# Increasing Student Choice to Engage in Math by Altering the Frequency of Interspersed Math Problems

A Dissertation Presented for the
Doctor of Philosophy
Degree
The University of Tennessee, Knoxville

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August 2024

**Acknowledgements**

I would like to acknowledge the numerous individuals who have supported me throughout graduate school and through the dissertation process. First, I would like to thank my dissertation advisor, Dr. Chris Skinner. Dr. Skinner, thank you for listening and stepping back and letting me "learn how to do" research. Your excitement for research has been contagious, as evidenced by our discussions surrounding potential studies. To Dr. Merilee McCurdy, thank you for spearheading the program and for the constant support you give us as students. Dr. Brian Wilhoit, thank you for your mentorship and for your calm demeanor in the often stressful and chaotic experience of graduate school. To Dr. Tara Moore, thank you for jumping into this committee and for your advice and mentorship. Your time and experience are greatly appreciated.

I would like to thank my cohort, including David Castleman who snuck in, for their warmth and support. Without you all I don't know that I would have finished graduate school. You have all become the deepest of friends.

To my wife Natalie and my wonderful children, who have supported me and been my personal team of cheerleaders, I owe most of my success. I cannot thank you enough for your patience, devotion, and love. I cannot express my gratitude enough. I hope that I will one day repay the debt.

To my parents, who consistently put themselves on the backburner so that we as children could have more than you did, thank you. To the rest of my friends and family, thank you for the constant encouragement, support, and love. It was not wasted, and I am fulfilling my dreams to help the next generation and hopefully leave the world a little better than I found it. You have all helped me to accomplish this.

## Abstract

Researchers have posited that the completion of problems on worksheets serves as a reinforcing event as outlined by the discrete task completion hypothesis. This hypothesis has been demonstrated through the additive interspersal procedure, in which educators can add brief problems to a worksheet to increase student preferences compared to a worksheet that contains no added problems. Previous research has supported these findings across participants; however, much of the previous research has been done with a single added brief problem for every third target problem on a worksheet. This study evaluates student preferences and rates of problem completion when the number of brief target problems added to a worksheet is increased. Specifically, this study compares problem completion rates, participant preference, accuracy, target problem completion rates, and participant perceptions across worksheets that contain no added brief problems, one brief problem for every three target problems, one brief problem for every target problem, and three brief problems for every target problem.

Results of this study provide additional evidence to support the discrete task completion hypothesis through the additive interspersal procedure. Although three brief problems for every target problem worksheet required students to complete 45 additional brief problems, it also yielded the greatest problem completion rates and significantly more students preferred this worksheet. In addition, participant perception of time and effort to complete worksheets decreased as the number of interspersed problems increased. Accuracy and the rate of target problem completion were not influenced by increases in interspersed brief problems. Discussion focuses on theoretical and applied implication of this study. Study limitations and considerations for future researchers are also discussed.

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# Chapter I

## Literature Review

The primary goal of teaching is to facilitate learning in another (Pearson, 1989). Learning, which results in a relatively permanent change in knowledge and skills (O'Donnel et al., 2007), generally occurs in multiple stages. Garnett (1992) discusses three general stages that learners should undergo to develop their math facts. These three stages include the development of procedural knowledge of basic math facts, development of a means to remember the math facts, and finally a declarative knowledge stage where learners can readily retrieve known facts. Miller and Heward (1992) further distill this process into two stages that are proposed to contain the core components of several theories of learning development. Learners first undergo an acquisition stage in which one learns how to do the skills, and a practice stage where learners practice newly acquired math skills. During the acquisition stage, learners are to develop accuracy in solving problems. During the practice stage, learners develop fluency by repetition and repeated trials.

To guide learners through the acquisition phase, teachers provide direct instruction, feedback, guidance, and assess student learning (Goodyear, 2015). These activities allow students to obtain the ability to complete new tasks accurately. Once students develop accuracy, they then develop fluency through frequent practice such as daily repetition or drills (Ramos-Christian et al., 2008).

Learning is often solely mistaken for the ability to complete tasks accurately. Miller and Heward (1992) propose that learning is more directly tied to fluency as opposed to accuracy. Fluency is the ability to complete a behavior accurately and rapidly, with little effort. They illustrate their point by providing an example of learners who complete the same worksheet with

100% accuracy; however, one learner completes the sheet in two minutes and one in five minutes. The learner who completed the sheet in two minutes demonstrates better learning.

Research suggests that students who develop fluency show improved maintenance and generalization of skills (Ivarie 1986) and are better prepared to acquire other skills and concepts as they progress through curricula. Students who could successfully complete math computation problems (i.e., basic math facts) at a rate of 30 or more digits correct per minute progress more easily into increasingly complex mathematics skills (Haughton, 1972). Van Houton (1980), in citing unpublished research by Van Houten and Sharma, showed that daily drills of basic single digit multiplication facts, which are used to develop fluency, increased accuracy on long division and multi-digit multiplication problems in learners.

Even after learners develop fluency, teachers continue to provide opportunities to practice and review materials to ensure that students do not forget the materials that they have learned. Ebbinghaus' forgetting curve outlines the need for distributed practice and repetition of the same materials for maximum retention of skills (Ebbinghaus, 1850/1909). Shortly after acquiring information, learning deteriorates without several distributed practice sessions (Murre & Dros, 2015). While teachers spend a great deal of time focusing on how to teach to enhance acquisition, they also need to provide opportunities for students to practice skills so that they can develop fluency prior to moving on to new skills and intricate learning (Hattie, 2009).

**Need for Interventions**

Even when teachers prepare and deliver high quality instruction designed to engage the learner and provide ample practice, students can fail to obtain the expected growth in an appropriate timeframe. There are several potential reasons that students fail to thrive in school

environments. Idiosyncratic factors in the students such as developmental delays, specific learning disabilities, or social and emotional difficulties may hinder learning (Kuper et al., 2014).

Frequently for these cases, teams of school personnel including special education teachers, school psychologists, and school counselors, and other highly trained staff are available to select interventions or to develop a specialized education plan (Lytle & Bordin, 2001). Such interventions are often focused on altering the methods of instruction delivery, the environment, or altering the curriculum based on the individual student. These changes can include individualized education plans, functional behavioral assessment, and specialized interventions designed to increase student access to acquisition and fluency building needed. For academic deficits, students will often be provided additional learning opportunities in small group instruction (e.g., Tier 2 in Response to Intervention programs) or specialized classrooms and individualized instruction (e.g., Tier 3 in response to intervention programs) using curriculum designed to target student skill deficits (Fuchs & Vaughn, 2012).

No instructional practices or curricula are going to be very effective unless students choose to attend and engage with instruction designed to enhance accuracy and choose to complete assignments that are designed to enhance fluency. Myerson and Hale (1984) described the classroom environment as a continuum of choice. In classrooms students constantly choose between engaging in instruction and practice materials, or engaging in other activities such as socialization or academic games on an iPad that are increasingly found in classrooms. Students with disabilities (Wagner & Cameto, 2004) or at-risk for developing academic deficits are less academically engaged (often less than 50% of the time and upwards of 75% of the time) compared to peers (Johns et al., 2008). Thus, students who most need to complete assignments

designed to enhance fluency, are more likely to choose to engage in alternative behaviors (Skinner, 2002).

Students who have deficits or specific disabilities in academic areas can find engaging in practice materials to be overwhelming and tiresome, increasing the chances that they will engage in alternative behaviors. These students often appear as if they are engaged when they are not (Ennis et al., 2018). As such, the very students who need the practice required to develop fluency are at an increased risk of choosing alternative, low effort behaviors.

Choosing not to engage in practice materials, over time, will increase academic deficits in students. Increasing deficits will compound the problem unless appropriate interventions are applied. As many as 75% of students with challenges, both academic and behavioral, are in general education (Tier 1) classrooms (National Center for Education Statistics, 2015). As such, interventions that are targeted to increasing student's choice to engage in materials that are easily applied to the general education classroom are ideal.

**Effects of Altering Effort**

Altering effort is one of several options in changing behavior. Behaviors, according to researchers, are always embedded in an economic matrix in which individuals are constantly weighing the costs versus the benefits of their behaviors (Herrnstein, 1961, 1970). Altering effort, rate of reinforcement, quality of reinforcement, or the delay in reinforcement are all options in altering an individual's choice to engage in competing behaviors. As one or more of these variables are altered, so are an individual's behaviors (Friman & Poling, 1995).

Increasing effort is generally seen as aversive. Increased effort has been shown to increase activity in the sympathetic nervous system (e.g., increased blood pressure, ventilation, sweating, plasma norepinephrine release) that is similar to when one experiences an aversive

stimulus (Inzlict et al., 2018). Individuals generally prefer tasks that require lower effort opposed to higher effort (Wilder et al., 2021). As the effort required to complete a task increases, so does the likelihood that an individual will attempt to escape from the situation (Miller, 1968a, 1968b). As effort requirements increase, rates of responding can decrease (Wilder et al., 2021). These resulting changes in behavior preferences due to increased effort have been noted to be similar to punishment procedures (e.g., lower response rate).

Wilder et al. (2021) examined recent research involving altering effort and the behaviors individuals choose. Several methods across various studies were used to manipulate effort. Proximity to stimuli (e.g., proximity to picture exchange cards on manding and aggression) and problematic items (e.g., access to Pica items) was found to be effective in altering behaviors of research participants (Buckley and Newchok, 2005; Piazza et al., 2002). In addition, manipulation of the physical force required to engage in a behavior (e.g., weights on limbs of individuals with self-injurious behaviors) was also effective (Wallace et al., 1999).

Overcorrection requires an individual to engage in increased effortful behaviors that are directly or logically related to a behavior that needs to be modified (Cooper et al., 2007). For example, a student who throws their crayons off the table could be required to pick up their crayons and in addition be asked to pick up the toys in the play area. This is known as restitutional overcorrection (Zager et al., 2017). Overcorrection can also be used to interrupt a problem behavior followed by an increase practice of an alternative response, or positive practice overcorrection (Peters & Thompson, 2013). If a student spells a word incorrectly, they can be required to write the word correctly five times. Anderson and Le (2011) decreased vocal stereotypy of a child with autism using positive practice overcorrection procedures. They found overcorrection to be superior to differential reinforcement of alternative behaviors.

Reducing effort can also modify behaviors. Richman et al. (2001) decreased the number of steps or number of responses required to engage in appropriate behaviors, which in turn resulted in decreased problem behavior in a young boy with intellectual disability. Specifically, the boy had three behaviors to obtain access to desired items. The boy could sign "please", use communication cards, or he would engage in aggressive behaviors to obtain his desired tangible items. When the number of discrete steps and movements was altered in these three specific access behaviors, responses varied according to the effort required to engage in each response. As steps were shortened to accomplish the more appropriate behaviors including signing "please" or using the communication card, his use of aggressive behaviors reduced.

Manipulating effort of responding as well as reinforcement rates are found in several interventions and accommodations that are used to increase the probability that students choose to engage in academic tasks. One accommodation often found in individualized education plans is to reduce the amount of expected work (Jones, 2012). For a student who has difficulty starting or completing a math worksheet, asking them to only complete ten instead of all twenty problems on a math sheet will often increase the likelihood of the student engaging in the worksheet.

While interventions that alter effort and increase reinforcement opportunities may increase the probability that students choose to complete assignment, they may hinder fluency development. Specifically, such strategies reduce the opportunities for students to practice recently developed skills which can prevent them from developing fluency and maintaining skills. Thus, while these strategies amount to watering down curriculum (Skinner et al., 2005).

Researchers have developed other assignment alteration procedures that may enhance the probability of students choosing to engage in academic tasks that do not reduce student

expectations for practicing recently acquired skills. One strategy has been to alter academic assignments so that students respond verbally or sub-vocally, as opposed to providing written responses (Skinner et al., 1993; Skinner et al., 1997). This strategy decreases effort, while also increases rates of responding or practice, which can enhance fluence development (Skinner et al., 1996).

The brief sheet intervention (Wallace et al., 2003) also enhances the probability of students choosing to engage in academic tasks, without reducing overall assignment demand. This intervention requires a teacher to take a practice worksheet and cut it into parts. As the student completes each part (i.e., each brief sheet), they turn it in to the teacher who praises the learner and gives the student the next portion of the assignment (i.e., a second brief sheet). This practice increases the rate of reinforcement for completing academic tasks, while reducing the amount of effort required to obtain reinforcement. The brief sheet intervention allows the opportunity for a student to complete the entire worksheet over time, as opposed to reducing the amount of expected work. The primary limitation of the brief sheets intervention is the amount of time teachers must spend praising students and handing out assignments.

Reducing the amount of effort required can have additional negative impacts and consequences on learners. Across several studies, increased effort has been linked with increased value to goods and outcomes (Inzlicht et al., 2018). Individuals who must work hard to enter a group are likely to value the group more than those who did not work hard to join. People also tend to be willing to pay more for furniture that requires effort to build themselves as opposed to the same object assembled by others. Even when donating to charity, individuals donate more money to events that will require more effort such as a 5-mile run as opposed to attending a picnic.

As high effort is consistently paired with high rewards, this can serve to form a conditioned reinforcer. This process is known as learned industriousness (Eisenberger, 1992). Given enough repetitions, effort itself, or the feeling of putting in effort, can serve as a secondary reinforcer. Research has shown that as rats are reinforced for exerting high levels of force on a lever, they persist longer on an unrelated task (Eisenberger, 1979). College students and children who are rewarded for a cognitively difficult task have also been observed to persist longer on unrelated tasks (Eisenberger et al., 1980; Eisenberger & Adornetto, 1986). These findings provide support that effort, rather than task completion, can become a secondary reinforcer for participants. Reducing effort for specific academic tasks has the potential to reduce effort across other tasks and demands in an education setting. In addition, there is the potential for students to have reduced opportunity to allow effort to become a reinforcer.

**Matching Law**

In classroom environments teacher behaviors have been found to influence student choice. Teacher rates of reinforcement have been found to have a direct and predictable impact on what behaviors students choose to engage in. Herrnstein's (1961, 1970) research on choice behavior allowed the development of a mathematical model known as the matching law, that accurately predicts chosen behavior as a direct result of relative reinforcement rates. Behaviors that learners choose to engage in are directly impacted and will match reinforcement rates. For example, a student who is reinforced by teacher attention every minute he is off task, compared to every 2 minutes he is on task, will be expected to engage in off-task activity twice as often as they are choosing to be on-task (i.e., two hours off task for every one hour on task).

Martens and Houk's (1989) research support the matching law in the classroom environment. In the school environment, the competing behaviors of being on-task or off-task

were altered by manipulating interval schedules of reinforcement. The reinforcement given was teacher attention. The teacher was instructed when to deliver attention based on researcher communication through a "bug in the ear" device. The student's on and off task behaviors were accurately predicted and controlled relative to teacher praise, as observed by the matching law.

Further support for the matching law has been observed by researchers investigating assignment choice. Students were given repeated opportunities to choose to work on either division or multiplication problems on math cards. When rates of reinforcement were equivalent for both types of problems, students spent approximately equal amounts of time on each. However, when reinforcement was given at twice the rate for one type of problem, students spent nearly twice the amount of time on that card type (Mace et al, 1990).

These applied studies, while increasing student's choice to engage in desired activities that facilitate learning, required constant monitoring to deliver reinforcement linked to the student's choice of behavior. Monitoring and reinforcement requirements of this level are not practical in most general education settings (Skinner, 2002). Not all student behaviors are reinforced by attention and might require access to tangible items (e.g., edibles, access to small toys). Students who require tangible items will increase monetary demands on the school or teacher. Despite these difficulties, the matching law identifies variables that allow educators to predict and modify students' choice behaviors, including choosing to engage in assigned academic work.

**Discrete Task Completion Hypothesis**

Researchers developed a theory known as the discrete tasks completion hypothesis and tested a strategy known as the additive interspersal procedure that may allow educators to manipulate rates of reinforcement without constant monitoring and providing reinforcement

(Skinner, 2002). Over their educational career, learners can develop a long history of reinforcement for assignment completion. Assignments may be completed to avoid consequences, such as staying in during recess to complete an assignment or having to take an uncompleted assignment home to complete as additional homework (Skinner et al., 1999). In this case, completing an assignment becomes a negative reinforcer. Students are also positively reinforced for work completion. When students complete their assignments in a timely manner, they are often allowed to engage in a preferred activity (Logan & Skinner, 1998) such as coloring or time on academic based apps on an iPad.

Given enough repetitions, each completed assignment that is followed by these positive or negative reinforcers, can become classically conditioned as a reinforcing stimulus (Skinner et al., 1999). When this conditioning occurs and completed assignments are reinforced, any stimuli that comes before the completion of the assignment can become reinforcing stimuli through higher order conditioning, just as the bell became a conditioned reinforcer for Pavlov's dogs (Pavlov, 1927). Thus, when given an assignment comprised of multiple discrete tasks (e.g., math computation problem), each complete discrete task is a conditioned reinforcer.

Skinner (2002) provided the following example to illustrate how discrete tasks such as individual math problems on a worksheet, can become reinforcing when completed. Most people have a learning history of being reinforced contingent upon assignment completion. In a classroom a teacher instructing students to complete a five-problem multiplication assignment acts as the primary antecedent stimulus. When students are finished with the assignment, they are positively reinforced (e.g., praise, ability to engage in preferred behaviors). The completed first problem of the assignment is a discriminative stimulus that is followed immediately by the student beginning to work on the second problem. This process continues until students complete

the final response, which serves as a terminal discriminative stimulus. If students have a learning history of assignment completion being followed by reinforcement, each completed problem becomes a conditioned reinforcer. In this example, the students would, assuming a learning history of reinforcement, undergo four conditioned reinforcing stimulus events. The final response would be reinforced by praise or opportunity to engage in preferred behaviors.

This process of task completion serving as a conditioned reinforcer is supported by research on chained schedules of reinforcement (Catania et al., 1980). This research suggests that the tasks completed early in the assignment may be a lower quality reinforcer. While of a lower-quality, research in second-order conditioning suggests that lower-quality reinforcement (each item completed) delivered at high rates may be enough to increase responding if the assignment is followed by a high quality and preferred reinforcer.

Supporting results have been observed in primate responses (Findley & Brady, 1965). Two separate schedules were used to allow access to reinforcement. A fixed ratio schedule allowed access to food every 4000 responses, while a second-order schedule used the same 4000 response requirement but was supplemented with a conditioned reinforcer. In this case, a bright light was used every 400th response. The second-order response schedule resulted in higher response rates and increased rates of seeking reinforcement as measured by shorter pauses after receiving reinforcement.

Discrete task completion research offers a potential explanation as to why many students are able to sit, work, and remain on task while completing academic work without any observed reinforcement. Assuming a learning history of reinforcement for assignment completion, students are experiencing conditioned reinforcement for completion of each problem. In accordance with the matching law, assignments that provide higher rates of reinforcement should

be preferred by students. This preference has been observed across several studies evaluating the effectiveness of an intervention known as the additive interspersal procedure (Skinner, 2002).

Most research investigating the additive interspersal procedure alters math assignments by interspersing additional math problems among standard or control assignments that contain problems which require more time to complete (Skinner, 2002). Because these additional problems take less time to complete, adding them enhances problem completion rates. Thus, based on the discrete task completion hypothesis this strategy enhances rates of reinforcement. Because problems are added to the assignment, this strategy also increases the effort required to complete the assignment. Although these altered assignments required more effort to complete, students preferred and chose those assignments over the standard or control assignment.

Research participants across several studies demonstrated a preference for math assignments (i.e., chose) sheets that had briefer problems interspersed compared to control assignments that did not contain interspersed problems. Participants included college students (Skinner et al., 1996, Skinner et al., 1999, Wildmon et al., 1998), sixth grade students, (Logan & Skinner, 1998), and high school students (Wildmon et al., 1999). Across all experiments, students worked on both the control and the experimental assignment with the additional interspersed briefer problems. The target problems on both the control and experiment assignment were matched for difficulty, such as both containing 10 three-digit by two-digit multiplication problems on each assignment. The experimental assignment contained briefer, low effort problems such as one digit by one digit multiplication added to the 10 original problems. Each interspersed problem was presented after three target problems. Participants across each study were informed that they need to choose their next assignment and can choose one similar to the control or experiment worksheet. Despite there being more problems on the experimental

assignment, which would require increased effort to complete, the proportion of students who chose the interspersed assignment was statistically significantly greater across all studies.

Cates and Skinner (2000) extended the interspersal research. High school students in remedial mathematics classes were exposed to three pairs of computation sheets. Three sheets were control assignments, and each was paired with similar experimental assignments that contained interspersed briefer problems. The control assignment contained 15 problems. Each experimental assignment contained the addition of interspersed items, which occurred after every third problem. One experimental assignment retained the 15 target problems plus the interspersed problems, one contained 18 target problems and interspersed problems, and one contained 21 target problems along with the interspersed problems. Results showed that students preferred and chose the experimental assignments over the control assignments, even when the experimental sheet contained 21 longer target problems, which is an increase of 40% more target problems. Researchers delivered no reinforcers while students completed worksheets. Thus, this research provides further evidence that completing a problem served as a reinforcer and that the additive interspersal procedure can enhance rates of reinforcement enough to cause students to choose an assignment that requires over 40% more effort to complete.

Interspersing lower effort problems into math worksheets have been observed to be preferred by many learners and have a reinforcing effect that is potentially strong enough to encourage students to choose assignments that contain an increase in target problems and to choose to engage in work. McCurdy et al. (2001) demonstrated an increase in on-task behaviors when the additive interspersal procedure was used for a student who was often off task during math work. Given that problem completion serves as a secondary reinforcer, increasing the rates of interspersal potentially serves as an opportunity to further increase student preferences.

Despite this possibility, most research on interspersing simpler mathematics problems retained a ratio of three target problems for every low effort problem. Little research can be found that uses alternative ratios of target to interspersed problems.

The addition of simpler and briefer items and tasks serves not only to increase student preference but has been observed to have other benefits as well across reading acquisition, spelling, and math. Neef et al. (1977) added known sight words into lists of target sight words that six students with intellectual disabilities were learning to read. The learners increased acquisition and retention of sight words under the conditions in which simpler, known words were interspersed as opposed to non-interspersal baselines. Researchers observed an increase in spelling acquisition and retention under conditions in which known words were interspersed into practice sessions compared to baseline and high-density reinforcement conditions (Neef et al. 1980). Not only were acquisition and retention higher compared to baseline, but students also reported a preference for the interspersal condition.

Robinson and Skinner (2002) offered students who were at risk in mathematics four different conditions in which they were required to complete mathematics. Paper and pencil multiplication problems both with and without added interspersed problems were given to students. Additionally, students were asked to solve problems cognitively both with and without interspersed brief problems. Robinson and Skinner (2002) found significant improvements on the mental computation task that contained interspersed problems.

In a similar manner, Hawkins et al. (2005) had students complete six math assignments that contained two task demands and three different interspersal ratios. The interspersal ratios included no interspersal, one interspersed problem for every three target problems, and one interspersed problem for each target problem. The two task demands included a written, paper

and pencil condition to solve problems and one condition where the experimenter read problems to the participants who were required to solve problems cognitively, without paper and pencil. Participants, while solving problems cognitively, demonstrated significantly increased accuracy when an interspersed problem was presented after every third target problem. For written assignments, a one-to-one ratio of interspersed problems increased target problem solving accuracy. While differences in accuracy were demonstrated, data on student preferences or choice was not obtained.

**Summary and Purpose of Research**

After teachers provide instruction (demonstration, explanation, modeling) that allows students to acquire a skill, they often assign independent seatwork which is designed to enhance students' skill fluency. A variety of factors may influence whether students choose to engage in this assigned independent seat work. Two factors are the rate of reinforcement for engaging in the assigned work and the effort required to complete the assigned work. Increasing rates of reinforcement can enhance the probability that students choose to engage in the assigned work. Reducing the effort required to complete assignments can also enhance the probability of students choosing to engage in assigned work.

The additive interspersal procedure has been shown to increase the probability that students choose to engage in assignments that require more effort, which supports the theory that a completed discrete task is a reinforcer (i.e., supports the discrete task completion hypothesis). Researchers investigating the effects of the additive interspersal procedure have typically used a ratio of one interspersed problem for every three target problems. This research is to extend the current research on student choice using the interspersal procedure by altering the ratio of interspersed items on math worksheets.

Adding even more additional problems can increase rates of reinforcement, which should enhance preference and choice. However, adding additional brief problems also enhances the effort required to complete the assignment. Furthermore, adding these problems can decrease the number of target problems completed; thereby hindering their skill develop on target problems.

During the current study, students worked on four assignments. Each assignment contained target problems that are three-digit by two-digit multiplication problems. The control assignment contained fifteen target problems. Three experimental assignments also contained fifteen target problems with additional one-digit by one-digit problems interspersed. One worksheet, similar to previous research, had one brief interspersed problem after every third target problem (1B:3T). To counterbalance this ratio, another experimental sheet contained three brief interspersed problems for every target problem (3B:1T). The final experimental sheet, fitting in the middle of these experimental sheets, had one brief interspersed problem for every target problem (1B:1T).

Based on previous additive interspersal research, it is anticipated that participants will complete more overall problems on worksheets with increased amounts of brief problems, such as the 1B:1T or 3B:1T worksheet. Similarly, based on the discrete task completion hypothesis, we anticipate that participants will likely demonstrate a preference for worksheets that occasion these higher rates of problem completion. However, increasing the number of interspersed problems also increases effort. It is possible that the 3B:1T worksheet requires too much effort, resulting in fewer participants choosing this assignment and fewer overall problems completed.

To investigate these questions, we test examined differences across assignments for three math problem performance variables: total problem completion rates, target problem completion rates, and target problem accuracy. Additionally, we will determine if there are statistically

significant differences in the number of students who choose a subsequent assignment to complete after exposure to all four assignments. Finally, we will test for significant differences in students' rankings of assignment for effort to complete and time to complete. These two rankings will also be tested for correlation.

# Chapter II

# Methodology

## Participants

Participants included 38 students at a large midwestern university. Two participants were ultimately excluded from the study due to failure to follow directions, resulting in a final total of 36 participants. Participants were recruited from a teacher education program and included 11 participants in their freshman year, 14 in their sophomore year, 10 in their junior year, and 1 in their senior year. Approximately 91.67% of identified as female, and 8.33% as male. Of the 36 participants, 88.89% identified as Caucasian/white, 5.56% identified as Hispanic, and 5.56% identified as multi-racial.

Prior to recruitment, ethics approval was obtained. Students from the Applied Educational Psychology and Psychoeducational Issues in Human Development classes were asked to volunteer for participation by teacher announcements and class wide emails. Participants were informed that volunteering would obtain them extra credit in their course. Those who declined participation were given the option to earn the same amount of extra credit points by completing a published research article review, a task that would take approximately the same time and effort as participating in the study.

## Materials

Participants were given a packet that included the consent to participate forms (Appendix C), four experimental worksheets (Appendix D-G), a survey (Appendix H), and an additional four parallel worksheets (Appendix I-L). The order of the worksheets, both experimental and parallel, was alternated between the participant packets to control for sequencing effects. These experimental and choice worksheets contained one-by-one digit

multiplication problems, and target problems which were three-by-two multiplication problems. The one-by-one multiplication problems only included digits that ranged from zero to five so that the response can be rapid. The three-by-two multiplication problems only included numbers that were four or greater. This forced the participants to always carry numbers as they solve each problem.

The consent form was at the beginning of each participant packet and stapled. Below this form, were the four experimental worksheets. These experimental worksheets were stapled with a title sheet that read "Part A: Please Wait for Instruction." Similar to previous research, the control worksheet (Appendix D) started with one, one-by-one digit multiplication problem followed by fifteen three-by-two multiplication problems. Titles were required at the top of each experimental worksheet so participants could refer to the worksheets while completing the survey. Random letters were chosen from the middle of the alphabet to reduce the chance that participants would imply an order or hierarchy while completing the survey. The control was labeled "TT" at the top. The following worksheets also began with a one-by-one digit multiplication problem, but the ratios of how many one-by-one to three-by-two multiplication problems differed. The math worksheet labelled "VV" (Appendix E) contained three one-by-one multiplication problems for every three-by-two multiplication problem (3B:1T). The math worksheet labelled "MM" (Appendix F) had a one-to-one ratio, or a single one-by-one problem for every three-by-two multiplication problem (1B:1T). The final math worksheet labelled "PP" (Appendix G) had a single one-by-one problem for three, three-by-two problems (1B:3T).

Next, was the four parallel choice worksheets. The four parallel choice worksheets were paperclipped to allow participants to pull out their selected sheet. This paperclipped section also contained a title sheet that read "Part B Please Wait for Instruction." These choice worksheets

contained the same ratio of interspersed problems as the experimental worksheets. However, these choice worksheets contained no title at the top. The choice worksheet parallel to the control, found in Appendix I, began with one brief problem and contained no others. The worksheet parallel to the 1B:1T worksheet can be found in Appendix J. The parallel worksheets to the 1B:3T and the 3B:1T experimental worksheets are found in Appendix K and Appendix L, respectively.

Finally, below the choice worksheets in the packet was the survey which was stapled to a title page that read "Part C Please Wait for Instruction." The survey, found in Appendix H, contained two forced choice ranking questions. These questions allowed participants to select which of the experimental worksheets would take the most to least time to complete. The second question asked participants to rank which worksheet would take most to least effort to complete. An example of how to appropriately fill out these questions was at the top of the survey. Additionally, the survey contained three demographic questions asking participants to identify their sex, current year in school, and ethnicity.

Instructions for administering the study, found in Appendix M, were read to participants, and informed them when to move on to a new worksheet as a group, when to make a worksheet selection, and when to begin the survey and start their worksheet selection. The instructions also indicate for every experimental worksheet, that participants are to work in order and to not skip any problems.

**Independent Variable**

The independent variable is the total number of brief, interspersed problems on each worksheet. The control sheet contained one brief one-by-one digit multiplication problem at the beginning followed by 15 of the target three-by-two multiplication problems. The 1B:3T

worksheet contains 5 brief interspersed problems, while the 1B:1T worksheet contains 15 interspersed problems. Finally, the 3B:1T worksheet contains the highest number of brief problems with a total of 45.

**Dependent Variables**

The primary dependent variable was the number of participants who choose each parallel worksheet after working on each experimental worksheet. In addition, the total number of problems completed were evaluated. The number of target problems completed, and target problem accuracy were analyzed across the experimental worksheets. Additionally, participant perceptions of most to least time and effort to complete with be analyzed across worksheets.

**Procedures**

Potential participants were given two invitation emails and two announcements in class by their professors about the opportunity to assist in this research for a few extra credit points. Those wishing to earn the same points but not participate in research were given additional information about an assignment of roughly the same time and difficulty that they could complete to earn the additional credit for their courses.

After participants arrived at the testing area, which was a classroom in the university education building, they were given a packet containing the consent form, the four worksheets, the four choice sheets, and the survey. The consent form was read aloud by a research assistant, participant questions were answered, and signed consent forms were collected from everyone who chose to participate. Those who did not wish to participate were excused. Participants were instructed to work for the entire duration given for each math worksheet, to not skip any problems, and to work accurately. Specific instructions can be found in Appendix M. Participants were given 300 s to complete each worksheet and were moved through the target

worksheets as a group, starting and stopping together and receiving instruction between each sheet.

After all four target worksheets were completed, participants were instructed to choose one of the parallel, choice worksheets that they would complete after the survey. After each individual in the group decided which sheet they wanted to work on, they were instructed to return the other three sheets to the packet. They were then instructed to begin the survey and afterwards begin working on their preferred math worksheet. When all participants completed their survey and had worked on the math worksheet for a few problems, they were instructed to stop. Participants were thanked for their participation and dismissed after answering any additional questions.

**Data Analysis**

After all the data were collected, the worksheets that participants chose were entered into SPSS under numerical values 1 for the control worksheet, 2 the 1B:3T worksheet, 3 the 1B:1T worksheet, and 4 the 3B:1T worksheet. A chi-squared goodness of fit test was used to determine if any worksheet choice was selected at a significantly different rate than the rest. One worksheet was significantly different from the rest. As such, the data was plotted to aid in determining which worksheet participants selected differently from the rest.

The total number of problems completed on each worksheet, including brief and target problems tallied and compared. As one worksheet failed normality testing, a Friedman's test was used to assess differences in total problem completion rates. Post hoc analysis using Wilcoxon signed rank tests with a Bonferroni adjustment were used to determine which worksheets differed statistically one from another.

To determine if the number of brief problems impacted the rates of target problem completion, the number of target problems completed was tallied and compared using a repeated measures ANOVA. To determine if any style of worksheet had an impact on participant accuracy, the total number of target problems solved accurately was tallied for each worksheet. The total number of target problems solved correctly failed Shapiro Wilk tests of normality. As such, a Friedman's test was used to compare target problem accuracy differences across worksheets.

Participants were required to complete a survey at the completion of the worksheets. The survey asked participants to rank the worksheets on which would take the most to least time to complete as well as the most to least effort to complete. Chi square tests were used to determine if the difference in participant rankings of effort and time to complete were significantly different between worksheets. In order to evaluate if participants were ranking time and effort similarly, a chi-squared test of independence was used for the participant rankings of time and effort for each worksheet (e.g. time rankings of the control worksheet were compared to effort rankings on the control worksheet).

In addition, a chi-squared test of independence was used to determine if the year in school that each participant was related to worksheet choice. Gender and ethnicity had little variability making statistical analysis ineffective.

**Procedural Integrity and Interobserver Agreement**

A secondary researcher was present for 36.3% of the administration sessions. The research assistant had a copy of the research administration instructions (Appendix F). The secondary researcher followed along and checked off each bullet point as it was read. For the sessions attended by the secondary researcher, procedural integrity was 100%.

At the completion of data collection, a secondary researcher randomly selected 40% of participant's completed worksheets. These worksheets were scored again by the research assistant to check for accuracy in scoring. Interobserver agreement was 99.3% accuracy across the worksheets. Participant handwriting on one problem made a difference in scoring on a single problem between scorers. The research assistant also counted the total number of problems completed across these worksheets. Interobserver agreement was 100% for total number of problems completed. Parallel worksheet choice selection, effort rankings, and time rankings were also at 100% interobserver agreement across the selected participant packets.

# Chapter III

# Results

## Choice and Problem Completion Rates

After working on each assignment for 3 min, participants were allowed to choose which new parallel worksheet they would complete. Figure 1 (Appendix B) shows the number of participants that selected each worksheet. Most participants ($n$ = 24, 66.67%) selected the 3B:1T worksheet. This majority of participants was statistically significant using a chi-squared goodness of fit test, $\chi^2$ (3, $n$ = 36) = 34.2, $p$ < .001. This analysis showed students chose the assignment with the three brief problems for every target problem (3B:1T). Thus, the majority of participants choose to complete a new assignment with 45 additional problems.

The total number of problems completed on each worksheet, including brief and target problems, was tallied. Table 1 (Appendix A) displays the means, standard deviation, and range of the total problems completed across each worksheet. As Table 1 indicates, as the number of 1 by 1 problems increased, so did problem completion rates. Thus, students completed the most total problems on the 3B:1T assignment with 45 1 by 1 problems, followed by the 1B:1T (15 brief problems), then followed by 1B:3T (5 brief problems). Students completed the fewest problems on the control assignment with only 1 brief problem. These data showed that researchers successfully manipulated relative problems completion rates via interspersing brief problems.

Due to the small sample size, a Shapiro-Wilk test was performed to evaluate normality of the total number of problems solved across each worksheet. The 1B:3T ($W$ = 0.96, $p$ = 0.18), the 1B:1T ($W$ = .95, $p$ = 0.08), and the 3B:1T worksheet ($W$ = .95, $p$ = 0.13) showed evidence of falling within a normal distribution. The total number of problems solved on the control worksheet departed significantly from normality ($W$ = 0.93, $p$ = .02). As such, a Friedman's test

was used to assess if differences between total number of problems completed between worksheets was significant. Differences between the worksheets were statistically significant, $\chi^2(3, n = 36) = 94.24$, $p < .001$. Post hoc analysis with Wilcoxon signed-rank tests was conducted with a Bonferroni correction applied, resulting in a significance level set at $p < .0083$. Table 2 (Appendix A) displays the findings of the post hoc analysis, which demonstrated that the number of problems completed on each worksheet differed statistically from one another. Overall, participants completed significantly more problems on the 3B:1T worksheet.

Figure 2 (Appendix B) displays the number of participants who selected each worksheet alongside the average number of total problems completed for each worksheet. Overall, the relationship between the number of participants who selected a worksheet and total problems completion rates were correlated with one exception. Fewer students choose the 1B:1T than total problems completion rate data would have predicted. This relationship between worksheet selection and total problem completion demonstrates that item completion is a reinforcing event in accordance with the discrete task completion hypothesis.

**Target Problem Performance**

To evaluate if the addition of interspersed problems resulted in reduced rates of responding to target problems, the number of target problems completed was counted and compared across worksheets. The average number of target problems completed along with the mean and standard deviation is displayed in Table 3 (Appendix A). Due to the small number of participants, a Shapiro-Wilk test was used to evaluate normality. The control worksheet ($W$ =.95, $p$ = 0.96), the 1B:3T worksheet ($W$ = .95, $p$ = .11), the 1B:1T ($W$ = .95, $p$ = 0.57), and the 3B:1T worksheet ($W$ = .96, $p$ = 0.16) demonstrated evidence of normality. As such, a repeated measures ANOVA was used to determine if the mean number of target problems completed differed

significantly between worksheets. The number of target problems completed across worksheets did not statistically differ between each worksheet ($F(3, 105) = 1.06$, $p = .37$).

These data show that participants were not completing significantly different numbers of target problems across worksheets. This result implies that the addition of interspersed problems, even on the 3B:1T worksheet, did not significantly reduce how many target problems participants completed. Thus, adding the 1 by 1 problems did not interfere with practice opportunities on the target problems. Additionally, the data suggest that adding the 1 by 1 problems did not significantly increase the time required to complete each worksheet.

The total number of target problems completed correctly is displayed in Table 4 (Appendix A). Ten of the participants did not complete any of the target problems accurately across all worksheets. This negatively skewed the data across all the worksheets. Failed normality was also observed through a Shapiro-Wilk test on the control worksheet ($W = .86$, $p < .001$), the 1B:3T worksheet ($W = .81$, $p < .001$), the 1B:1T worksheet ($W = .87$, $p < .001$), and the 3B:1T worksheet ($W = .88$, $p < .001$). As the data failed normality tests, a Friedman's test was used to evaluate differences in target completion accuracy. The differences in target problem accuracy across worksheets was not significant, $\chi^2(3, n = 36) = .44$, $p = .93$. Thus, the addition of interspersed problems as well as the number of interspersed problems between target problems did not increase or decrease the accuracy of target problems. For the classroom setting, this means that accuracy was neither improved nor hindered using the additive interspersal procedure or the number of interspersed problems.

**Participant Perceptions of Effort and Time**

Table 5 (Appendix A) displays the average participant rankings of how much effort each worksheet would take to complete. Ranking ranges from 1-4 with 1 indicating most effort. The

relationship between effort ranking and number of additional 1 by 1 problems was linear. Most participants ranked the control worksheet with only 1 additional 1 by 1 problem as taking the most effort, followed by the 1B:3T (5 additional 1 by 1 problems), then 1B:1T (15 additional 1 by 1 problems). Finally, students ranked the 3B:1T worksheet (45 additional 1 by 1 problems) as taking the least effort to complete. Table 6 (Appendix A) displays the number and percentage of participants who ranked each worksheet as taking the most to least effort. As the number of additional 1 by 1 problems increases, the percentage of participants who perceived the worksheet as taking more effort decreases.

A chi squared goodness of fit test was used to determine if differences in participant rankings were significant. The control worksheet, ranked by most participants as taking the most effort to complete was statistically significant, $\chi^2(3, 36) = 38.44$, $p < .001$. The 1B:3T worksheet was ranked as taking the second most effort to complete by most participants was also significant, $\chi^2(3, 36) = 9.33$, $p = .025$. Most participants significantly ranked the 1B:1T worksheet as taking the third most effort to complete, $\chi^2(3, 36) = 31.78$, $p < .001$. Finally, a significant proportion of participants ranked the 3B:1T worksheet as taking the least amount of effort to complete, $\chi^2(3, 36) = 36.17$, $p < .001$. One may assume that each additional problem increases effort. Thus, with 45 additional 1 by 1 problems, the 3B:1T worksheet should require the most effort to complete. However, most participants perceived the 3B:1T worksheet as taking the least amount of effort to complete.

Table 7 (Appendix A) displays the average participant rankings of how much time each worksheet would take to complete. Ranking ranges from 1-4 with 1 indicating most time to complete. The relationship between time to complete and the number of additional 1 by 1 problems was linear. Most participants ranked the control worksheet with only 1 additional 1 by

1 problem as taking the most time to complete, followed by the 1B:3T worksheet (5 additional 1 by 1 problems), then 1B:1T worksheet (15 additional 1 by 1 problems). Finally, students ranked the 3B:1T worksheet (45 additional 1 by 1 problems) as taking the least time to complete. Table 8 (Appendix A) displays the number and percentage of participants who ranked each worksheet as taking the most to least time to complete. As the number of additional 1 by 1 problems increases, the percentage of participants who perceived the worksheet as taking more time to complete decreases.

A chi squared goodness of fit test was used to determine if differences in participant rankings were significant. The control worksheet, ranked by most participants as taking the most time to complete was statistically significant, $\chi^2(3, 36) = 29.33$, $p < .001$. The 1B:3T worksheet was ranked as taking the second most time to complete by most participants was also significant, $\chi^2(3, 36) = 10.44$, $p = .015$. Most participants significantly ranked the 1B:1T worksheet as taking the third most time to complete, $\chi^2(3, 36) = 18.44$, $p < .001$. Finally, a significant proportion of participants ranked the 3B:1T worksheet as taking the least amount of time to complete, $\chi^2(3, 36) = 43.78$, $p < .001$.

As previously discussed, participants completed a similar number of target problems across each worksheet despite the addition of interspersed problems. This suggests that the completion of each worksheet would happen within a similar time. Despite this, participant perceptions of time differed with most participants viewing the worksheet with the greatest number of interspersed problems, the three brief for every target worksheet, as taking the least time to complete.

A chi-squared test of independence was used to determine if participants ranked time and effort similarly for each worksheet. Participants ranked time and effort in a similar manner for

the control worksheet with those ranking the worksheets as the most time also ranking the worksheet taking the most effort, the worksheet taking the second most time as also taking the second most effort and so on, $\chi^2(9, 36) = 29.343$, $p < .001$. Participants also ranked time and effort to complete each worksheet in a similar manner on the 3B:1T worksheet, $\chi^2(3, 36) = 9.33$, $p = .025$, the 1B:1T worksheet, $\chi2(3, 36) = 31.78$, $p < .001$, and the 3B:1T worksheet, $\chi2(3, 36) = 36.17$, $p < .001$.

**Year in School on Choice**

Most of the participants were in their sophomore year of college ($n$ =14, 38.89%), while 11 (30.56%) were freshman, 10 (27.78%) were juniors, and 1 (2.78%) participant was a senior. The current year in school that the participants were in was found to have no relationship with their choice of worksheet. A chi squared test of independence resulted in retention of the null hypothesis, $\chi^2(9, 36) = 7.334$, $p = .602$.

**Total Problems Completed, Choice, and Perceptions**

Figure 3 (Appendix B) displays the average total problems complete, the percentage of participants who selected or chose each worksheet to complete, total effort rankings, and total time rankings. Effort and time rankings are reverse order, with the highest scored indicating the less effort and time. As shown in Figure 3, as total problem complete rates increase, perceived effort and time to complete an assignment decrease. Also, with one exception (1B:1T), as total problems completed increased so did the percentage of students who chose to complete a parallel worksheet.

# Chapter IV

## Discussion

Previous researchers investigating the additive interspersal procedure found that students in college (Skinner et al., 1996, Skinner et al., 1999, Wildmon et al., 1998), middle school (Logan & Skinner, 1998), and high school (Wildom et al., 1999) demonstrated a preference for math worksheets that included the addition of brief problems compared to worksheets that were similar in difficulty but did not contain the additional problems. Students continued to prefer the added problems even when the overall number of target, more difficult problems was increased by an additional 40% (Cates & Skinner, 2000). The current findings support the general findings of previous research in that students continue to show a preference for worksheets that have more additional brief problems.

### Theoretical Implications of Findings

#### *Discrete Task Completion Hypothesis*

Over their educational careers students have opportunities to be rewarded for assignment completion. As such, tasks (e.g., each individual problem on a math worksheet) that precede this reinforcement can become reinforcers themselves (Skinner, 2002). The discrete task completion hypothesis offers an explanation as to how students can complete assignments without any visible reinforcement, as each completed problem acts as a reinforcing event. As such, worksheets that offer brief tasks (i.e., can be completed quickly) have been found to be preferred by students. While this study and previous researchers have found support for this hypothesis, previous researchers have focused on adding brief problems only after every third target problem. According to the discrete task completion hypothesis, worksheets that have an even greater number of added brief problems should be preferred by students.

Participants ($n$ = 24, 66.67%) in this study showed a statistically significant preference for the worksheet that offered the highest number of brief problems overall, which was 3B:1T worksheet. In addition, total problem completion rates were highest for the 3B:1T worksheet. This choice along with total problem completion rates offers additional support for the discrete task completion hypothesis as participants favored the worksheet that offered the highest rate of reinforcement, or the highest number of total problems completed.

The number of participants who selected each worksheet was correlated to the total number of problems completed. As the total number of problems completed increased, so did the number of participants who selected the worksheet, with one exception. Fewer students chose the 1B:1T worksheet that the total problem completion rate data would have predicted. While this difference does not appear to support the discrete task completion hypothesis, there were not significant differences among the remaining, lower problem completion rate worksheets (control, 1B:3T, and 1B:1T). One factor that may have contributed to these nonsignificant differences is that 66.67% chose the sheet with the highest ratio of 1 by 1 problems. Thus, the number of students choosing other assignments was very small which may have prevented finding significant difference.

### *Effort on Choice*

Altering the amount of effort required to complete a behavior has been used to modify behaviors. Increasing effort is generally aversive (Inzlict et al., 2018) and decreases the rates of responding (Wilder et al., 2021) similar to punishment procedures. Researchers have reduced response rates of self-injury through increasing weight on limbs (Wallace et al., 1999) and reduced instances of Pica when items are in further proximity to the individual requiring more effort to obtain them (Piazza et al., 2002). Decreasing effort generally increases the response

rates of individuals. This effect can be seen by increased use of picture exchange cards that are in proximity as opposed to aggressive behaviors (Buckley & Newchok, 2005) and the number of steps required to obtain a desired item (Richman et al., 2001). Similar reduction in effort has been used to engage students in academic tasks (Jones, 2012) by reducing the number of problems students are expected to complete on an assignment.

While increasing effort usually reduces engagement in a task, previous additive interspersal procedure research found increasing effort by adding brief problems increased, as opposed to decrease the probability that students would choose to engage in the assignment with the additional problems (Cates & Skinner, 2000; Hawkins et al., 2005; Skinner et al., 1996; Skinner et al., 1999; Wildmon et al., 1998). As significantly more students choose the assignment that required the most effort to complete (3B:1T), the current study supports researchers who suggested that adding these brief problems may enhance effort, but also enhance rates of reinforcement while working on assignments (Skinner, 2002). Thus, the current finding support the discrete task completion hypothesis.

***Participant Perceptions of Effort and Time***

Participants in this study had the opportunity to rank which worksheets they believe would take the most, second most, third most, and least effort and time to complete. In ranking time and effort in this study, participants ranked time and effort in a similar manner. The worksheets that were ranked as taking the most time were also ranked as taking the most effort to complete, while the worksheet that was ranked as taking the second most time was also ranked as taking the second most effort and so on. Further research into the relationship between perceptions of time and effort might be beneficial.

Participants ranked the control worksheet as taking the most time to complete. The 1B:3T worksheet was ranked as second most time to complete while the 1B:1T worksheet was ranked as taking the third most time to complete. Finally, the 3B:1T worksheet was reported as taking the least amount of time to complete. While perceptions of time to complete each worksheet differed as reported by participants, no statistical difference in target rate completion existed. This suggests that participants would complete the worksheets in the same amount of time. As such, participant views on time to complete each worksheet are inaccurate. Differences in time might be found if participants were allowed to complete each worksheet, however, under a timed condition no difference exists. Future research allowing participants to complete worksheets and time perceptions might be beneficial.

Each worksheet completed by participants contained the same number of target problems, but differed in the number of brief interspersed problems. As the number of interspersed problems increases, the amount of effort to complete a worksheet increases as well. Despite this, participant selection on ranking of effort were inverse to which worksheets would take the most effort to complete. For example, participants reported the 3B:1T worksheet as requiring the least amount of effort to complete despite having the highest number of problems. The worksheet that contained the second highest number of problems, the 1B:1T, was reported as taking the second most effort. The 1B:3T worksheet was reported as taking the third most effort by participants. Finally, the control worksheet was reported as taking the most time and effort to complete despite having the least number of problems.

While participants ranked effort to complete each worksheet inversely to the actual amount of effort it would take to complete, these rankings align with choice behavior research. Behaviors are embedded in an economic matrix where individuals weigh the costs versus the

benefits of their behaviors (Herrnstein, 1961, 1970). Such costs weighed by individuals include the amount of effort a behavior would take, the rate of reinforcement, quality of reinforcement, or how long until they can obtain reinforcement (Friman & Poling, 1995). As the costs change, so do the behaviors that individuals choose to engage in, or in this case, which worksheet the participants choose to complete.

Despite increases in effort, participants in previous research (Skinner et al., 1996; Logan & Skinner, 1998; Wildmon et al., 1999) and in this study continue to choose worksheets with additional interspersed problems. This implies that the additive interspersal procedure is a powerful behavior modifier. One possibility is that rates of reinforcement are increased as hypothesized by researchers (Skinner, 2002) of the discrete task completion hypothesis. An additional possibility is that completed problems are not a lower quality of reinforcement as previous researchers have hypothesized (Skinner, 2002). Finally, a combination of higher rates of reinforcement and completed problems being a stronger reinforcer than previously hypothesized is a possibility.

**Applied Implications**

When learners have obtained initial skills, they need practice to continue to develop fluency (Hattie, 2009; Miller & Heward, 1992). Even when teachers prepare high quality opportunities for this practice, students can choose to engage in other, more reinforcing behaviors (Myerson & Hale, 1984). Several interventions are used to increase student choice to engage in practice materials. Decreasing the amount of effort to complete an assignment (e.g., reducing the number of problems on a math worksheet) (Jones, 2012), brief sheets (Wallace et al., 2003), or even allowing students to respond vocally (Skinner et al., 1993, Skinner et al., 1997) have been used to increase student engagement and responses to materials. However, they

are not without negative effects. Decreasing the amount of work reduces practice opportunities and fluency development. In addition, reducing effort can have negative consequences in the loss of opportunity to value outcomes of work (Inzlicht et al., 2018), and lost opportunity to pair high effort with high rewards through learned industriousness (Eisenberger, 1992). Allowing students to respond vocally (Skinner et al., 1993; Skinner et al., 1997) also reduces practice in modes of responding that might later be required (e.g. state testing).

The brief sheet intervention, while effective, is heavy on the use of teacher time as students continually return to the teacher to receive reinforcement and the next portion of the assignment (Wallace et al., 2003). Previous research (Martens & Houk, 1989) into the matching law also found increases of student engagement with teacher reinforcement; however, the reinforcement required is at a level that is not appropriate for general education classrooms in which many interventions take place.

The additive interspersal procedure also adds to required teacher time, however, the time required to create the worksheet is outside of instructional time. This study and previous research have found evidence that the use of the additive interspersal is preferred by students and has the potential to increase engagement and choice to practice (Skinner, 2002). This procedure is ideal in that it does not take from instructional time and does not reduce the opportunities to practice materials. Previous researchers (Skinner et al., 1996; Logan & Skinner, 1998; Wildmon et al., 1999) have used math worksheets that contain an interspersed problem after every three target problems. Current evidence suggests that higher rates of interspersed problems, such as three interspersed problems for every target problem, is preferred by students compared to no interspersed problems, one for every three target problems, or even one for every target problem.

As teachers increase the number of interspersed math problems, the chances that students will engage in practice materials increases as well.

### *Time to Complete Worksheets*

Those who implement the additive interspersal procedure in their classrooms might be concerned that additional problems might increase the time required to complete each assignment. Increases in time to complete a worksheet can reduce practice opportunities for new skills and time away from other academic activities. Statistically, participants did not complete any more or less target problems on any given worksheet, suggesting that no worksheet would take any more time or less time to complete compared to the others.

### *Grade of Participant on Worksheet Selection*

Previous researchers found that participants across grade levels such as college students (Skinner et al., 1996, Skinner et al., 1999, Wildmon et al., 1998), sixth grade students, (Logan & Skinner, 1998), and high school students (Wildmon et al., 1999) preferred worksheets that included interspersed brief problems compared to worksheets that did not. These findings further support previous research. The survey presented to participants allowed for the selection of which year in school each participant was in including freshman, sophomore, junior, or senior. Across all grades, no significant relationship was found between grade and worksheet selection.

## Limitations and Future Research

### *Participants*

This study consisted of 36 college age students from a teacher preparation program. Most of the participants were female and identified as Caucasian. Only one participant identified as being in their senior year of college. While previous researchers (Skinner et al., 1996, Skinner et al., 1999, Wildmon et al., 1998), have identified worksheets with added, brief items to be

preferred by college-age students, further research is needed to demonstrate if increased rates of interspersed math problems continue to be a preference. Specifically, a greater number and more diverse population of college-age students should be included in the research literature. This diversity can and should include sex, grade levels, and other programs outside of education preparation. Additionally, similar studies should be conducted with K-12 general education students and students with disabilities (e.g., EBD, ADHD).

Almost all previous research on written mathematical problem solving showed that the additive interspersal procedure did not alter accuracy on target problems (Skinner, 2002). The current results support these findings. However, two studies found increases in accuracy when students were required to complete match tasks cognitively or without paper and pencil (Hawkins et al., 2005; Robinson & Skinner, 2002). Researchers posited that cognitive tasks require higher levels of sustained attention. Additional research should be conducted to determine how and under what conditions the additive interspersal procedure enhances accuracy on target problems. Such research may result in a procedure that not only enhances preference and the probability that students will choose to do assignment, but also their performance on those assignments.

While this study did not demonstrate any differences in accuracy, there is the possibility that accuracy might differ for those that struggle with attention such as learners who have attention deficit-hyperactivity disorder. As paper and pencil tasks require less attention, those that struggle with attention might perform differently in accuracy and target problem completion rates compared to those who do not have attention difficulties. Higher rates of reinforcement such as three brief problems to every target problem might be an additional aid to those who struggle with attention and build on the research of Hawkins et al. (2005). In a similar manner,

future research should include those with diverse disabilities and the use of increased ratios of interspersed math problems.

Participants in this study consisted of college students in a teacher preparation program. Many in this program are not involved in mathematics curriculum. Ten of the participants (27.78%) did not complete any target problems accurately on any worksheet. Preference for worksheets with increased interspersed problems can be due to lack of practice in solving math problems by hand. Including other students from other programs where mathematics is a greater focus might reveal different worksheet preferences.

### *Need for Longitudinal Research*

Most research on the additive interspersal procedure takes place one time and asks participants to compare worksheets (Cates & Skinner, 2000; Hawkins et al., 2005; Skinner et al., 1996; Skinner et al., 1999; Wildmon et al., 1998). Unlike these studies, McCurdy et al. (2001) used an alternating treatment design (alternating between worksheets with and without added interspersed problems) over time to show that time on-task increased when the additive interspersal procedure was used. However, this study contained one elementary school student that was displaying difficulties with remaining on-task during assignments. Further research is needed on the long-term effects of the use of the additive interspersal procedure on multiple areas tied with academics such as choice behaviors (on-task, increased in problems completion), grades, and retention of materials.

### *Alternative Academic Subject Areas*

The additive interspersal procedure has been found to be effective across several subject areas including reading acquisition, spelling, and math (Cates et al., 2003; Neef et al., 1977, 1980). Increasing rates of interspersed brief problems can also be included in similar academic

areas to observe if students also show an increase in preference to assignments in other subject areas. In addition, accuracy and time to complete should also be evaluated for work in other subject areas.

### *Increased Effort on Reinforcement*

Individuals are constantly weighing the costs (e.g., effort, rate of reinforcement) and benefits of their behaviors (quality of reinforcement, delay of the reinforcement) (Friman & Poling, 1995; Herrnstein, 1961, 1970). According to the discrete task completion hypothesis (Skinner, 2002), each completed problem on a worksheet is a lower quality reinforcer that aides in sustaining behavior until a high quality and preferred reinforcer can be obtained, such as time talking with friends or activities on an iPad that occur when class assignments are completed. While the addition of brief interspersed math problems has been observed to increase student choice of worksheets at a rate of three brief problems for every target problem, there is the potential that the addition of problems and effort will overcome the reinforcement properties of the discrete task completion hypothesis. When increased effort overcomes additional secondary reinforcement is unknown and a potential area of future research.

## Conclusion

This study found further evidence for the use of the additive interspersal procedure in increasing student preference for worksheets with brief, additional, problems added to a math worksheet. As participants showed a preference for the worksheet with the highest ratio of interspersed problems, further evidence is also provided for the discrete task completion hypothesis as a potential causal mechanism for reinforcement in assignment completion in classrooms.

For educators, the addition of brief problems in math worksheets has been found to be effective in increasing choice for the worksheet that contains the highest number of interspersed problems, which in this case was the worksheet with three brief problems for every target problem. Increasing the choice to engage in  worksheets has the potential to increase the learning and on-task behaviors of learners. This study provided evidence that further increasing the rate of brief problems to each target problem, such as three brief problems to each target problem, further increases preference for the worksheet compared to others, without the decrease in the number of problems solved accurately or the time to complete each worksheet. Further, those worksheets that had the highest number of brief problems added were observed by participants as taking less time and effort to complete.

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# Appendices

## Appendix A

Tables

**Table 1**

*Descriptive Statistics for Total Problem Completion Rates*

| | Mean | SD | Range |
|---|---|---|---|
| Control | 5.75 | 3.02 | 2-13 |
| 1B:3T | 7.81 | 4.37 | 1-17 |
| 1B:1T | 10.75 | 5.67 | 1-25 |
| 3B:1T | 23.19 | 11.33 | 7-55 |

**Table 2**

*Results of Wilcoxon Signed Rank Tests for Post hoc Analysis of Total Problems Completed*

| | Control | | 1B:3T | | 1B:1T | |
|---|---|---|---|---|---|---|
| | *Z* | *p* | *Z* | *p* | *Z* | *p* |
| 1B:3T | -3.82 | <0.001 | - | - | - | - |
| 1B:1T | -5.19 | <0.001 | -4.18 | <0.001 | - | - |
| 3B:1T | -5.23 | <0.001 | -5.24 | <0.001 | -5.25 | <0.001 |

**Table 3**

*Descriptive Statistics for Target Problem Completion Rates*

| | Mean | SD | Range |
|---|---|---|---|
| Control | 4.81 | 3.03 | 0-12 |
| 1B:3T | 5.25 | 3.29 | 0-12 |
| 1B:1T | 4.83 | 2.86 | 0-12 |
| 3B:1T | 5.14 | 2.76 | 1-13 |

**Table 4**

*Descriptive Statistics for Target Problems Completed Accurately*

| | Mean | SD | Range |
|---|---|---|---|
| Control | 2.81 | 2.93 | 0-11 |
| 1B:3T | 2.56 | 3.04 | 0-11 |
| 1B:1T | 2.53 | 2.55 | 0-8 |
| 3B:1T | 2.56 | 3.04 | 0-8 |

**Table 5**

*Average Participant Rankings of Effort*

| | Mean | SD |
|---|---|---|
| Control | 1.53 | 0.91 |
| 1B:3T | 2.33 | 0.89 |
| 1B:1T | 2.61 | 0.65 |
| 3B:1T | 3.53 | 1 |

**Table 6**

*Participant Rankings of Effort*

| | Control<br>n (%) | 1B:3T<br>n (%) | 1B:1T<br>n (%) | 3B:1T<br>n (%) |
|---|---|---|---|---|
| Most Effort | 25 (69.4%) | 6 (16.7%) | 2 (5.6%) | 3 (8.3%) |
| 2nd Most Effort | 5 (13.9%) | 16 (44.4%) | 11 (30.6%) | 4 (11.1%) |
| 3rd Most Effort | 4 (11.1%) | 10 (27.8%) | 22 (61.1%) | 0 (0%) |
| Least Effort | 2 (5.6%) | 4 (11.1%) | 1 (2.8%) | 29 (80.6%) |

**Table 7**

*Average Participant Rankings of Time*

| | Mean | SD |
|---|---|---|
| Control | 1.67 | 1.01 |
| 1B:3T | 2.47 | 0.88 |
| 1B:1T | 2.5 | 0.81 |
| 3B:1T | 3.36 | 1.1 |

**Table 8**

*Participant Rankings of Time*

| | Control<br>n (%) | 1B:3T<br>n (%) | 1B:1T<br>n (%) | 3B:1T<br>n (%) |
|---|---|---|---|---|
| Most Effort | 23 (63.9%) | 4 (11.1%) | 5 (13.9%) | 4 (11.1%) |
| 2nd Most Effort | 5 (13.9%) | 16 (44.4%) | 10 (27.8%) | 5 (13.9%) |
| 3rd Most Effort | 5 (13.9%) | 11 (30.6%) | 19 (52.8%) | 1 (2.89%) |
| Least Effort | 3 (8.3%) | 5 (13.9%) | 2 (5.6%) | 26 (72.2%) |

## Appendix B

Figures

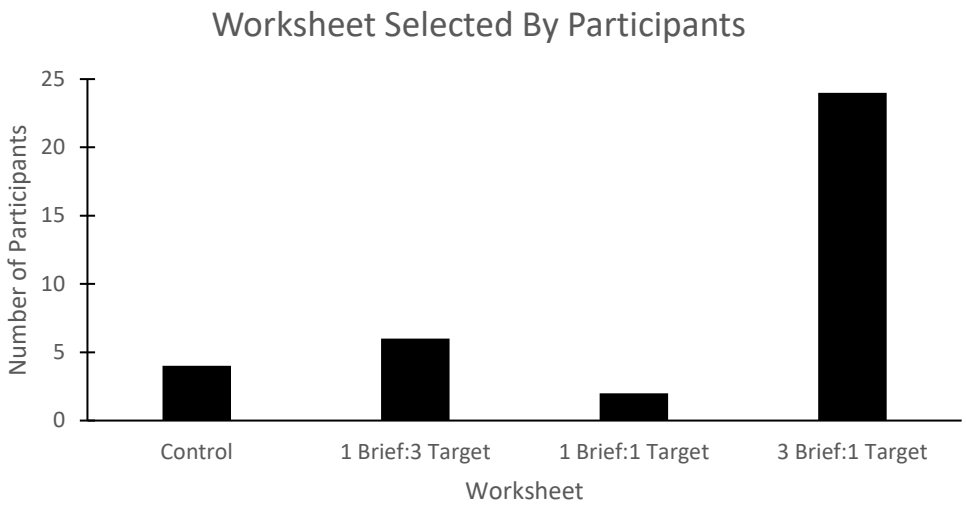



**Figure 1**

*Number of Participants who Selected Each Worksheet*

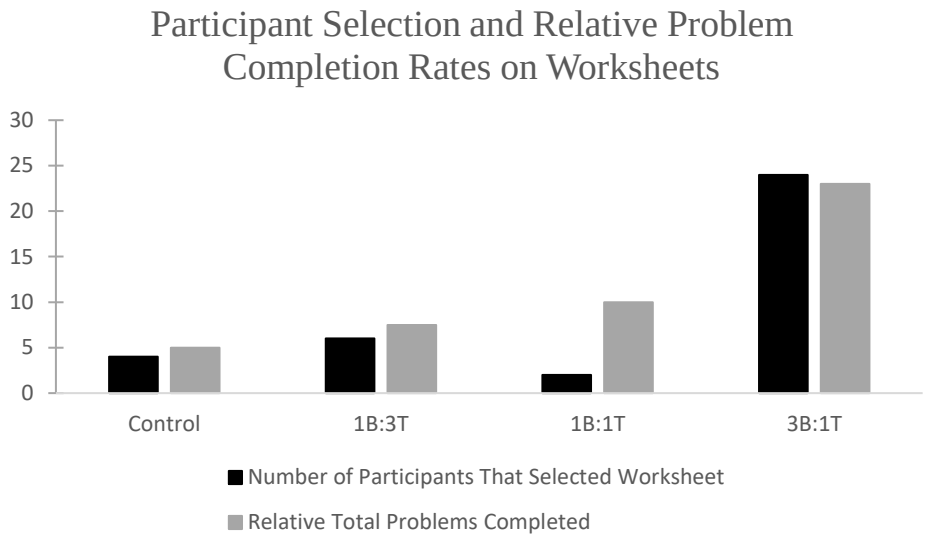



**Figure 2**

*Participant Worksheet Selection and Total Problem Completion Rates*

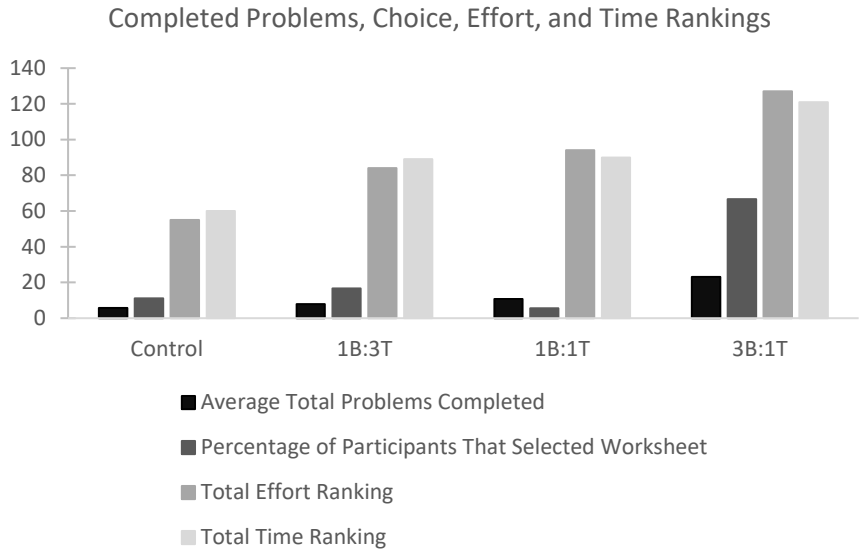



**Figure 3**

*Comparison of Completed Problems, Choice, Effort, and Time Rankings*

**Appendix C**

Consent Form

# Consent for Research Participation

**Research Study Title:** The effects of altering the ratio of interspersed, simpler math problems on student preference.

**Researcher(s):** Jared Thomas John, M.S., University of Tennessee, Knoxville
Chris Skinner, Ph.D., University of Tennessee

## Why am I being asked to be in this research study?

We want to study different styles of math worksheets has on college age student preferences. We are asking you to be in this research because you are college age students.

## What is this research study about?

The purpose of the research study is to see what type of math worksheets students prefer and if they perform better on any given style of math worksheet.

## Who is conducting this research study?

This study is being conducted by researchers at the University of Tennessee, Knoxville. Researchers are professors or doctoral students in the school psychology program and have completed research training requirements and background checks for research through the University. While some of the researchers in the program might be your instructors, they will not be able to attach your name to the data collected today.

## How long will I be in the research study?

If you agree to be in the study, your participation will last between for 45 minutes.

## What will happen if I say "Yes, I want to be in this research study"?

If you agree to be in this study, we will ask you to work on several math worksheets for short durations of time. At the conclusion of the math worksheets, you will choose two more sheets that you would like to work on. After choosing, you will fill out a short survey

outlining your preferences and short demographic questions about yourself. The remainder of the time will be used to complete your chosen math worksheets.

## What happens if I say "No, I do not want to be in this research study"?

Being in this study is up to you. You can say no now or leave the study later. Either way, your decision won't affect your grades, your relationship with your instructors, or standing with the University of Tennessee, Knoxville. Instead of participating in the study, possible options to earn extra credit include selecting a short research paper and providing a two-paragraph outline of the research and its findings. More specific details can be obtained through your course instructors.

## What happens if I say "Yes" but change my mind later?

Even if you decide to be in the study now, you can change your mind and stop at any time.

If you decide to stop before the study is completed, please raise your hand to let the researchers know you wish to withdraw. Any information collected up until that point will be discarded and not used in any analysis. After the completion of this 45-minute session and you leave the room, there is no way to attach your name to any collected data. At that time, removing your data from the study will not be possible

## Are there any possible risks to me?

It is possible that someone could find out you were in this study, but we believe this risk is small because of the procedures we use to protect your information. These procedures are described later in this form.

## Are there any benefits to being in this research study?

We do not expect you to benefit from being in this study. Your participation may help us to learn more about student preferences on math worksheets. We hope the knowledge gained from this study will benefit others in the future.

## Who can see or use the information collected for this research study?

The following is how we plan on protecting the confidentiality of your information. After deciding if you wish to participate in this study and signing your consent to participate, if you choose, you will immediately hand the consent form over to the researchers. All the rest of the information you complete including math worksheets and the survey will not have your name attached to it. These signed consent sheets will be stored in a locked filing cabinet in the primary investigator's office. After your data is input into computer files, the

math worksheets and surveys will be destroyed. Only those members of the research team will have access to any electronic data.

If information from this study is published or presented at scientific meetings, your name and other personal information will not be used.

We will make every effort to prevent anyone who is not on the research team from knowing that you gave us information or what information came from you. Although it is unlikely, there are times when others may need to see the information, we collect about you. These include:

- People at the University of Tennessee, Knoxville who oversee research to make sure it is conducted properly.
- Government agencies (such as the Office for Human Research Protections in the U.S. Department of Health and Human Services), and others responsible for watching over the safety, effectiveness, and conduct of the research.
- If a law or court requires us to share the information, we would have to follow that law or final court ruling.

## What will happen to my information after this study is over?

We will keep your information to use for possible publication in scientific journals or presentations at scientific meetings. Your name and other information that can directly identify you will be kept secure and stored separately from your research data collected.

## Will I be paid for being in this research study?

Extra credit has been offered for your participation in this research study. Your professors have, as part of the invitation to participate in this research study, outlined how many points will be awarded for your participation.

## Will it cost me anything to be in this research study?

It will not cost you anything to be in this study.

## What else do I need to know?

This research study will have a relatively small sample size of under four hundred participants. Due to this, there is a risk that others might discover that you have participated in this research or be able to identify you based on the information we collected from you. The information collected will include math sheets, your sex and student classification (example: Freshman, Sophomore, Junior, Senior).

## Who can answer my questions about this research study?

If you have questions or concerns about this study, or have experienced a research related problem or injury, contact the researchers, Jared Thomas John at jjohn8@vols.utk.edu. You may contact Dr. Chris Skinner at 865-974-8403 or by email, cskinne1@vols.utk.edu

For questions or concerns about your rights or to speak with someone other than the research team about the study, please contact:

Institutional Review Board
The University of Tennessee, Knoxville
1534 White Avenue
Blount Hall, Room 408
Knoxville, TN 37996-1529
Phone: 865-974-7697
Email: utkirb@utk.edu

## STATEMENT OF CONSENT

I have read this form and the research study has been explained to me. I have been given the chance to ask questions and my questions have been answered. If I have more questions, I have been told who to contact. By signing this document, I am agreeing to be in this study. I will receive a copy of this document after I sign it.

| Name of Adult Participant | Signature of Adult Participant | Date |
|---|---|---|

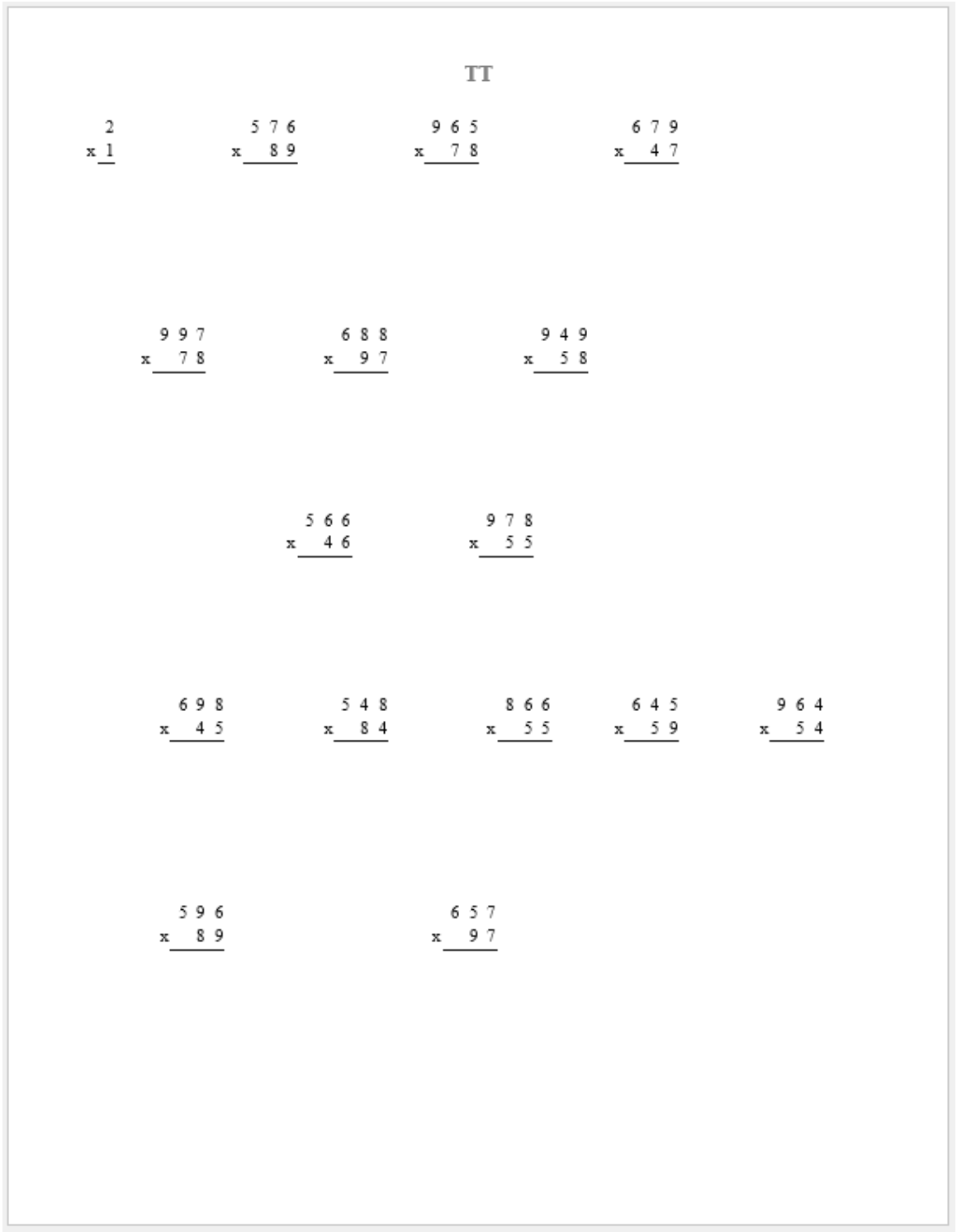
**Researcher Signature** (to be completed at time of informed consent)

I have explained the study to the participant and answered all of his/her questions. I believe that he/she understands the information described in this consent form and freely consents to be in the study.

| Name of Research Team Member | Signature of Research Team Member | Date |
|---|---|---|

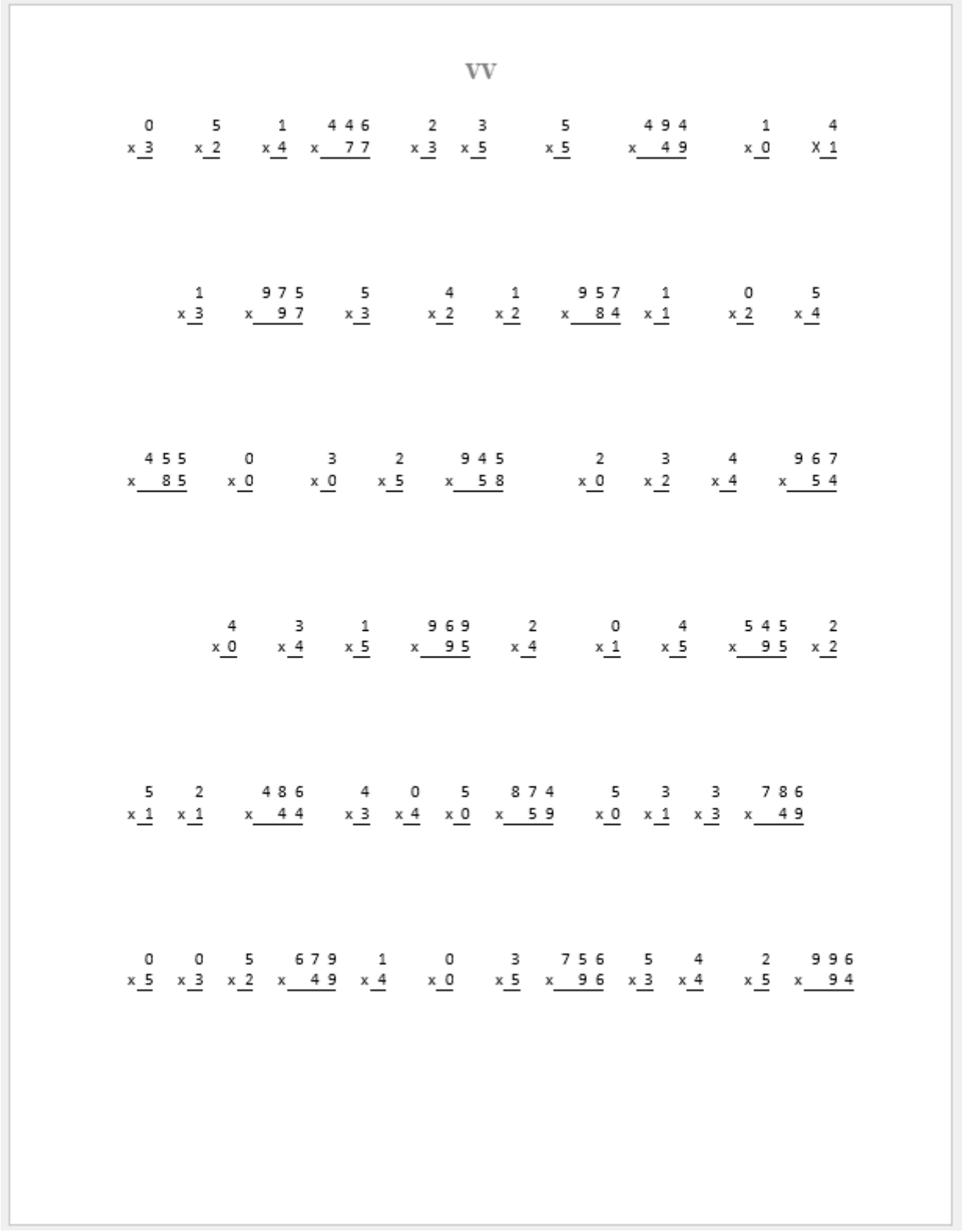
## Appendix D

Control Worksheet



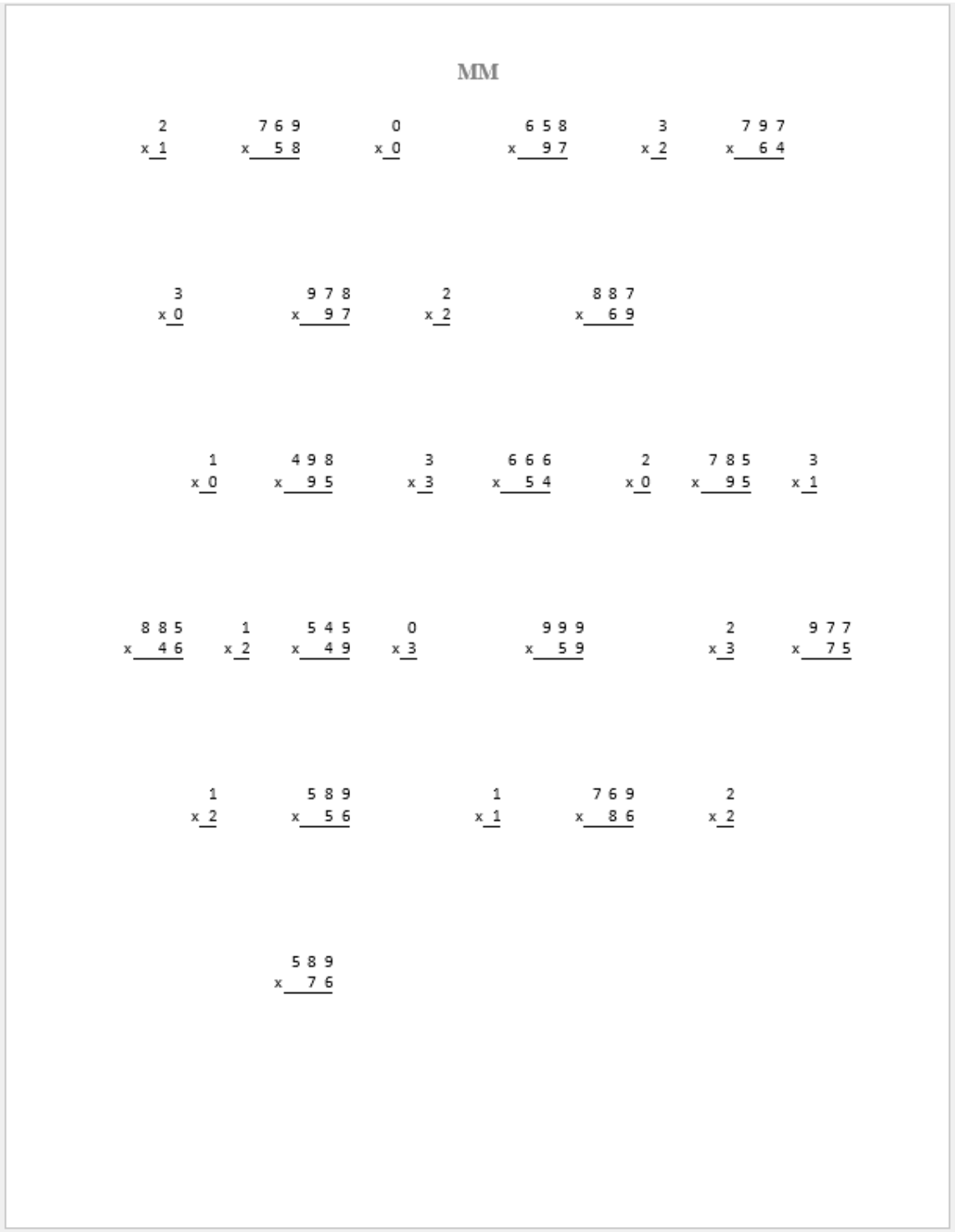
## Appendix E

Three Brief Problems to Every Target Problem Worksheet



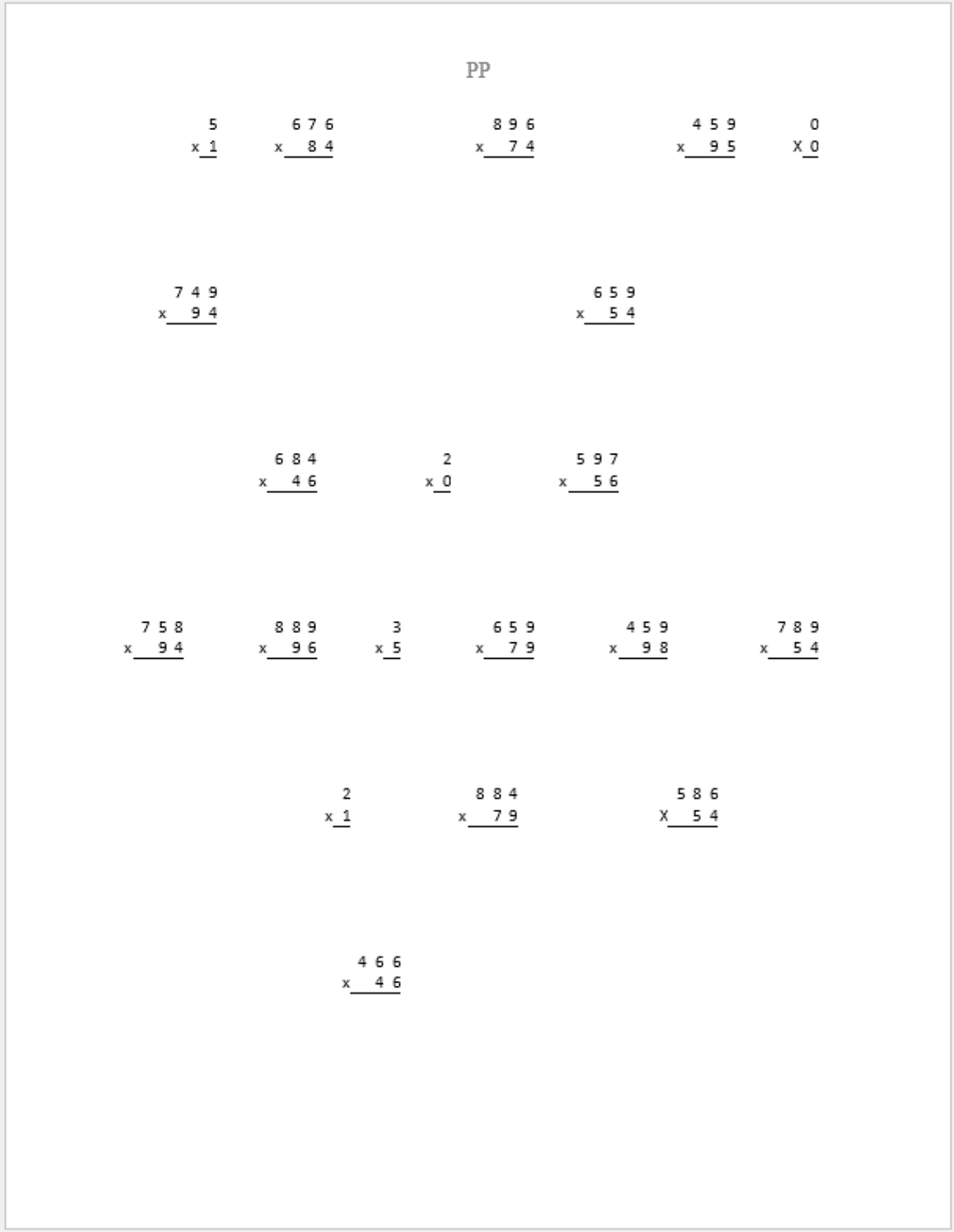
## Appendix F

One Brief Problem to Every Target Problem Worksheet



## Appendix G

One Brief Problem to Every Three Target Problems Worksheet



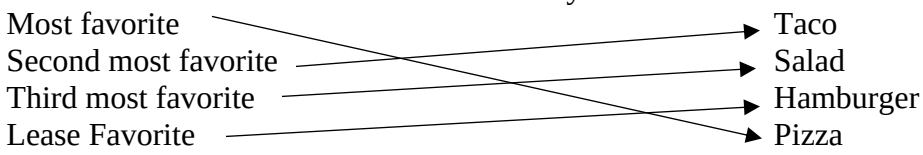
## Appendix H

Interspersal Survey

**Please Rank the Following. Look at the example first.**

Example:

Please rank your favorite foods.




---

1) Which math sheets would take the most time to complete?

| | |
|---|---|
| Most time | "PP" |
| Second most time | "TT" |
| Third most time | "MM" |
| Least time | "VV" |

2) Which math sheets would take the most effort to complete?

| | |
|---|---|
| Most effort | "PP" |
| Second most effort | "TT" |
| Third most effort | "MM" |
| Least effort | "VV" |

**Please Circle the Response that Best Matches You:**

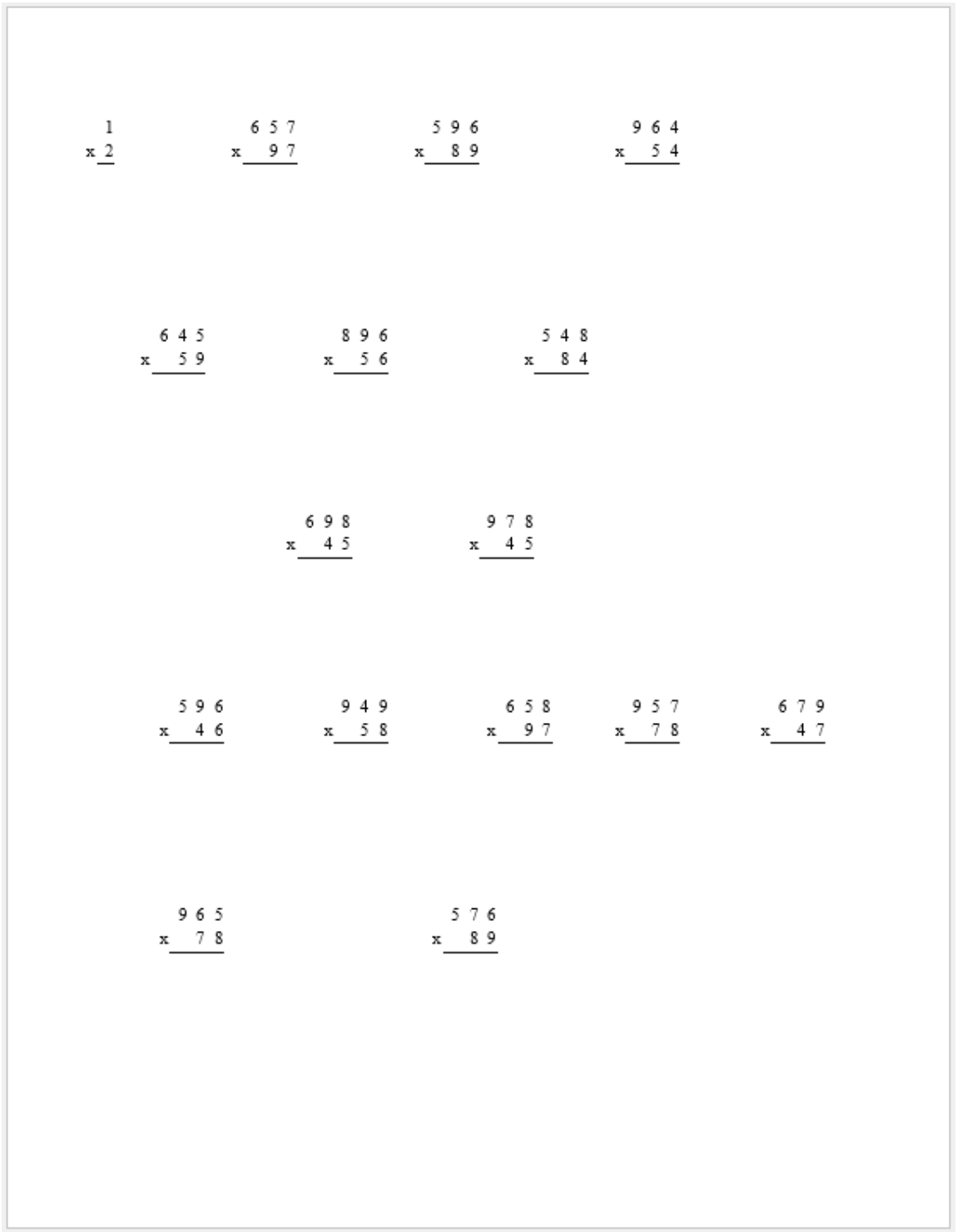
4) What is your Sex? Male Female Prefer Not to Answer

5) What is your current year in school? Freshman Sophomore Junior Senior

6) What is your Ethnicity? Caucasian/White African American Native American Hispanic Asian Hawaiian/Pacific Islander Multi-Racial

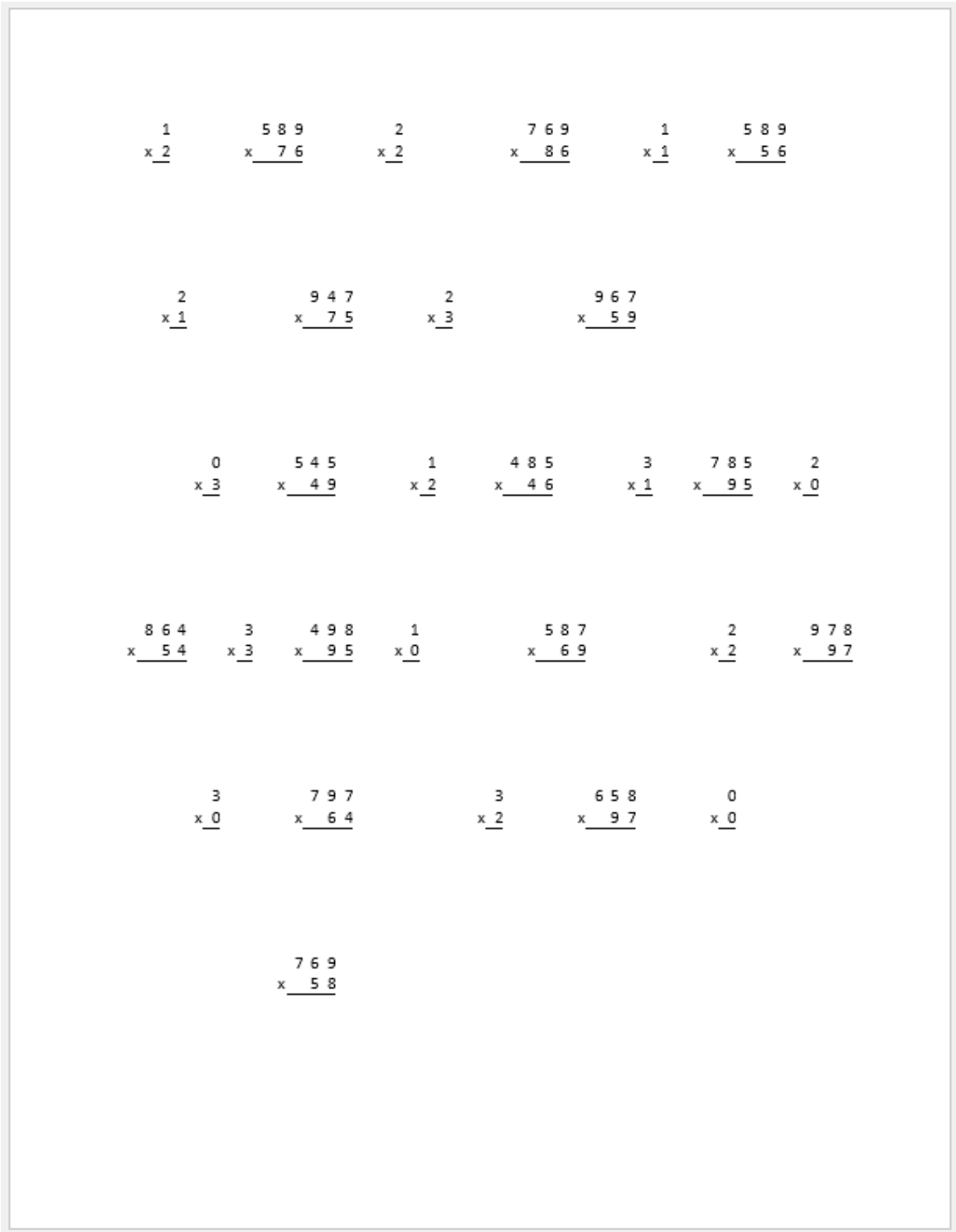
## Appendix I

Parallel Control Choice Worksheet



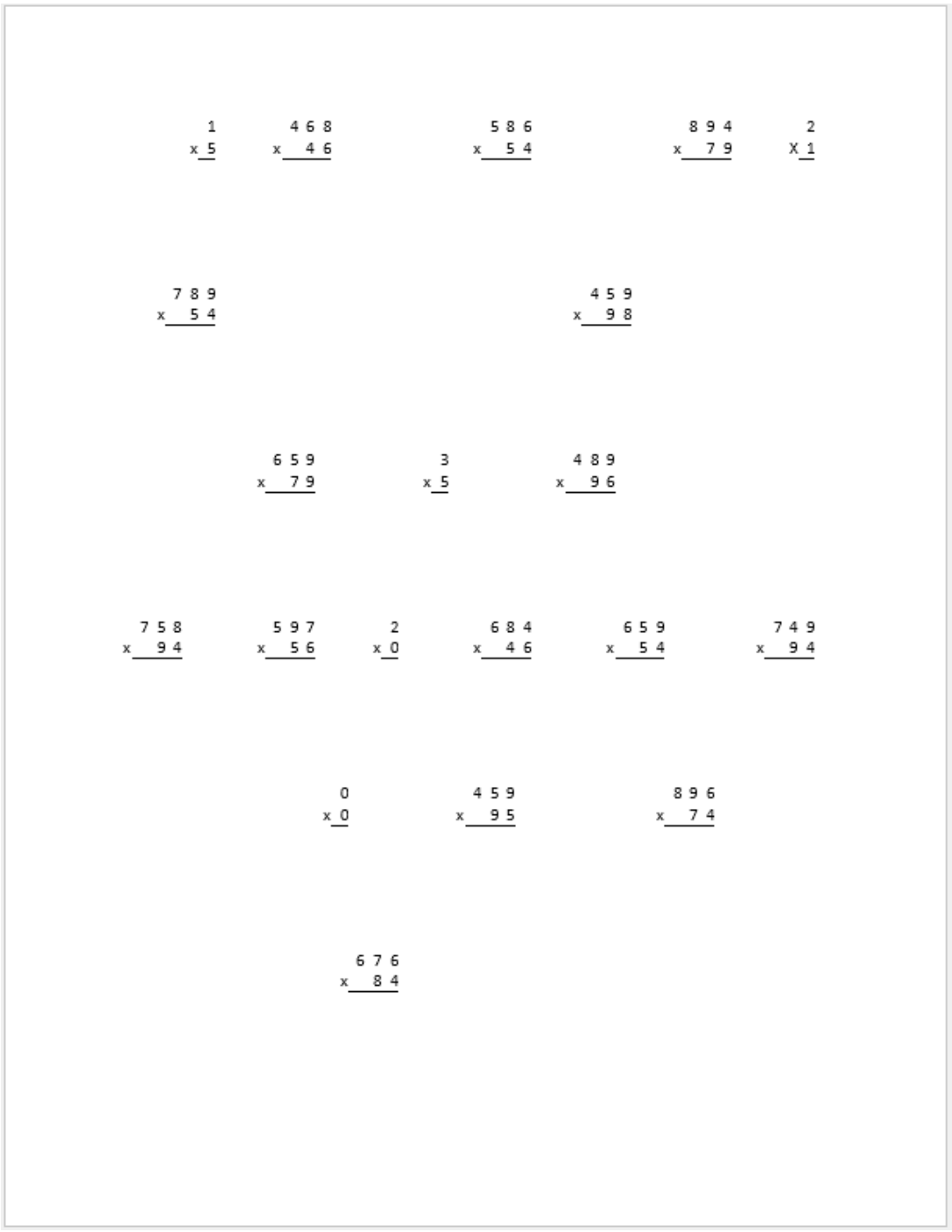
## Appendix J

Parallel One Brief to Every Target Problem Choice Worksheet



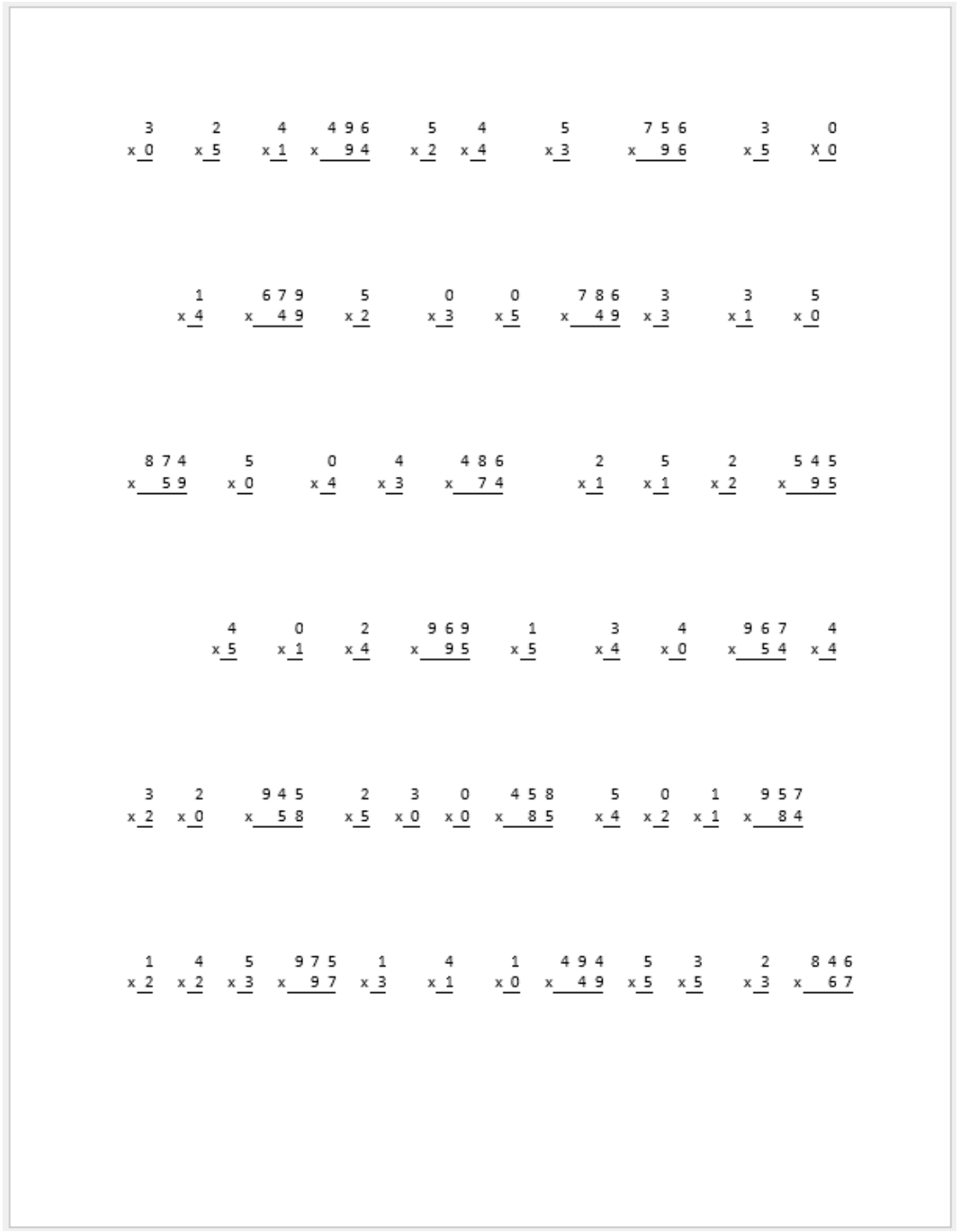
## Appendix K

Parallel One Brief for Every Target Problem Choice Worksheet



## Appendix L

Parallel Three Brief for Every Target Problem Choice Worksheet



## Appendix M

Instruction Forms

- Thank you all for joining today. To start, I will read the consent form out loud. Please pull your own copies of the form and follow along. Afterwards, I will answer any questions.
    - Read Consent Form
    - Any questions? (Answer Questions)
    - If there are no further questions, and you wish to continue with your participation, please sign the back of your consent form. If you do not wish to participate, you are free to leave now. You may wish to write your teachers name on the bottom of the consent form to receive your extra credit.
- Collect Consent Forms
- There are two parts to this project. On the first part, you will be asked to work through four different mathematics assignments. Do not start working until instructed. Work through as many problems as possible without sacrificing accuracy. Start with the top row and work from left to right without skipping any problems. Work until time is called or when you reach the bottom of the page. Stop when you reach the bottom of the page or time is called and wait for further instructions. After completing the first part, you will select the next mathematics assignment you wish to complete in its entirety. After making your selection, you will be asked to answer questions on a brief survey before completing your chosen assignment.
- <u>Please open your folder and remove part A. You may set the folder aside.</u> When I say "Begin", please turn the page and begin working on the math assignment. Stop when time is called or when you reach the bottom of the page and wait for further instructions. Any questions? (Answer any questions)
- "Begin"
- Time for 5 mins (300 s)
- "Stop" When I say Begin, please turn the page, and begin working on the next assignment. Remember to go in order from left to right starting from the top line and without skipping any problems. Begin.
- Time for 5 min (300 s)
- "Stop" When I say Begin, please turn the page, and begin working on the next assignment. Remember to go in order from left to right starting from the top line and without skipping any problems. Begin.
- Time for 5 min (300 s)
- "Stop" When I say Begin, please turn the page, and begin working on the next assignment. Remember to go in order from left to right starting from the top line and without skipping any problems. Begin.
- Time for 5 min (300 s)
- "Stop" Now I would like you to open your folders. Please remove Part B. Look through the pages of Part B and carefully select the assignment you want to complete, in its

entirety, in a moment. Please keep the assignment out and put the rest of part B back in the folder.

- Please remove Part C from the folder. You will be answering questions about the assignments you completed for part A and will need to refer to the assignments. The questions on the brief survey ask you to rank different aspects of the assignments you completed by drawing arrows to the different assignments. Please note that the options on the survey match the titles at the top of the assignments.
- When you have finished the survey, please start the assignment you chose to work on a moment ago. You may begin the survey now.
- Look to see that everyone completes the survey (might have to walk around room and remind one or two to start the assignment). **When all have completed the survey, and everyone has at least started their chosen worksheet**:
    - "Stop", you do not need to complete this worksheet. Please put all your materials back into your folders. Thank you for your participation. Are there any questions that I can answer before you go today?
    - Answer questions
    - Thank you all for your participation today. You are dismissed.

## Vita

Jared “Thomas” John was born to Jared John and Marianne Pratt. He grew up in Blythe, California with his parents and younger brothers Curtis and Hayden John, along with his younger sister, Megan John. He married his wife, Natalie Boelter in May 2012. He attended Brigham Young University – Idaho for his undergraduate studies. During his undergraduate studies, his first two children, “Eli” and “Abbie”, were born. He graduated in December 2016 with his Bachelor of Science degree in Psychology, and a minor in Engineering. Shortly after he worked with youth in a developmental disability agency, as a school paraprofessional, and then as a special education teacher for two years. His third child, Taryn, was born during his first year of teaching. He began graduate school in the Fall of 2019 at the University of Tennessee: Knoxville pursuing his Ph.D. in School Psychology. Thomas obtained his Master of Science degree in Applied Behavior Analysis from the University of Tennessee in 2022. His current research interests include class wide management strategies, applied behavior interventions in the school setting, and teacher support. Thomas will be completing his pre-doctoral internship with the Tennessee Internship Consortium at the Maryville School District in 2023-2024. He will complete his doctoral degree in 2024.