assistance] *vs.* students in traditional classrooms, n = 6), student type (typical students, n = 46, *vs.* "atypical" students, n = 20 [i.e., students receiving either Committee on Special Education services, academic intervention services, a Section 504 Accommodation Plan, and/or having a diagnosis of attention deficit hyperactivity disorder]), and ethnicity. In the case of ethnicity, the students were coded as having an ethnicity (e.g., being African American (AA)) as a "1" and not having that ethnicity as a "0".

Table 2 shows that students' gender and class type did not relate significantly to any of the dependent measures, nor did Caucasian or Hispanic ethnicity. Grade level, student type (typical or atypical), and African American ethnicity did show some relationships with dependent measures during either control or interspersal assignments or both.

Table 2

Correlations Between Participant Descriptors and Dependent Variables

	Time		Score		VB		VS		K	
Variable	I	C	I	C	I	C	I	C	I	C
Grade	.38**	.37**	-.18	-.03	-.16	-.30	-.24*	-.25*	-.06	-.04
Gender	-.20	-.10	-.01	-.01	-.02	-.22	-.14	-.19	.05	.08
Class Type	-.20	-.11	.02	-.03	-.06	.07	-.01	.00	-.10	-.06
Student Type	-.12	-.20	.59**	.60*	-.24*	-.11	-.46*	-.23	-.34*	-.17
Hispanic	.15	.04	.02	.04	.07	.01	-.03	-.11	.07	.15
AA	.04	.16	-.25*	-.21	-.12	-.03	.05	-.06	-.10	-.04
Caucasian	-.20	-.20	.22	.18	.03	.06	.00	.20	.06	-.11

Note: * $p < .05$; ** $p < .01$, I = Interspersal assignment, C = Traditional assignment, Time = Problem completion rate (for 20 total problems), Score = average score (based on range of 0-100%), VB = Verbal off-task behavior, VS = Visual off-task behavior, K = Kinesthetic off-task behavior (see behavioral definitions above), AA= African American, $N = 66$ for all comparisons

These descriptors were potentially useful as covariates in accounting for performance during the study. So, if a potential descriptive covariate was significantly related to an outcome (problem completion rate, score, VB, VS, K), that variable was included in an analysis of covariance (ANCOVA) to test that hypothesis. Because interspersal (I) and control (C) were repeated measures within participants, a significant correlation with I outcomes or with C outcomes was sufficient for a variable to be included as a covariate in hypothesis testing.

The significant correlation values in Table 2 indicated that Grade level was a potential covariate for assessing Time and VS, so Grade level was included in ANCOVA analyses for Time and for VB. Student type significantly correlated with Score, VB, VS, and K, so it was included as a covariate in ANCOVAs assessing Score, VB, VS, and K. African American ethnicity significantly correlated with Score, so AA was included in ANCOVAs assessing Score.

Hypothesis Testing

The three hypotheses investigated whether additive interspersal would result in significantly higher problem completion rates (HY1), problem accuracy rates (HY2), and off-task behavior rates (HY3). Each hypothesis was tested in two phases. First, a repeated measures analysis of variance (ANOVA) was conducted to determine whether scores from the additive interspersal condition were significantly higher than the control (traditional) condition. Second, an analysis of covariance (ANCOVA) was conducted to determine whether the relationship between assignment type (additive interspersal or control) and outcomes were still evident after controlling for covariates (i.e., gender, grade level, class type, and African American ethnicity).

Next, data was analyzed from four consecutive student surveys to determine student preference for the two types of assignments. The data were analyzed using descriptive measures, as well as paired *t*-scores based on the week of the study. Last, survey data from the teachers reflecting their opinions of the study overall was analyzed using descriptive measures.

Hypothesis 1 (HY1). Hypothesis 1 stated that the independent seatwork mathematics relative problem completion rates using additive interspersal would be significantly higher than completion rates using traditional mathematics assignment presentation. Time to Completion descriptives are presented by grade level in Table 3. Grade 3 participant Time to Completion averaged 27.51 (SD = 9.12) in the interspersal condition and 29.83 (SD = 8.04) in the control condition. Grade 4 Time to Completion averaged 21.83 seconds (SD = 4.61) in the interspersal condition and 27.55 (SD = 7.62) in the control condition. Grade 5 participant Time to Completion averaged 35.02 (SD = 11.01) in the interspersal condition and 40.03 (SD = 14.77) in the control condition.

Table 3

Time to Completion Descriptives by Grade Level

		Interspersal		Control	
Grade	N	Mean	SD	Mean	SD
3	12	27.51	9.12	29.83	8.04
4	18	21.83	4.61	27.55	7.62
5	36	35.02	11.01	40.03	14.77
Total	66	30.06	10.88	34.78	13.34

Table 4 and Figure 2 show that time to completion per problem was significantly lower in the interspersed condition (M = 30.06 seconds, SD = 10.88 seconds) than in the control condition (M = 34.77seconds, SD = 13.33 seconds) by repeated measures ANOVA, F (1,65) = 9.02, p < .004.

Table 4

ANOVA Within-Subjects Source Table for Time to Completion (in seconds)

Source	*SS*	*df*	*MS*	*F*	*p*-value
Time	735.00	1	735.00	9.02	0.004
Error(Time)	5296.19	65	81.48		

Note. SS = sum of squares; MS = Mean Square.

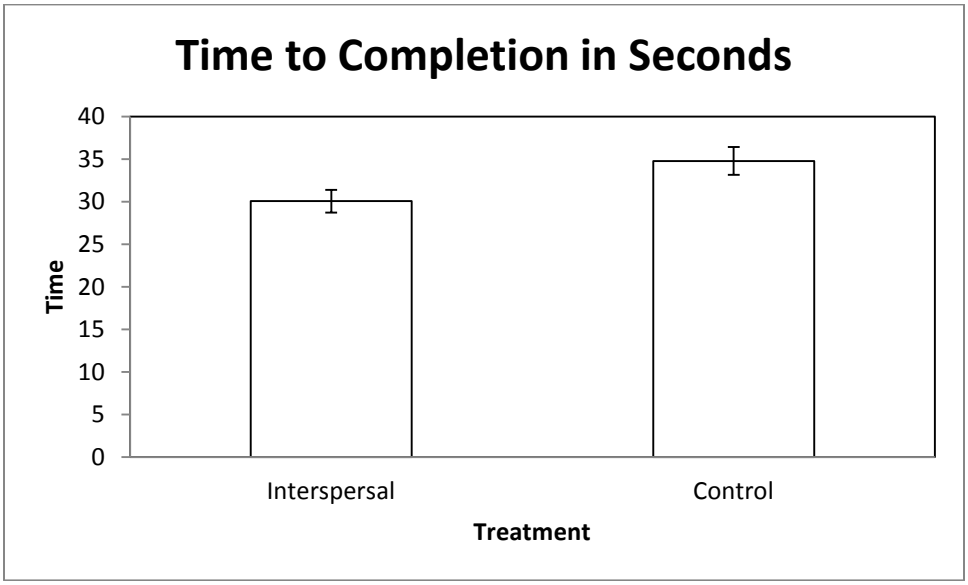


Figure 2. Average time to completion (in seconds) of assignments by interspersal and control conditions.

However, when grade level was accounted for via analysis of covariance (ANCOVA), there was no statistically significant difference was evident between the interspersed condition and the control condition (F (1,64) = 0.001, p = .97) and no significant time x grade level interaction (F (1,64) = 0.24, p = .63) (Table 5). Table 6 shows grade level was significantly related to Time to Completion (F (1,64) = 15.13, p < .0002).

Table 5

ANCOVA Within-Subjects Source Table for Time (in seconds)

Source	*SS*	*df*	*MS*	*F*	*p*-value
Time	0.11	1	0.11	0.001	0.97
Time * Grade	19.79	1	19.79	0.24	0.63
Error(Time)	5276.40	64	82.44		

Note. SS = sum of squared deviations; MS = Mean Square.

Table 6

ANCOVA Between-Subjects Source Table for Time

Source	*SS*	*df*	*MS*	*F*	*p*-value.
Intercept	194.79	1	194.79	1.10	0.30
Grade	2669.09	1	2669.09	15.13	0.0002
Error	11291.99	64	176.44		

Note. SS = sum of squared deviations; MS = Mean Square.

These findings did not support Hypothesis 1, because the additive interspersal procedure did not result in significantly faster time to assignment completion after grade level was controlled.

Hypothesis 2 (HY2). The second hypothesis stated that mathematics problem accuracy rates (i.e., scores) using the additive interspersal presentation would be significantly higher than accuracy rates using traditional mathematics assignment presentation. Score accuracy descriptives are presented by grade level in Table 7. Grade 3 participant Score Accuracy averaged 74.16 (SD = 16.90) in the interspersal condition and 73.33 (SD = 16.90) in the control condition. Grade 4 Score Accuracy averaged 74.60

seconds (SD = 13.87) in the interspersal condition and 73.00 (SD = 13.87) in the control condition. Grade 5 participant Score Accuracy averaged 67.22 (SD = 19.67) in the interspersal condition and 72.05 (SD = 19.67) in the control condition.

Table 7

Score Accuracy Descriptives by Grade Level

		Interspersal		Control	
Grade	N	Mean	SD	Mean	SD
3	12	74.16	16.90	73.33	16.90
4	18	74.60	13.87	73.00	13.87
5	36	67.22	19.67	72.05	19.67
Total	66	70.50	17.89	72.54	17.89

Table 8 and Figure 4 show that scores (on a scale from 0-100%) for the interspersal condition (M = 70.49, SD = 17.89) were not significantly higher than the scores on the control assignments (M = 72.54, SD = 19.25) by repeated measures ANOVA, F (1,65) = 1.67, $p < .20$.

Table 8

ANOVA Within-Subjects Source Table for Score

Source	*SS*	*df*	*MS*	*F*	*p*-value
Time	137.84	1	137.84	1.67	0.20
Error(Score)	5367.16	65	82.57		

Note. SS = sum of squares; MS = Mean Square.

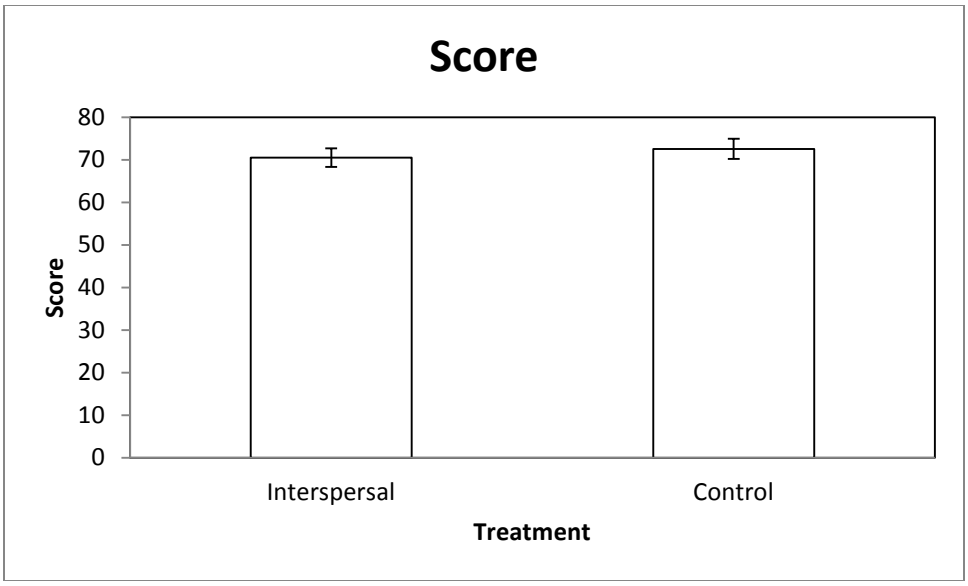


Figure 3. Average scores (on a scale from 0-100%) obtained on interspersal and control assignments over a 16-day time period.

When Student Type and African American ethnicity demographics were accounted for by analysis of covariance (ANCOVA), no statistically significant difference was evident between the interspersed condition and the control condition, F (1,63) = 0.001, p = .98 (Table 9). Non-African-American students averaged 73.12 (SD = 16.62) in the Interspersal condition and 75.44 (SD = 17.86) in the control condition, while African-American averaged 64.47 (SD = 18.97) in the interspersal condition and 67.13 (SD = 20.93) in the control condition. No significant Score * Student Type interaction (p = .47) or Score * African American ethnicity interaction (p = .68) were detected. Atypical students averaged 56.22 (SD = 17.23) in the interspersal condition and 56.82 (SD = 21.13) in the control condition, while Typical students averaged 78.14 (SD = 12.98) in the interspersal condition and 80.95 (SD = 11.49) in the control condition. Table 10 shows that Student Type was a significant covariate (F (1,63) = 38.52, p < .00001) but that African American was not (F (1,58) = 1.50, p = .23).

Table 9

ANCOVA Within-Subjects Source Table for Scores

Source	*SS*	*df*	*MS*	*F*	*p*-value
Score	0.06	1	0.06	0.001	0.98
Score * Student Type	44.89	1	44.89	0.53	0.47
Score * African American	14.69	1	14.69	0.17	0.68
Error(Score)	5315.77	63	84.38		

Note. SS = sum of squared deviations; MS = Mean Square, student type = typical students vs. "atypical" students (i.e., students receiving either Committee on Special Education services, academic intervention services, a Section 504 Accommodation Plan, and/or having a diagnosis of attention deficit hyperactivity disorder).

Table 10

ANCOVA Between-Subjects Source Table for Scores

Source	*SS*	*df*	*MS*	*F*	*p*-value
Intercept	115706.00	1	115706.00	315.54	0.0001
Student Type	14124.09	1	14124.09	38.52	0.0001
African American	548.39	1	548.39	1.50	0.23
Error	23101.25	63	366.69		

Note. SS = sum of squared deviations; MS = Mean Square.

Combined across ANOVA and ANCOVA analyses, these findings suggest that scores on the interspersal assignments were not significantly higher than those on control assignments either before or after demographics were taken into account. Hypothesis 2 was not supported.

Hypothesis 3 (HY3). Hypotheses 3 stated that the on-task behavior rates using additive interspersal would be significantly higher than on-task behavior rates using traditional mathematics assignment presentation. This hypotheses examined three areas of behavior were examined: verbal off-task, visual off-task, and kinesthetic off-task behaviors.

Verbal off-task behavior (VB). Verbal off-task behavior was defined as any time that a student made an utterance to oneself, a peer, or called out to the teacher during the interspersal and control conditions. Verbal off-task behavior (VB) descriptives are presented by grade level in Table 11. Grade 3 participant VB averaged 0.00103 (SD = 0.00177) in the interspersal condition and 0.00060 (SD = .00099) in the control condition. Grade 4 VB averaged 0.00076 seconds (SD = 0.00107) in the interspersal condition and 0.00120 (SD = 0.00124) in the control condition. Grade 5 participant VB averaged 0 00046 (SD = 0.00142) in the interspersal condition and 0.00016 (SD = 0.00034) in the control condition.

Table 11

Verbal Off-Task Behavior Descriptives by Grade Level

		Interspersal		Control	
Grade	N	Mean	SD	Mean	SD
3	12	.00103	.00177	.00060	.00099
4	18	.00076	.00107	.00120	.00124
5	36	.00046	.00142	.00016	.00034
Total	66	.00065	.00140	.00052	.00091

The verbal off-task behaviors (VB) for the interspersal condition (*M* = .0007, *SD* = .0014) were not significantly lower than the VB for the control assignments (*M* = .0005, *SD*= .0009) by repeated measures ANOVA, *F* (1, 65) = 0.64, *p* = .43 (Table 12; Figure 4).

Table 12

ANOVA Within-Subjects Source Table for Verbal Off-Task Behaviors

Source	*SS*	*df*	*MS*	*F*	p-value
VB	0.000001	1	0.000001	0.64	0.43
Error(VB)	0.000051	65	0.000001		

Note. SS = sum of squares; MS = Mean Square. VB = verbal off-task behaviors.

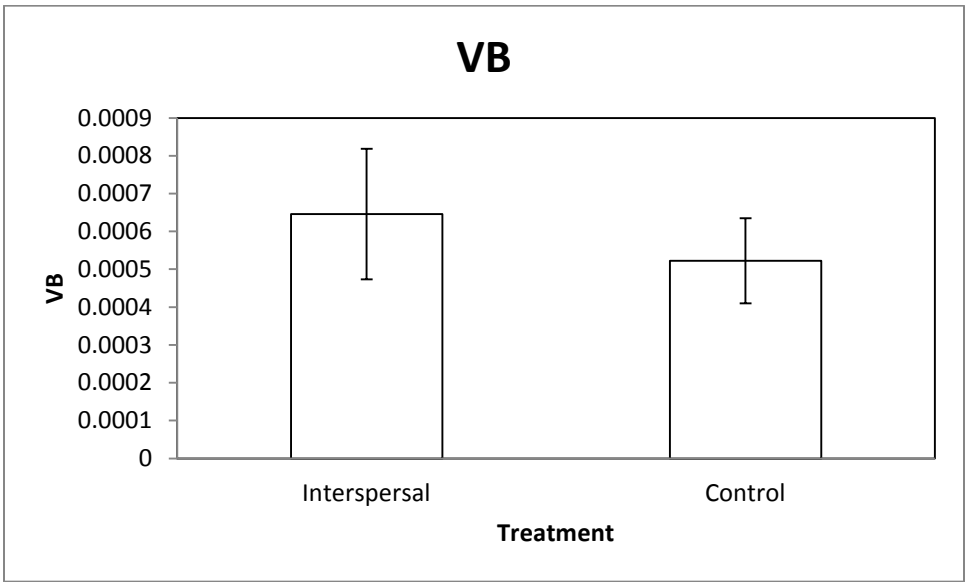


Figure 4. Average verbal off-task behaviors by interspersal and control assignments over a 16-day time period.

ANCOVA revealed no statistically significant difference between the interspersed condition and the control conditions in VB (*F* (1, 64) = 2.97, *p* = .09), and no significant VB * Student Type interaction (*F* (1, 64) = 2.39, *p* = .13) (Table 13).

Table 13

ANCOVA Within-Subjects Source Table for Verbal Off-Task Behaviors

Source	*SS*	*df*	*MS*	*F*	*p*-value
VB	0.000002	1	0.000002	2.97	0.09
VB * Student Type	0.000002	1	0.000002	2.39	0.13
Error(VB)	0.000049	64	0.000001		

Note.. SS = sum of squared deviations; MS = Mean Square. VB = verbal off-task behaviors.

Table 14 shows that VB did not differ significantly according to Student Type (F (1, 64) = 3.14, p = .08). Typical student VB averaged 0.0004 (SD = 0.0007) in the interspersal condition and 0.0005 (SD = 0.0009) in the control condition, while Atypical students averaged 0.0011 VB (SD = 0.0021) in the interspersal condition and 0.0007 (SD = 0.0010) VB in the control condition.

Table 14

ANCOVA Between-Subjects Source Table for Verbal Off-Task Behaviors

Source	*SS*	*df*	*MS*	*F*	p-value
Intercept	0.00004	1	0.00004	18.23	0.0001
Student Type	0.00001	1	0.00001	3.14	0.08
Error	0.00012	64	0.00000		

Note. SS = sum of squared deviations; MS = Mean Square.

Combined across ANOVA and ANCOVA analyses, these findings indicated that VB on the interspersal assignments were not significantly higher than those for control conditions before or after Student Type was taken into account. Hypothesis 3 was not supported by these verbal off-task findings.

Visual off-task behavior (VS). Off-task visual behaviors were defined as any time that a student broke eye contact from his or her paper while the student was expected to be completing the assignment. Off-task visual behaviors (VS) on the interspersal assignments did not decrease significantly compared to off-task visual behaviors on the control assignments after demographics were taken into account. Visual off-task behavior (VS) descriptives are presented by grade level in Table 15. Grade 3 participant VS averaged 0.00814 (SD = 0.00661) in the interspersal condition and 0.03527 (SD = .09760) in the control condition. Grade 4 VS averaged 0.00634 seconds (SD = 0.00394) in the interspersal condition and 0.00907 (SD = 0.01027) in the control condition. Grade 5 participant VS averaged 0.00500 (SD = 0.00476) in the interspersal condition and 0.00486 (SD = 0.00591) in the control condition.

Table 15

Visual Off-Task Behavior Descriptives by Grade Level

		Interspersal		Control	
Grade	N	Mean	SD	Mean	SD
3	12	.00814	.00661	.03527	.09760
4	18	.00634	.00394	.00907	.01027
5	36	.00500	.00476	.00486	.00591
Total	66	.00593	.00501	.01154	.04229

VS for the interspersal condition (*M* = .006, *SD* = .005) was not significantly lower than VS on the control assignments (*M* = .011, *SD*= .042) by repeated measures ANOVA, *F* (1,65) = 1.23, *p* = .27 (Table 16; Figure 5).

Table 16

ANOVA Within-Subjects Source Table for Visual Off-Task Behaviors

Source	*SS*	*df*	*MS*	*F*	*p*-value
VS	0.001	1	0.001	1.23	0.27
Error(VS)	0.055	65	0.001		

Note. SS = sum of squares; MS = Mean Square.

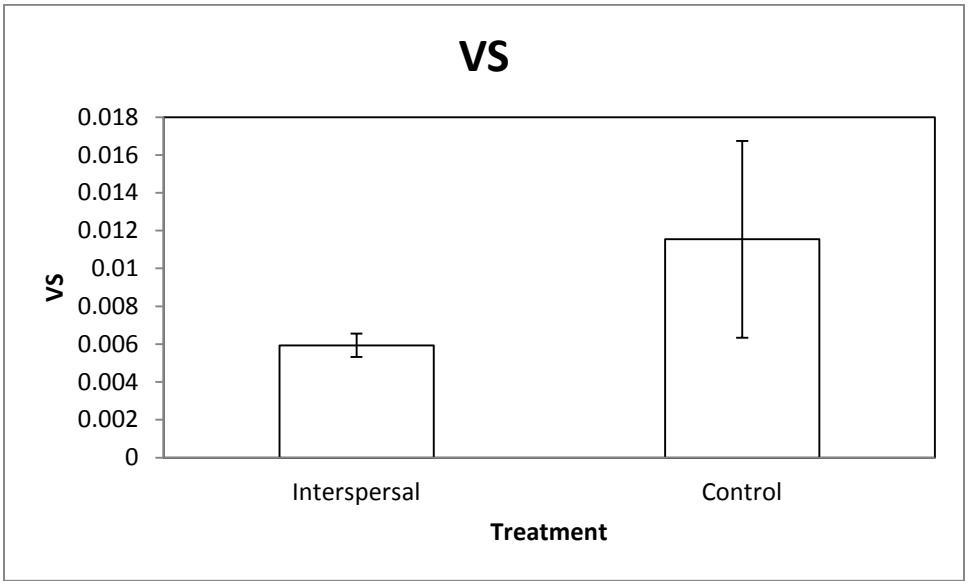


Figure 5. Average visual off-task behaviors by interspersal and control assignments over a 16-day time period.

However, VS was significantly lower in the interspersal condition compared to control when Student Type and Grade level were accounted for via ANCOVA, (*F* (1, 63) = 5.28, *p* = .02). The VS * Grade level (*F* (1, 63) = 3.37, *p* = .07), and VS * Student Type (*F* (1, 63) = 2.14, *p* = .15) interactions were not significant (Table 17). Atypical students

averaged 0.009 VB (*SD* = 0.006) in the interspersal condition and 0.025 (*SD* = 0.071) VS in the control condition. Table 18 shows that Grade level (F (1, 63) = 4.91, $p < .03$) and Student Type (F (1, 63) = 5.23, $p < .03$) were each statistically significant.

Table 17

ANCOVA Within-Subjects Source Table for Visual Off-Task Behaviors

Source	*SS*	*df*	*MS*	*F*	*p*-value
VS	0.004	1	0.004	5.28	0.02
VS * Grade	0.003	1	0.003	3.37	0.07
VS * Student Type	0.002	1	0.002	2.14	0.15
Error(VS)	0.050	63	0.001		

Note. SS = sum of squared deviations; MS = Mean Square. VS = visual off-task behaviors.

Table 18

ANCOVA Between-Subjects Source Table for Visual Off-Task Behaviors

Source	*SS*	*df*	*MS*	*F*	p-value
Intercept	0.009	1	0.009	10.51	0.001
Grade	0.004	1	0.004	4.91	0.03
Student Type	0.005	1	0.005	5.23	0.03
Error	0.054	63	0.001		

Note. SS = sum of squared deviations; MS = Mean Square.

Off-task visual behaviors were significantly lower on interspersal assignments compared to control assignments, but only when Grade level and Student Type demographics were taken into account. These findings supported Hypothesis 3 for VS.

Kinesthetic off-task behavior (K). Kinesthetic off-task behaviors (K) were defined as any time that a student broke contact with his or her seat to move around or walk around, accompanied by not working on the assignment. Kinesthetic off-task behavior (K) descriptives are presented by grade level in Table 19. Grade 3 participant K averaged 0.00015 (SD = 0.00040 in the interspersal condition and 0.0 (SD = 0.0) in the control condition. Grade 4 K averaged 0.00002 seconds (SD = 0.00009) in the interspersal condition and 0.00015 (SD = 0.00053) in the control condition. Grade 5 participant K averaged 0.00008 (SD = 0.00024) in the interspersal condition and 0.00002 (SD = 0.00006) in the control condition.

Table 19

Kinesthetic Off-Task Behavior Descriptives by Grade Level

		Interspersal		Control	
Grade	N	Mean	SD	Mean	SD
3	12	.00015	.00040	0.0	0.0
4	18	.00002	.00009	.00015	.00053
5	36	.00008	.00024	.00002	.00006
Total	66	.00007	.00025	.00005	.00028

As Table 20 and Figure 6 demonstrate, the kinesthetic off-task behaviors for the interspersal condition (M = .00007, SD = .0002) were not significantly lower than the kinesthetic off-task on the control assignments (M = .00005, SD = .0003) by repeated measures ANOVA, F (1,58) = .32, p = .58.

Table 20

ANOVA Within-Subjects Source Table for Kinesthetic Off-Task Behaviors

Source	*SS*	*df*	*MS*	*F*	*p*-value
K	0.00000002	1	0.00000002	0.32	0.58
Error(K)	0.00000457	65	0.00000007		

Note. SS = sum of squares; MS = Mean Square.

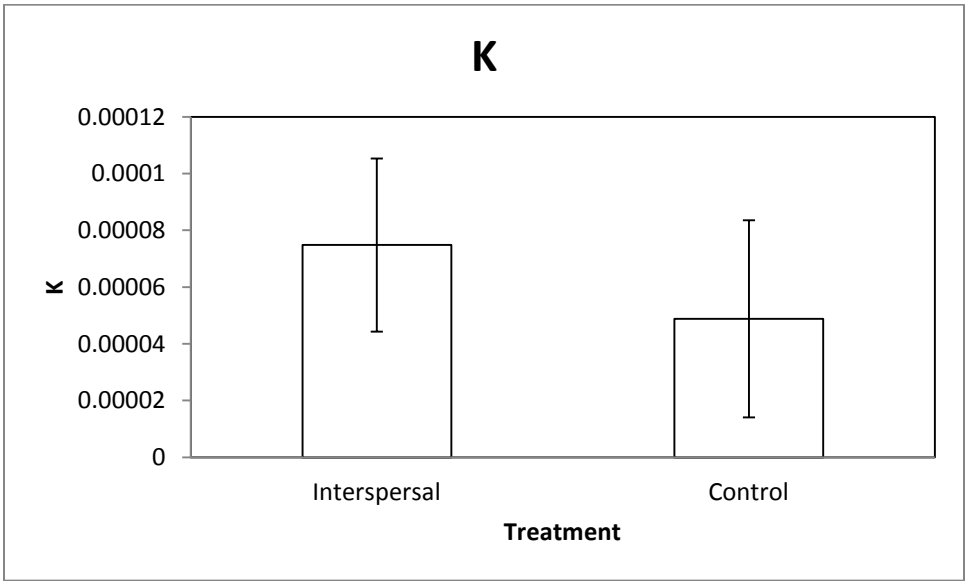


Figure 6. Average kinesthetic off-task behaviors by inetrspersal and control assignments over a 16-day time period.

ANCOVA revealed no statistically significant difference for kinesthetic off-task behavior between the interspersed condition and the control condition (F (1,64) = 0.33, p = .33) and no significant K * Student Type interaction (F (1,64) = 0.64, p = .43) (Table 21).

Table 21

ANCOVA Within-Subjects Source Table for Kinesthetic Off-Task Behaviors

Source	*SS*	*df*	*MS*	F	*p*-value
K	0.00000007	1	0.00000007	0.96	0.33
K * Student Type	0.00000005	1	0.00000005	0.64	0.43
Error(K)	0.00000453	64	0.00000007		

Note. K is an abbreviation for kinesthetic off-task behavior.

Typical student K levels averaged 0.00001 (*SD* = 0.00006) in the interspersal condition and 0.00001 (*SD* = 0.00007) in the control condition, while Atypical students averaged 0.00019 K (*SD* = 0.00039) in the interspersal condition and 0.00011 (*SD* = 0.00047) in the control condition. Table 22 shows that Student type was statistically significant, (F (1,64) = 8.95, *p* = .004).

Table 22

ANCOVA Between-Subjects Source Table for Kinesthetic Off-Task Behaviors

Source	*SS*	*df*	*MS*	*F*	*p*-value
Intercept	0.00000105	1	0.00000105	16.66	0.0001
Student Type	0.00000057	1	0.00000057	8.95	0.004
Error	0.00000404	64	0.00000006		

Note. K is an abbreviation for kinesthetic off-task behavior.

This analysis suggests that kinesthetic off-task behaviors on the interspersal Off-task kinesthetic behaviors on the interspersal assignments did not decrease significantly compared to kinesthetic off-task behaviors on the control assignments after

Student Type was taken into account. Therefore, HY3 was not supported by these kinesthetic off-task findings.

In sum, only one of the three off-task behaviors (i.e., VS) was significantly less during interspersal than control assignments. Thus, there was some support for Hypothesis 3. Students "kept their eyes on their papers" more frequently during interspersal tasks, but their verbal and motor off-task behaviors did not differ by conditions.

Hypothesis 4 (HY4). Hypothesis 4 stated that students would rate the additive interspersal assignments as being significantly easier and more preferred than the traditional mathematics assignments.

Once per week, participating students were given a survey during which they indicated on a 4-point Likert scale how much they liked the control and interspersal assignments and how easy they thought the control and interspersal assignments were to complete. The Likert scale ranged from "1" (*Disagree*) to a "4" (*Agree*). The survey was voluntary, and an overall average of 63% (166 out of a possible 264) of the surveys were returned.

The resulting data were examined first using descriptive statistics. After that, a chi-square analysis was used to determine whether the 4 questions differed from one another on student descriptive variables. However, as 25% or more of the cells had less than the expected count, this analysis was deemed unsuitable. Therefore, paired sample *t*-tests were used to compare the means of the answers to the questions from week to week. Last, in order to double-check the accuracy of the *t*-tests, a non-parametric test (Wilcoxon Signed Rank) was employed, based on the rankings of each of the questions.

The results showed that the percentage of surveys completed each week ranged from 61% (39 out of 66) to 71% (46 out of 66), with a mean score of 63%. In answer to the question about whether students liked questions on days that a "C" was on top of their paper, 44.3% (n = 74) of students responded with a "4" (Agree). The mean for this question was 3.13 (SD = .94). On the question that asked whether students found the questions easier when a "C" was on the top of the paper, 42.8% of students (n = 74) answered "4" (Agree"). The mean for the question was 3.24 (SD = .83). When asked whether the students liked the assignments that had an "I" on the top, 43.4% of students (n = 75) responded with a "4" (Agree). The mean for the question was 3.03 (SD =1.01). When asked whether they thought the questions with an "I" on top of the paper were easy, 43.4% of students (n = 75) answered with a "4". This question had a mean of 3.14 (SD = .91). Figures 7 and 8 show the comparisons between the conditions by week with means and standard errors.

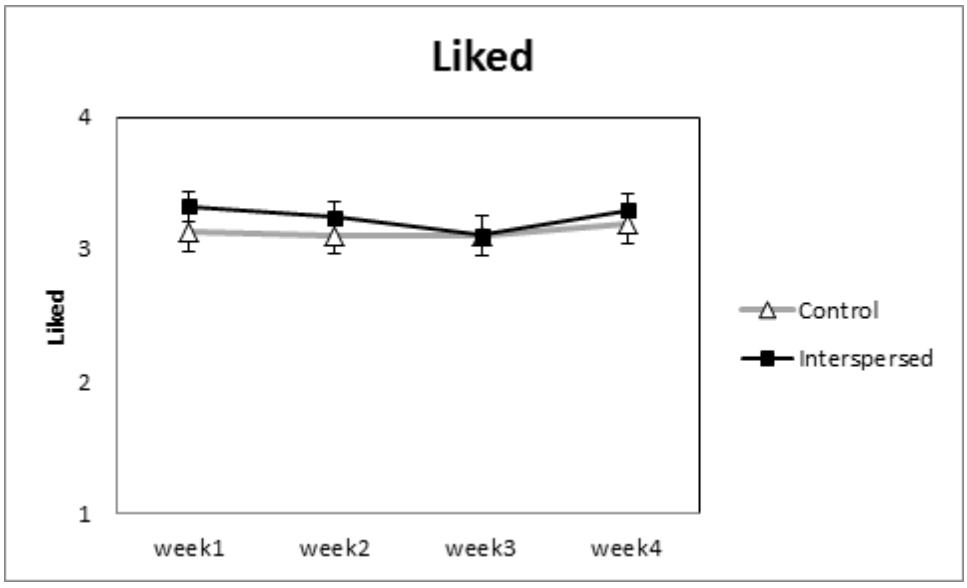


Figure 7. Student preference ratings on student survey by week (means and standard errors).

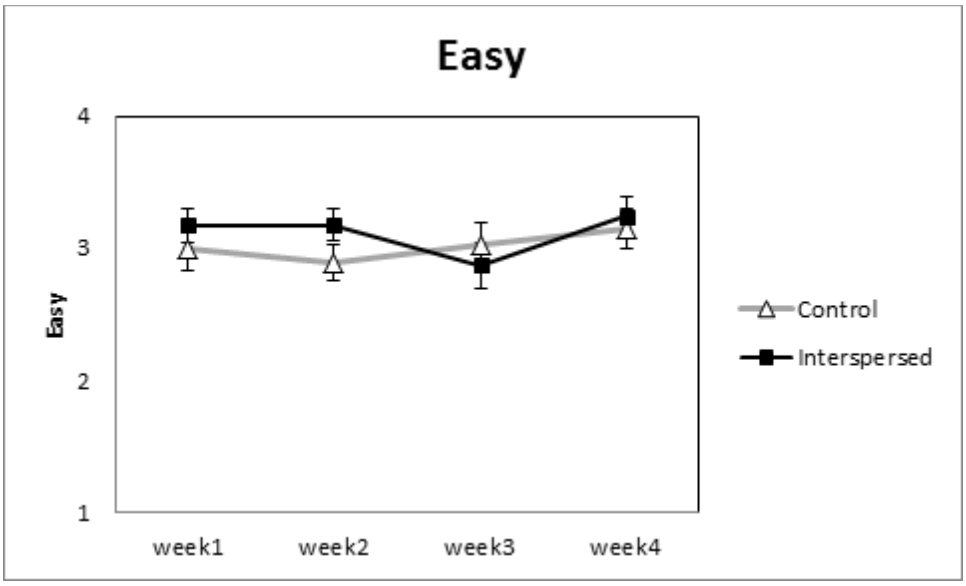


Figure 8. Student easiness ratings on student survey by week (means and standard errors).

Appendix Q shows the breakdown of responses for each question on the student preference survey. Comments from students included, "I enjoyed being part of this study.", "So far I like the study because it's more math practice and it's what we learn during math class.", "I think that this study helps me learn math more and makes it easy for me.", "This is very easy.", and "I forgot which had "I" and which had "C" on them."

These figure results suggest that students preferred both the control assignments and the interspersal assignments. When paired *t*-tests were employed to compare ratings, there were no significant differences between the control and interspersal assignments, even when they were examined week-by-week.

Therefore, HY4 was not supported by the present study, because students did not indicate a significant preference for the interspersal assignments over the control assignments.

Other findings. After the last study day, the five participating teachers also completed a survey. The survey examined eight areas that Gresham (1989) suggested to evaluate teacher acceptability of classroom interventions. The Likert-scale ranged from "1" (*Strong disagreement*) to "6" (*Strong agreement*). The results presented in Table 18 show that overall the teachers did not believe that the interspersal intervention was too complex (M = 2.2, SD = 1.6), reverse scoring because of negative wording) and they believed that it did not take too much time (M = 1.6, SD = .55). The teachers felt that they had the necessary means and materials to carry out the intervention on their own (M = 5.2, SD =.84). Teachers felt motivated to try the interspersal intervention (M = 4.8, SD =.50) and did not feel that too many people were required to effect the intervention (M = 2.6, SD = 2.16). Appendices R and S show the means and respective summary of answers to the teacher survey. Overall, the teachers ratings were positive regarding their acceptance of the interspersal technique.

Summary. The three hypotheses that suggested that using interspersal assignments for math seatwork would result in significantly higher rates of problem completion, higher scores, and less off-task behavior were generally not supported by the data, with the exception that visual off-task behavior was significantly lower on the interspersal assignments compared to controls assignments. Interspersal and control assignments otherwise yielded generally similar results. The hypothesis of an advantage of interspersal assignments over control assignments in student-rated likability and easiness was not supported. Teacher acceptance survey responses were positive in nature, suggesting that teachers felt optimistic regarding the interspersal procedure.

CHAPTER V

Discussion

The "No Child Left Behind" Act indicates that "America's schools are not producing the math excellence required for global economic leadership and homeland security in the 21st century" (NCLB, p.16). At the time of the enactment of the law, only about one-quarter of fourth through eighth graders were meeting grade-level expectations in the area of mathematics. Evidence-based approaches to assist students in improving mathematics performance remain relatively undefined. Thus, this study looked at whether using an interspersal procedure during independent mathematics work time would improve student problem completion rates, accuracy rates, and on-task behaviors in the classroom. Also, it was conjectured that students would prefer the interspersal assignments significantly more than the control assignments and would also find them easier to complete. None of these hypotheses were supported upon analysis of the study data. Below is a discussion of each of the hypotheses and other specific findings of this study.

Interpretation of Results

Problem completion rates. Students' problem completion rates on interspersal assignments were predicted to be significantly faster than on the control assignments based on theories such as the matching law (Herrnstein, 1961), behavioral momentum (Nevin, 1974), and the discrete task completion hypothesis (Skinner, 2002). Previous studies supported these theories by demonstrating how the interspersal procedure helped students work faster on independent assignments (Billington & Skinner, 2002; Cates & Skinner, 2002; Logan & Skinner, 1998, 1999; Skinner et al., 1999). The results of this study did not support the theories and did not replicate previous findings. Differences existed between

the participants and assignments in this study and those chosen by the other investigators. Although the items presented during this study were teacher chosen and therefore deemed to be appropriate for the student participants, no significant differences were found between assignment types and problem completion rates. This suggests that the rates of reinforcement on the interspersal assignments were not adequate enough for the students in the current study to result in better completion rates.

Accuracy rates. The interspersal procedure was predicted to assist students in increasing their accuracy rates on target items based on previous research (e.g., Banda et al., 2007; Skinner et al., 1999; Wildmon et al., 1998, 1999). This hypothesis was not supported as student accuracy rates on interspersal assignments showed no significant increase over assignment accuracy rates on control assignments. The previous studies had participants that were older than the ones in the current study and presented assignments that were not grade-appropriate. A previous study conducted by McDonald (2007) also found no significant differences in problem completion rates and employed an age group close to the current study's age group and actual classroom assignments. During the current study, teachers who had classes participating in the study noted that they usually introduce new topics that will be worked on the following year and review previously learned materials at the end of the year. Rhymer et al. (2002) found that students had better accuracy rates on easier tasks than more difficult tasks. The current study may have had assignments that were more difficult for students than those used in previous studies, thereby not reflecting a good match between the effort required by students and reinforcement received during the interspersal assignments.

On-task behaviors. It was hypothesized that the on-task behavior rates of students working on interspersal assignments would be significantly higher than the on-task behaviors of students working on control assignments. The current study suggests that there was a significant increase in visual on-task behaviors when students were working on the interspersal assignments. The other two behavior categories did not show significant results within the data. These findings concur with those found by McCurdy et al. (2001), Skinner et al. (2004), and Wildmon et al. (1999) during their studies. Students in the current study appeared to have a good match between the effort required to complete the tasks and the level of inherent reinforcement (Herrnstein, 1961; Skinner, 2002). This was demonstrated by the significant increase in the visual on-task behavior when students were working on the interspersal assignments. This finding is important since students in the study kept their visual attention tuned in to the assignments. Although accuracy rates and problem completion rates did not increase, sustained visual attention while employing the interspersal procedure may lead to increased mastery of academic tasks for students.

Ethnicity was not found to be a significant predictor for time, score, verbal off-task behavior, visual off-task behavior, or kinesthetic off-task behavior. No significant time x ethnicity, score x ethnicity, visual off-task behavior x ethnicity, verbal off-task behavior, or kinesthetic off-task behavior x ethnicity interactions were detected.

Student perceptions. The current study sought to determine whether students would prefer completing interspersal assignments more than completing control assignments. Also, this investigation looked at whether students thought that the interspersal assignments were easier than the control assignments. Student preference ratings via a 4-point Likert scale suggested that students rated the interspersal and control

assignments statistically similar to one another on aspects of preference and easiness. McDonald's (2007) study had similar findings because students did not indicate a preference for the interspersal assignments. In the past, student preference was frequently judged by asking student participants to choose a hypothetical homework assignment, rather than asking them to complete a survey (Skinner, 2002). Also, the exposure to the interspersal and control assignments ranged from one to only a few times. Also, as most of the previous studies gave students exposure to each condition only one to a few times, students in the current study may have exhibited a fatigue effect to each of the conditions.

Teacher acceptability. All five teachers returned the teacher acceptability survey. The survey examined eight areas that were suggested by Gresham (1989) to see whether classroom intervention were acceptable. The results suggested that overall the intervention was not too complex, did not require too many people to do the intervention and did not take too much time. Teachers felt that they had the necessary means and materials to carry out the intervention on their own and felt motivated to try the interspersal intervention. Overall, the teachers ratings were positive regarding the interspersal technique.

Strengths of the Present Study

The present study expanded and extended previous research in several areas. First, the current study used a very diverse student population. The participants involved in this study were 73% non-Caucasian. No previous studies have employed such a varied population. Also, 30% of the student participants were either receiving special education services (18%), academic intervention services (3%), or had a Section 504 Accommodation Plan in place (9%). Fifteen percent of the students (who may have also received the above services) were diagnosed with attention deficit hyperactivity disorder.

This participant make-up is truly unique for a study using the interspersal procedure. The combination of a prolonged study duration (16 days) within an applied (classroom) setting using authentic assignments (assignments the teachers would have been using) makes it distinctive among studies examining the interspersal procedure. Last, the breakdown of on-task behaviors into three areas (i.e., verbal, visual, and kinesthetic behaviors) is an unprecedented method of analysis for the study of the interspersal procedure.

Limitations of the Present Study

When studies are conducted in applied settings, circumstances may arise that necessitate a change in procedures during the study. Such occurrences may limit the validity and reliability of the outcomes of the study. Several limitations emerged throughout the present study that may limit its generalization to other settings and may have affected the results. The limitations of the current study are discussed below.

Human factors. As previously mentioned (p. 79), the research assistants mistakenly handed out the wrong assignments to specific students on certain days. Although the percentage of time that this happened was only found to be 1% for the length of the study, this occurrence may have disrupted the randomization of the assignments.

Lack of true baseline measure. Baseline data were not obtained. The teachers, without the investigator's knowledge, gave the students easier assignments during the first 3 days that the research assistants were in the classrooms. The resulting means and standard deviations were significantly higher than any of the interspersal and control assignment means on all dependent measures. Therefore, this time period was used exclusively as an "acclimation" phase prior to starting the formal study.

Timing of study. Another substantial limitation of the present study was that it took place at the end of the school year (during the month of June). The timing of the study may have influenced the motivation level of the students who participated, thereby decreasing the accuracy levels and problem completion rates on the assignments. Although the students did not indicate displeasure to the research assistants, several teachers mentioned to the research assistants that the students were "done with the year". Because the school year was “done”, students may not have tried their best to complete work in a timely fashion and with typical accuracy.

Content of assignments. After discussing the topics with the research assistants, the teachers shared that at the end of the year, new concepts are introduced, and they conduct an overall review of the year’s mathematical concepts. The variation of the assignments at the end of the year may have influenced accuracy and problem completion rates throughout the length of the study.

A related limitation of the study had to do with assignment topics throughout the 16 days. The topics changed several times in each class throughout the study. Unlike other studies that kept with the same mathematical topic (e.g., 2-digit by 1-digit multiplication for each session), this study used authentic assignments given by the teachers and therefore the topics were not able to be controlled by this investigator. This lack of control over the assignments may have affected the study results. Also, as previously mentioned, assignments were deemed by teachers to be generally more difficult at the end of the year, as new concepts for the following year were being briefly introduced. Acclimation phase assignments, however, were judged by teachers to have been easier for students, as they had likely mastered these topics. As Rhymer et al. (2002) suggested, students tend to

perform better when tasks are easier. Hua (2008) noted that "a response that requires more effort may also take longer to complete, thus delaying the delivery of reinforcers" (p. 46). Therefore, it would be consistent with the discrete task completion hypothesis, matching law, and behavioral momentum theory that students would not prefer the interspersal assignments over the traditional assignments if there were no differences detected between the rates of problem completion. Item difficulty perceptions of individual students may have affected the results of this current study.

Choice of measurement. McDonald (2005, 2007) assessed accuracy levels by noting digits correct rather than problems correct. She found this measure to be a far more sensitive way to assess accuracy, because students were able to access credit for partially correct answers. In the current study, problems correct were tabulated, with no partial credit given to students. If partial credit had been awarded, student accuracy scores might have been elevated and perhaps, an effect between the accuracy rates on the interspersal and control assignments would have been detected.

Although the research assistants were trained to observe students during the assignment completion, the operational definitions may not have been precise enough to detect verbal and kinesthetic behaviors that were occurring during assignment completion. Discussion with the research assistants during the study led to the conclusion that, occasionally, verbal and kinesthetic off-task behaviors would occur during the assignment completion that were not able to be coded using the given definitions (e.g., student using the restroom for a long period of time, student raising hand and waiting for teacher to come over to answer question). In these two instances, research assistants coded each behavior only one time. When the total behavior occurrences for each child were divided by the

overall time period of assignment completion for each student, the resulting off-task behavior percentage was not reflective of how long the children engaged in such a behavior. The level of precision of the operational behavior definitions may have affected the results of this study, as well as the observation technique used. A related limitation involves the method of inter-rater agreement. Although the research assistants who completed the observations were trained and calibrated to agreement of over 80% prior to the study, they each observed half of the students in each room during the actual study. The raters observed the same students for both the interspersal and control conditions across the 16-day study period. The third observer was assigned one student from each half of the students in each room during each of ten (10) observations (20 students total), and demonstrated agreement above 80% with the daily raters. However, because the daily raters were not observing the all of the students each day, a complete inter-rater reliability assessment was not possible for all observations in the present study.

On the student survey, it appears as if carryover effects (Barlow & Hayes, 1979) may have been present for some of the student participants, as a few students noted their confusion over the assignment type when giving a comment. For this age group, a forced-choice format for the student survey may have worked better. McDonald and Ardoin (2007) completed a study during which students circled whether they felt either the interspersal assignment or control assignment was easier and preferred. Using a procedure similar to that used by McDonald and Ardoin (2007) may have increased the reliability of student answers on the preference survey.

Incompatibility with matching law. The present study was not a true test the matching law theory. The assignments given to the students in the present study were

teacher designed and corresponded to the curriculum for each grade. In order to test the matching law theory, the assignments would need to be tailored to each individual student's ability level. In the present study, students may have found the presented tasks too easy or too difficult to complete, and therefore did not find the interspersed items to be reinforcing. For these reasons, the present study was not a true test of the matching law.

Areas for Future Research

The current study provided some support for the previous positive findings relating to the increase of on-task behaviors seen with the interspersal procedure. However, research regarding the increase in accuracy rates and problem completion rates was not supported. Therefore, several future research topics emerged. First, this study may have had different results if the study dates did not coincide with the end of the school year. As previously mentioned, this timing led to more difficult mathematics topics being introduced, as well as possible reduced motivation from students. Most investigators did not describe the time of year during which they completed their studies. In one study, Burns et al. (2009) discussed that the study took place in the fall. That study did not support the interspersal treatment as an effective intervention when it was compared to another treatment. Future investigators should not conduct interspersal studies during times in the year (i.e., end of semester, before holidays) when students are less likely to be focused on schoolwork.

Since the timing of the study may have coincided with lessened student motivation to work and since the study used more difficult target problems, future researchers may wish to examine the interspersal procedure while manipulating either student motivation

levels (perhaps by offering incentives to students) and/or controlling the difficulty of target problems.

Future investigators may wish to make indicators on students' assignments (i.e., "I" or "C") larger or focus students' attention to the letters, so that carryover effects do not occur and survey preferences may be accurately revealed. Since 31.8% of students indicated that they did not like the interspersal assignments (i.e., rating of "1" or "2"), further investigations could determine what it is about the interspersal assignments that some students do not like. More specific student survey questions involving preference for the length of assignment, time it took a student to complete the assignment, and other factors may allow investigators to get a clearer picture of why some students do not prefer interspersal assignments. A different type of structure for the survey (such as the forced choice method used by McDonald and Ardoin, 2007) may be more effective to obtain student opinions.

Premack (1959) suggested that people would be motivated for a task if the following task was desirable. During the present study, no assessment was made of the individual items that immediately preceded or followed the interspersed items. Future researchers may choose to assess individual items towards assessing the efficacy of additive interspersal.

Computerized adaptive testing (CAT) is gaining popularity for use with high-stakes testing instruments, including the SAT, LSAT, and GRE examinations (Van der Linden & Glas 2000; Wainer, 2000) In CAT, a calibrated test bank of examination items are utilized to optimize the determination of the ability level of the student. Future researchers may choose to assess the additive interspersal technique using CAT. In the present study, some

lower ability students may have not found the easier items to be reinforcing and some of the higher ability students may have found the easier items to be offensive. Future research into CAT and additive interspersal may wish to focus on the reactions of both high and low ability students to the perceived easier items. A pilot study may be helpful to test assignment items to determine whether they are difficult or easy items and what the student's reactions are to each of the items.

Future investigators may choose to explore a wider variety of observational techniques and operational definitions of off-task behaviors for assessing additive interspersal. It is possible that different operationalized behavior definitions would have resulted in different results regarding the effect of additive interspersal.

Implications for Educators

The present study suggests implications for the field of education. First, educators who choose to employ the interspersal procedure need to remain aware of the limitations of this study. Therefore, teachers should consider the time of school year and motivation level of their individual groups of students prior to attempting this technique. In the current study, the time of year and resultant report from teachers that the students were "done" with the year may have led to a reduction in motivation of the students involved. New procedures and techniques may be more effective if used during other times during the school year (e.g., beginning of school year).

The participant group used in this current study was new to the area of interspersal research, educators may wish to attempt this technique with students whose demographics are outside of the realm of this study. The current study included a very diverse set of participants; with a wide range of ethnicities represented; as well as different grade levels,

and students receiving various types of school assistance. Previous studies (Banda et al., 2007; Skinner et al., 1999; Wildmon et al., 1998, 1999) and a meta-analysis of the interspersal procedure (Skinner, 2002) have demonstrated success using the interspersal technique with students of different ages (i.e., sixth grade, high school, college students), ethnicities (i.e., majority of other studies' participants were Caucasian), and services received in school. Having future participants with different demographics than those seen in the current study may yield results generalizable to other student populations.

The interspersal procedure is predicted to be effective due to its reinforcing properties for students (Skinner, 2002). The current results, however, suggest that some students may not increase their accuracy and problem completion rates because of the reinforcing properties of the assignment alone. So teachers should consider using external reinforcers to increase student performance, as well.

In the field of education, teachers actively seek to find techniques and procedures that will help increase the learning and productivity of their students. The interspersal procedure was rated as acceptable to teachers and not disliked by students in the current study. In addition, the technique was found to significantly increase student visual on-task behavior. This technique should continue to be explored by researchers in the disciplines of educational and school psychology in order to support those educators who are in the field.

Appendix A

Superintendent's Letter of Permission to Conduct Study

PINE BUSH CENTRAL SCHOOL DISTRICT

Philip G. Steinberg, Superintendent of Schools
Deborha Brush, Assistant Superintendent for Administrative Services
Joan M. Carbone, Assistant Superintendent for Instruction

Mission Statement
Our mission is to prepare students for success in life

March 22, 2010

CUNY Graduate Center
Institutional Review Board
365 Fifth Avenue
New York, New York 10016

To whom it may concern:

I am writing this letter to support the project of Teresa A. Hatfield, school psychologist in the Pine Bush Central School District. Teresa is working on completing her final study at Pakanasink Elementary School entitled *"Use of an Interspersal Techniques to Enhance Work Completion Rate, On-task Behavior, and Accuracy on Independent Math Assignments.*

Mrs. Donna Geidel, Principal and I are supportive of Ms. Hatfield's project, and we intend to cooperate with her to see her project completed.

If you have further questions, please feel free to contact me.

Sincerely,

Philip G. Steinberg
Superintendent of Schools

cc: Donna Geidel, PAK Principal
Teresa Hatfield

PO Box 700 / 156 Route 302 / Pine Bush, NY 12566 / (845) 744-2031 / FAX (845) 744-6189
www.pinebushschools.org

Appendix B

School Principal's Letter of Permission to Conduct Study

PAKANASINK ELEMENTARY SCHOOL

"Learning and Living Go Hand In Hand"

P.O. Box 148
Circleville, NY 10919
(845) 744-2031, Ext. 5700
Donna Geidel, Principal

March 15, 2010

CUNY Graduate Center
Institutional Review Board
365 Fifth Avenue
New York, NY 10016

To Whom It May Concern:

I am writing to inform you that as the Principal of Pakanasink Elementary School, I have granted Teresa Hatfield permission to conduct her study entitled, Use of an Interspersal Technique to Enhance Work Completion Rates, On-Task Behavior, and Accuracy on Independent Mathematics Assignments", in our school. She will anonymously solicit teachers to participate in her study and she has assured me that she will gain appropriate parental permission and student assent before her research assistants begin their data collection. Mrs. Hatfield is a very valuable asset to our school and I am happy to support her in her pursuit of a doctoral degree. If you have any further questions, you may contact me at (845)744-2031, Ext. 5700.

Sincerely,

Donna Geidel

Donna Geidel
Principal
Pakanasink Elementary School

Appendix C

Script for Faculty Presentation to Request Participants

"As you may know, I am in the process of completing my doctoral dissertation at the City University of New York- Graduate Center. In May and June 2010, I will be beginning a study aimed at third through fifth grade students in an effort to determine whether a particular instructional technique can help improve student performance during independent math seatwork. Specifically, I will be taking math problems that you were already going to assign students and intersperse easier, briefer items after every third problem. I want to find out if this change in an assignment will help students with their on-task behavior, work completion rates, and accuracy.

"As I am an employee of this school, I will have to use research assistants to collect my data for me and be present in the classrooms during the study sessions. Their presence may cause you to feel uncomfortable at times. However, the study may yield good information that can assist you in your classroom in the future.

"At no time will I be made aware of you or your students' names and/or choice to participate. All names and classroom identifiers will be coded so that you and your students' identities may remain confidential.

"I will now hand out a letter further specifying the particulars of the study. If you would like to participate, please read the information thoroughly and sign where indicated. I will have a special mailbox slot for you to place your completed consent form in. It will be located in the Main Office with the other mailboxes.

"Please contact one of the research assistants through the mailbox slot with any questions or concerns that you may have. One of them will discuss your question or concern with me in a confidential manner. Thanks for listening!"

Appendix D

Teacher Consent Form for Participation in Study

May 2010

Dear Pakanasink Elementary Teacher:

Your voluntary assistance for a study entitled "Use of an Interspersal Technique to Enhance Work Completion Rates, On-Task Behavior, and Accuracy on Independent Math Assignments" is requested for May/June 2010. Your assistance will involve you allowing me to use your daily independent math work as a template and change some of the assignments to include easier, briefer items every 3rd problem. Either your original assignment (retyped onto copy paper) or the altered assignment will be presented to your students on a daily basis. You will be asked to grade the assignments, using a prepared key that I will provide. This study will take approximately three weeks to complete and will use classroom materials that were already going to be employed. At the end of the study, you will be asked to give your input regarding the study and the assignments by circling your answers on a short survey.

In order to minimize the possible effects of coercion (as I, in addition to being the School Psychologist at Pakanasink Elementary School, am also the principal investigator of this study), I will not be aware of your choice to participate during any part of the study. All identifying information regarding yourself and your students will be coded for privacy and kept confidential at all times in a locked cabinet in the Nurse's Office that will only be accessible to the research assistants. Identifying information of the study participants will be destroyed upon completion of the study by the research assistants with a shredding machine.

This study will pose no foreseeable risks to yourself or your students, other than that two to three research assistants will be present in your classroom for the length of the assignment completion during the daily research sessions and this may prove to be uncomfortable to you and/or your students. Benefits from this study may include that the additive interspersal technique may prove itself as an effective strategy for your use in the classroom.

Your participation is completely voluntary and you can withdraw your participation at any time. If you have any questions or concerns, please contact the research assistants, Kathy Mansfield, Barbara Sherman, and Kristan Maher (through the Pakanasink Main Office), who will then share the questions with me anonymously. My

phone number is (845)744-2031, Ext. 5709. My advisor's name at CUNY-Graduate Center is Dr. Georgianna Tryon and her phone number is (212)817-8293 and she can be reached by e-mail at gtryon@gc.cuny.edu. Also, the Institutional Review Board (IRB) representative at CUNY-Graduate Center, Kay Powell, can be reached at (212)817-7525 or by e-mail at kpowell@gc.cuny.edu.

If, at the end of the study, you are interested in the results obtained, you can contact me at the above number and I will be happy to share the details with you!

Thank you for your consideration in this matter.

Sincerely,

Terri Hatfield, CUNY-Graduate Doctoral Student

Your signature below indicates your consent for voluntary participation in the study, "Use of an Interspersal Technique to Enhance Work Completion Rates, On-Task Behavior, and Accuracy on Independent Math Assignments" in May 2010 at Pakanasink Elementary School. Please keep the above portion for your personal records.

Print Name_____
Signature _____
Date_____

Principal Investigator Signature_____

Appendix E

Parent/Guardian Explanation Form for Research Study

May 2010

Dear Parent or Legal Guardian:

As you may know, I am the school psychologist at Pakanasink Elementary School. I am also a doctoral student at the City University of New York (CUNY)- Graduate Center. To meet my requirements for graduation, I will be completing a study entitled "Use of an Interspersal Technique to Enhance Work Completion Rates, On-Task Behavior, and Accuracy on Independent Math Assignments" in May/June 2010 at Pakanasink Elementary School. This study will examine whether inserting briefer, easier problems into independent mathematics worksheets will make it easier for students to maintain attention, answer more questions correctly, and help the students to work faster. I am asking you to consider allowing your child to participate in this study.

Your child's participation will involve you allowing my three research assistants to present your child with either his or her teacher's original assignment (retyped onto copy paper) or a slightly altered assignment on a daily basis. As would typically happen in your child's classroom, your child will be expected to complete the assignment in its entirety, yet only your child's grade on the original assignment items will count for grading purposes. This study will take approximately three weeks to complete and will use classroom materials that were already going to be employed by your child's teacher. Each week of the study, your child will be asked to answer four questions about how they liked the assignments by circling their answer on a sheet of paper.

In order to minimize the possible effects of coercion (as I, in addition to being the School Psychologist at Pakanasink Elementary School, am also the principal investigator of this study), I will not be aware of your choice to allow your child to participate during any part of the study. All identifying information regarding your child will be coded for privacy and kept confidential at all times in a locked cabinet in the Nurse's Office that will only be accessible to the research assistants. Only the classroom teacher and research assistants will know whether your child is a participant in the study. Identifying information of all study participants will be destroyed by the research assistants after an allotted time period.

This study will pose no foreseeable risks to your child, other than that two to three research assistants will be present in your child's classroom for the length of the assignment completion during the daily research sessions. This may prove to be uncomfortable for your child. Benefits from this study may include that the instructional

technique I am studying may prove itself as an effective strategy for your use in your child's classroom.

Your child's participation is completely voluntary and you can withdraw your child's participation at any time. Your child will also be asked to assent to participate in this study, after a brief explanation by the research assistants in May 2010. I will not be aware of your choice to allow your child to participate nor your child's choice to assent to participate. Only those students who have parental/guardian consent and agree to assent on their own will be included in the study. Students who do not participate will be given the typical math assignment for that day.

On the Parental/Guardian Permission Form, I am requesting that you voluntarily provide additional confidential and personal information about your child's present use of academic services. This information will be helpful later when I analyze the study data. As stated above, this information is completely voluntary and will not affect your child's participation in any manner. Your child will be provided a code number, so that his or her identity will be unknown to me and all personally identifying data will be destroyed after an allotted time period.

If you have any questions or concerns, please contact the research assistants, Kathy Mansfield, Barbara Sherman and Kristan Maher (leave a message in the Pakanasink Main Office), who will then share your questions with me anonymously. My phone number is (845)744-2031, Ext. 5709. My advisor's name at the CUNY-Graduate Center is Dr. Georgianna Tryon and her phone number is (212)817-8293 and she can be reached by e-mail at gtryon@gc.cuny.edu. Also, the Institutional Review Board (IRB) representative at CUNY-Graduate Center, Kay Powell, can be reached at (212)817-7525 or by e-mail at kpowell@gc.cuny.edu.

If, at the end of the study, you are interested in the results obtained, you can contact me at the above number and I will be happy to share the details with you!

Thank you for your consideration in this matter.

Sincerely,

Terri Hatfield, CUNY-Graduate Doctoral Student

Appendix F

Parental/Guardian Permission Form

Dear Parent,

Your signature below indicates your permission for your child's voluntary participation in the study, " Use of an Interspersal Technique to Enhance Work Completion Rates, On-Task Behavior, and Accuracy on Independent Math Assignments" conducted by Mrs. Terri Hatfield.

Print Child's Name_____

Child's Teacher_____

Print Your Name_____

Your Signature _____

Date_____

For data purposes, please voluntarily check whether any of the following apply to your child. Parents /Guardians can opt to not provide this information and this will not disqualify your child from participating in the study. Please note that all information given will be held confidential and will be placed in a locked file cabinet. Upon completion of this study, this data will be destroyed after an allotted time period.

____ My child receives services through Academic Intervention Services (AIS).
____ My child receives services through the Committee on Special Education.
His/Her classification is _____.
____ My child has a 504 Accommodation Plan.
____ My child has a diagnosis of Attention Deficit Hyperactivity Disorder (ADHD or ADD).

****Please return this form to your child's teacher by May 28, 2010..

Principal Investigator Signature_____

Appendix G

Script for Informing Students About the Study and Obtaining Student Assent

"Hi, I am Mrs. Maher and this is Mrs. Mansfield and Mrs. Sherman. We will be working with your school psychologist, Mrs. Hatfield, on a study called, "Use of an Interspersal Technique to Enhance Work Completion Rates, On-Task Behavior, and Accuracy on Independent Math Assignments."

"Well, what that means is that Mrs. Hatfield, with our help, would like to see if a new kind of way for students to complete math assignments will help you. Maybe the new way will help you by letting you work quicker or by enjoying the assignment a little more. Maybe the new way won't do any of those things."

"You do not have to choose to participate if you do not want to. Mrs. Hatfield will not even know if you decide to participate or not, because we are going to give everyone a secret code number that she won't know. If you do choose to participate, you just need to come to class and we will do the rest. We will give you either your teacher's actual math assignment or one that has been changed just a little bit. If you don't decide to participate, nothing will change. All you have to do is your work for your teacher."

"We need you to decide whether you would like to participate or not. Either way, you may feel a little uncomfortable with us being in your classroom for a while each day. Also, maybe your teacher will like the new way to do things and start using it next year in her class."

"If you want to be a part of the study, you can drop out any time that you want to. Of course, you will still have to do the regular work that your teacher gives you while we are here.

"Does anyone have any questions?" [wait to answer questions]

"Here is an assent form." [hold up and show to students] "We will pass these out to everyone. After we hand these out, we will be leaving the class. If you want to participate, please sign the bottom and put it in this blue box. If you do not want to be part of the study, just hand it back without filling anything out. Thank you all so much for your excellent listening!"

[hand out to each student and collect from teachers the next day]

Appendix H

Student Assent Form

I would like to be a part of Mrs. Hatfield's study. I understand that she will not know whether I am participating or not, because only codes will be used, not my name. I also understand that I can quit the study at any time by telling my teacher, Mrs. Mansfield, Mrs. Maher, or Mrs. Sherman.

_____ I would like to volunteer for the study called, "Use of an Interspersal Technique to Enhance Work Completion Rates, On-Task Behavior, and Accuracy on Independent Math Assignments."

Signature_____
Print Name_____

Appendix I

Example of Traditional Assignment

C

23 x 7	44 x 4	25 x 3	31 x 7
15 x 6	35 x 9	92 x 4	33 x 8
67 x 6	87 x 3	41 x 5	17 x 8

Appendix J

Example of Additive Interspersal Assignment

I

23 x 7	44 x 4	25 x 3	3 x 7
31 x 7	15 x 6	35 x 9	4 x 9
92 x 4	33 x 8	67 x 6	8 x 2
87 x 3	41 x 5	17 x 8	2 x 2

Appendix K

Two Examples of Tables of Random Numbers from www.stattrek.com/tables/random.aspx

3	3
12	12
4	5
9	15
13	2
7	16
11	4
2	14
1	10
5	9
10	8
6	1
15	6
14	7
16	11
8	13

Appendix L

Script for Daily Assignment Directions

(*Pages are handed out upside down*) As I hand out these papers, please write your name in the box on the back of the paper on the sticky note (*demonstrate correct area to write name and give time for students to complete this direction*). When I tell you to begin, please turn your paper over and begin working on the math problems. Make sure that you complete each problem fully, without skipping any. When you are finished, please return your paper into this box (*point to designated box*). Your teacher will let you know what to do next. Are there any questions? O.K., ready… begin!" (*start timer*)

Appendix M

Daily Study Procedures

DATE_____

Classroom Code_____

Place a check by each circle as you complete the step.

- o Hand out daily assignment to students upside down.
- o Read script for daily assignment directions to students.
- o Ask students if they have any questions.
- o Remind students to place assignments in the specified box when they are completed.
- o Direct students to begin working and start timer in discrete, but accessible, location.
- o Place check mark by student's name (on seating chart) each time he or she exhibits an off-task behavior within each minute of completing the assignment.
- o As students finish assignments and bring papers up to place in the specified box, record completion time in appropriate corner of assignment sheet.
- o When all students are completed with assignments, collect assignments for grading purposes.
- o Code student assignments and return to me after removing sticky note.
- o Hand me next set of assignments that teachers will be using.

Steps Completed: _____/10

Appendix N

Student Preference Survey

Please answer the following questions by circling the number that describes how you feel. A "1" means No, not at all and a "4" means Yes, very much.

	NO			YES
1. I liked answering my math questions on days that a "C" was on top of my paper.	1	2	3	4
2. I thought that the math questions on days that a "C" was on the top of my paper were easy.	1	2	3	4
3. I liked answering my math questions on days that an "I" was on top of my paper.	1	2	3	4
4. I thought that the math questions on days that an "I" was on the top of my paper were easy.	1	2	3	4

Your comments about the study (please print):_____

_____

_____

THANK YOU SO MUCH FOR BEING PART OF THIS STUDY!!!

Appendix O

Teacher Acceptability Survey

Please circle your answer for the following questions based on this scale: "1" indicates strong disagreement, "6" indicates strong agreement.

DISAGREE AGREE

1. The intervention used in the study was too complex for me to implement on my own. 1 2 3 4 5 6

   Comments_____
   _____

2. The intervention used in the study took too much time for me to use in my classroom. 1 2 3 4 5 6

   Comments_____
   _____

3. I have the necessary means and materials to carry out this intervention in my classroom. 1 2 3 4 5 6

   Comments_____
   _____

4. There were too many people required to use this intervention in my classroom. 1 2 3 4 5 6

   Comments_____
   _____

5. I felt that this intervention was effective to help my students improve their work completion rates during independent math assignments. 1 2 3 4 5 6

   Comments_____
   _____

6. I felt that the intervention was effective to help my students improve their on task behavior during independent math assignments. 1 2 3 4 5 6

   Comments_____
   _____

7. I felt that the intervention was effective to help my students improve their accuracy during independent math assignments. 1 2 3 4 5 6

   Comments_____
   _____

8. I felt interested in the intervention throughout the study and feel motivated to try it in my own classroom. 1 2 3 4 5 6

   Comments_____
   _____

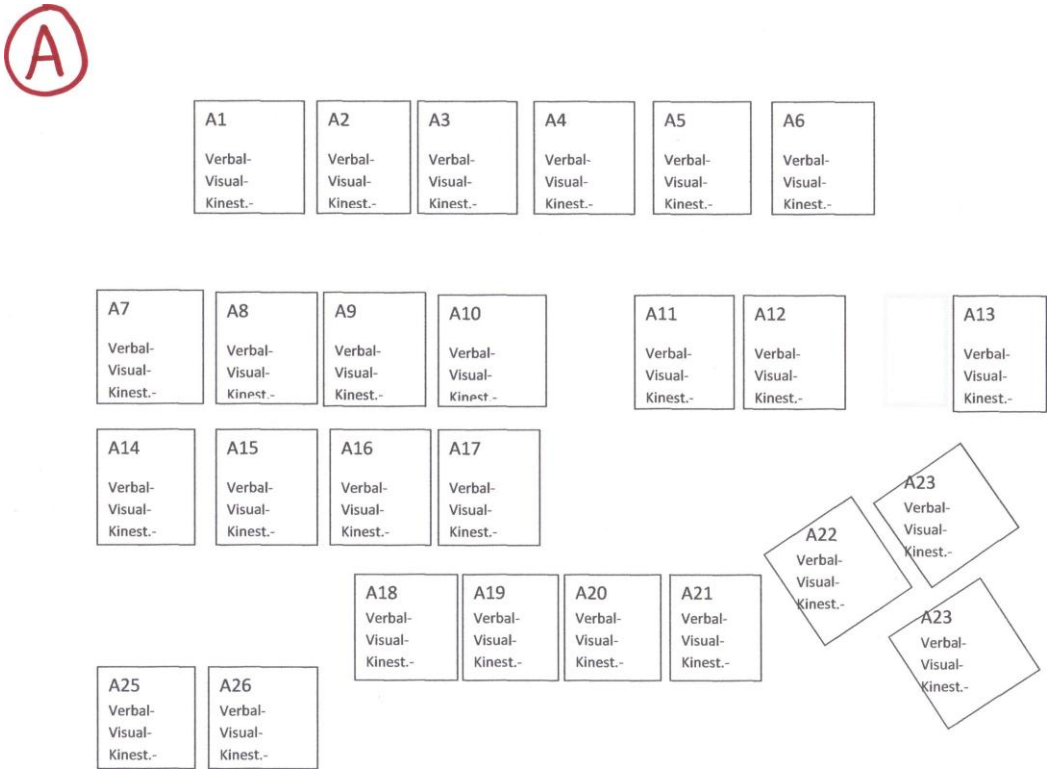
THANK YOU SO MUCH FOR YOUR PARTICIPATION IN THIS STUDY!!!!

Appendix P

Example of Seating Chart to Record Off-Task Behavior Levels

DATE_____
Research Assistant Name_____

Behavior Definitions	**Verbal Off-task Behavior**-e.g., any time that a student makes an utterance to oneself, a peer, or calls out to the teacher without raising his or her hand	**Visual Off-Task Behavior-** e.g., any time that a student breaks eye contact from his or her paper while expected to be completing the assignment	**Kinesthetic Off-Task Behavior**- e.g., any time that a student breaks contact with his or her seat to move around or walk around; accompanied by not working on the assignment



Appendix Q

Frequency Count of Answers to Student Survey by Item

	Overall Frequency Count of Ratings			
	Disagree			Agree
Question	1	2	3	4
Liked questions on "C" assignments (*n*= 167)	12	28	53	74
Thought "C" questions were easy (*n*= 166)	7	20	65	74
Liked questions on "I" assignments (*n*= 172)	15	40	42	75
Thought "C" questions were easy (*n*= 172)	9	33	55	75

Appendix R

Summary of Answers to Teacher Survey

Question	n	*M*	*SD*
Intervention too complex	5	2.20	1.60
Intervention took much time	5	1.60	0.60
Have means to carry out	5	5.20	0.80
Too many people required	5	2.60	2.10
Increased work rates	4	4.00	0.80
Improved off-task behavior	5	4.20	0.80
Improved accuracy rates	5	3.80	0.70
Felt motivated to try it	4	4.80	0.50

Appendix S

Frequency of Answers to Teacher Survey by Item

	Overall Frequency Count of Ratings					
	Disagree					Agree
Question	1	2	3	4	5	6
Intervention too complex (n = 5)	2	2	0	0	1	0
Intervention took much time (n = 5)	2	3	0	0	0	0
Have means to carry out (n = 5)	0	0	0	1	2	2
Too many people required (n = 5)	3	0	0	0	2	0
Increased work rates (n = 4)	0	0	1	2	1	0
Improved off-task behavior (n = 5)	0	0	1	2	2	0
Improved accuracy rates (n = 5)	0	0	2	2	1	0
Felt motivated to try it (n = 4)	0	0	0	1	3	0

Appendix T

Frequencies of Assignment Types and Absences Per Student Participant

Student Code	Number of Interspersal Assignments	Number of Traditional Assignments	Number of Absences
A2	6	9	1
A3	8	8	0
A5	9	7	0
A7	5	10	1
A11	6	9	1
A12	6	7	3
A13	8	8	0
A14	7	9	0
A19	7	8	0
A22	6	9	1
A23	9	7	0
A24	8	8	0
B1	8	8	0
B3	8	7	1
B4	8	7	1
B5	8	8	0
B7	8	6	2
B8	8	6	2
B9	7	8	1
B11	5	6	5
B13	8	4	4
B17	7	7	2
B18	8	5	3
B19	8	8	0
C2	8	8	0
C3	6	10	0
C7	5	8	3
C19	6	6	4
C20	8	8	0
C26	4	7	5
D1	6	7	3
D2	8	8	0
D4	8	7	1
D5	7	8	1
D8	8	8	0
D10	7	9	0
D11	8	8	0
D13	8	8	0
D14	8	8	0
D15	8	8	0
D16	6	4	6
D18	8	8	0

Student Code	Number of Interspersal Assignments	Number of Traditional Assignments	Number of Absences
D19	8	3	5
D21	9	7	0
D22	7	6	3
D23	8	8	0
D24	7	6	3
D25	6	9	1
E1	8	8	0
E3	4	11	1
E4	4	7	5
E5	8	8	0
E6	7	9	0
E8	7	7	2
E9	6	10	0
E10	6	10	0
E11	5	10	1
E12	8	8	0
E14	7	7	2
E15	6	7	3
E16	6	10	1
E21	4	6	6
E22	8	5	3
E23	6	10	0
E24	5	6	5
E26	5	11	0
Total Percentages	48%	52%	8%

Appendix U

Training Protocol for Behavioral Observations

Phase One: Preparation and Initial Training

1. Operational definitions and tally procedures were presented and discussed during two meetings with the three research assistants. The meetings lasted 30 minutes each.
2. Appendix P (operational definitions and seating chart) was shown to the assistants.
3. The operational definitions for verbal off-task behaviors (VB), visual off-task behaviors (VS), and kinesthetic off-task behaviors (K) were delineated and demonstrated by the investigator.
4. Questions regarding specific behaviors (such as students staring at the ceiling and leaving their seats to sharpen pencils) were discussed. The investigator made judgments regarding how to code these behaviors. All raters agreed to the operational definitions before the meeting concluded.

Phase Two: Practice Sessions

1. To ensure uniformity of interpretation, operational definitions for each behavior were reviewed and discussed for approximately 10 minutes prior to the practice observations.
2. Two practice observation sessions were completed in a 2nd grade classroom (May 20th and 21st). Raters sat beside the students who were being observed. Each rater had a clipboard and a seating chart similar to the one shown in Appendix P.
3. Three students were observed by all raters using the operational definitions (see Appendix P). Practice observation sessions lasted 30 minutes each.

Phase Three: Calculation of Inter-Rater Agreement

1. Practice session tallies of the verbal, visual, and kinesthetic off-task behaviors for each of the three practice session students were given to the investigator.
2. Inter-rater agreement between the three raters was calculated to be over 80% for each of the practice observation sessions, which was considered adequate to proceed to formal data gathering.

Phase Four: Determination of Rater-Assigned Students

1. To make observations more manageable, more reliable, and to avoid missing off-task behaviors, it was decided that Raters A and B (the daily raters) would each observe half of the study participants in each class during the actual study days. Raters A would measure the same students every day, including acclimation days and both control and interspersal study days. Raters B would measure the remaining set of students every day, including acclimation days and both control and interspersal study days. This way, the same rater rated the same students throughout the study.
2. Rater C (the third observer) was randomly assigned one student from Rater A and one student from Rater B during ten (10) of the study sessions (20 students total). This meant that two raters were observing the same two students on days that Rater C was also completing observations. Agreement between the third observer (Rater C) and the daily raters (Raters A and B) exceeded 80% agreement.

Phase Five: Acclimation and Study Days

1. Raters A and B sat beside the students during the 3 acclimation days and 16 study days. The students that each rater observed were the same students throughout the study.
2. All three raters agreed that if inter-rater agreement was found to be less than 80% for any week of the study, another training period would be scheduled. This step was not necessary during the study, as inter-rater agreement stayed above 80% each week.

Summary of Training Protocol for Behavioral Observations

Three raters were trained to observe and quantify off-task behaviors: verbal off-task behaviors (VB), visual off-task behaviors (VS), and kinesthetic off-task behaviors (K). Raters were trained across two preliminary meetings and two practice sessions. Protocol adjustments were made during these trainings towards optimizing the reliability of data gathering. In particular, it was decided to have the daily rater (Rater A and Rater B) each measure half of the students per class because rating all students per class would result in many missed off-task behavior. To ensure the ongoing quality of the daily raters, Rater C rated one student assigned to Rater A and one student assigned to Rater B during ten (10) study sessions (20 students total). Agreement exceeded 80% during the training phase and during the study days, which was considered to be adequate inter-rater agreement for assessing the hypotheses of the present study.

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