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Parents Supporting Their Adolescents' Independent Remedial Math Practice: The Effects
of a Multi-Component Intervention Package on Math Academic Performance

by

Mackenzie S. Sommerhalder

A DISSERTATION

Presented to the Faculty of
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Parents Supporting Their Adolescents' Independent Remedial Math Practice: The Effects
of a Multi-Component Intervention Package on Math Academic Performance

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University of Nebraska, Lincoln, 2018

Advisor: Edward J. Daly III

This dissertation examined the effects of high school students' independent, remedial, home-based math practice while receiving parent support on math computation fluency. The multi-component intervention package encompassed both home-based remedial practice and parent support. Teacher interviews, normative assessments, and a performance-deficit analysis were conducted to identify high-school students who displayed math academic skill deficits. Next, identification and analysis of individual skills (e.g., multiplication, division) to be targeted for intervention occurred for each participant included in the study. A multiple-baseline across participants design was used to examine teaching high school students to choose effective instructional components for math computation and subsequently given support to implement the intervention(s) of their choice on math computation fluency.

Conditions were implemented with a high degree of integrity, and results demonstrated that, though there were some performance increases, there were no observable increases in math academic performance and experimental control was not established. Results were discussed in terms of the importance of identifying appropriate instructional antecedents and consequences for establishing stimulus control, providing adolescents with instruction on intervention use, allowing students to choose intervention components, establishing an appropriate balance between parental involvement and

support and adolescent autonomy, and determining acceptability of all participants involved. Discussion also focused on the limitations of the current study, including time constraints, treatment integrity, and measurement issues, as well as directions for future research, such as examining intervention components separately, technology use, and exploring treatment strength and intensity in relation to acceptability.

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CHAPTER 1

Introduction and Literature Review

Remediating Skill Deficits

Mathematics is an essential skill necessary for adequate functioning across multiple domains of life, including employment, education, home management, leisure, health, community involvement, and interpersonal relationships (Patton, Cronin, Basset, & Koppel, 1997; Rivera, 1997). A review of multiple large-scale national research studies of mathematics and reading in Great Britain documented the consequences of poorly developed numeracy skills in children and adults (Gross, Hudson, & Price, 2009). Those with poor reading skills had fewer employment opportunities as well as lower wages once employed. Notably, outcomes were worse if mathematics skills were poor, even for individuals who had adequate reading skills. Moreover, poor mathematics skills have been associated with lower rates of full-time employment, more frequent periods of unemployment, higher rates of low-paying manual occupations, and lower rates of promotion (Geary, 2012) when compared to individuals with poor reading skills.

In spite of the well-established importance of mathematics, high school students in the United States continue to perform poorly in mathematics when compared to national and international standards (Aud et al., 2012; National Mathematics Advisory Panel, 2008). According to the most recent National Assessment of Educational Progress (NAEP) data available, only 25% of twelfth-grade students in the United States demonstrated grade-level proficiency (i.e., scored at or above the cut score for the Proficient or Advanced level) in mathematics on a nationally representative assessment (National Center for Education Statistics, 2015). Of the large national sample, only 37%

of high school students performed at the Basic level (partial mastery of the prerequisite knowledge and skills fundamental to proficient mathematics performance) in mathematics, while 38% performed below the Basic level, reflecting inadequate proficiency with prerequisite knowledge and skills.

The National Council of Teachers of Mathematics (NCTM, 2013) outlined five content standards to guide high-quality mathematics curriculum selection and development that includes (1) number and operations, (2) algebra, (3) geometry, (4) measurement, and (5) data analysis and probability. Number and operations is the standard that lays the foundation for the other standards and encompasses number sense, the understanding of basic arithmetic operations, and computation fluency (NMAP, 2008). Research has consistently demonstrated that proficiency with numbers and operations is critical to a high school student's ability to acquire higher-level mathematics skills. Deficits in this area will likely reduce academic achievement (Carson & Eckert, 2003; Lyon, 1996; NCTM, 2013; NMAP, 2008; Shapiro, 2004). For example, Jordan, Kaplan, Ramineni, and Locuniak (2009) examined the predictive relationship between early number competence and later mathematics achievement in children in elementary school. Participating children were assessed longitudinally a total of 11 times between kindergarten and third grade using a standardized number competence measure designed by the researchers and the Calculation and the Applied Problems portions of the Woodcock-Johnson III test of achievement. The results revealed that number competence in kindergarten significantly predicted number competence and overall mathematics achievement in third grade, indicating the importance of number competence in

establishing appropriate learning trajectories for elementary-school children in mathematics.

Computation fluency, or the ability to calculate math facts accurately, quickly, and with minimal effort, a skill subsumed under the number and operations construct, is crucial to the development of other mathematical skills (NCTM, 2013; NMAP, 2008; Shapiro, 2004). Advanced mathematics, such as algebra and geometry, are composite skills that require students to fluently use a combination of component skills (Binder, 1996; Johnson & Layng, 1992). For instance, basic number writing, addition, subtraction, multiplication, and division are the component skills necessary to factor an equation. Fluency with component skills directly affects acquisition of composite skills in that the higher the performance rates of component skills, the faster a complex composite skill will be learned (Binder, 1996; Johnson & Layng, 1992). As such, students who demonstrate computation fluency with basic math facts may be able to allocate more cognitive resources (e.g., attention; Pellegrino & Goldman, 1987) to understanding the more advanced skills, which can increase the likelihood of acquiring those advanced skills (Gagne, 1983). Researchers have also suggested that students who exhibit computation fluency may be more likely to willingly engage in complex math tasks than students who lack computation fluency (Billington & DiTommaso, 2003; Cates & Rhymer, 2003; McCurdy, Skinner, Grantham, Watson, & Hindman, 2001; Skinner, 1998). In contrast, students who fail to acquire computation fluency may avoid those more complex math tasks due to the time and effort required to complete them and/or the perception that they are too difficult to complete (Skinner, Pappas, & Davis, 2005). Thus, poor computation fluency may be a contributing factor to some high-school students'

poor proficiency on national standardized tests.

Instruction. In response to widespread deficit in basic skills, recommendations have been made to inform effective instructional practices. NCTM (2013) advanced six fundamental principles for high quality mathematics instruction in addition to the content standards previously mentioned. According to the NCTM (2013), teachers should promote access and attainment for *all* students, meaning that reasonable and appropriate accommodations should be made for individual students to ensure high expectations and strong supports for all. Moreover, the NCTM recommends that instruction be coherent, well articulated, and focused on important aspects of mathematics across grades to prepare students for school, home, and work settings. Additionally, the NCTM states that teachers must have a deep understanding of the mathematics being taught and should be able to provide that knowledge in a flexible manner based on assessment of student skills and through the use of technology. However, the NCTM principles are very general and do not provide specific recommendations for instructional strategies or *how* to apply these principles to practice; instead, these decisions are left up to teachers. For that, one must turn to well-validated instructional models.

Direct Instruction (DI) arose as an attempt to teach students in an effective and efficient manner while simultaneously acknowledging the different skill levels of individual students (National Institute for Direct Instruction, 2015). In fact, the guiding philosophy of DI is that if a student fails to learn, the instruction is at fault, not the student (Engelmann, 1969; Engelmann, 1993; Engelmann & Carnine, 1982). Gersten, Carnine, and White (1984) summarized the instructional-design principles on which DI was built, which are commonplace in most behavior-analytic models. They include

academically oriented feedback (Good & Beckerman, 1978), swift pacing of tasks (Carnine, 1976), routine correction of all student errors (Carnine, 1980), clear cues for responding (Cowart, Carnine, & Becker, 1976), continuous assessment of student progress, and high levels of academic engagement during lessons.

Over 50 years of research has demonstrated the positive impact of DI on student academic achievement across a variety of academic areas and grades (e.g., Borman, Hewes, Overman, & Brown, 2003; Coughlin, 2011; Hattie, 2009; Rosenshine & Stevens, 1986; Schug, Tarver, & Western, 2001; Stein & Goldman, 1980; Stockard, 2010, 2013). More specifically, the accumulated findings from decades of research consistently demonstrate that students taught using DI have greater academic achievement scores (Becker & Gersten, 1982), higher graduation rates (Meyer, et al., 1983), complete more college applications (Gersten et al., 1984; Meyer, et al., 1983), and have increased academic engagement (Gersten et al., 1984; Stallings, Almy, Resnick, & Leinhardt, 1975) than students taught with other curricula across academic areas (Darch, Carnine, & Gersten, 1984; Fielding, Kameenui, & Gersten, 1983), cognitive abilities (Gersten, Becker, Heiry, & White, 1981), grade levels (Becker & Gersten, 1982; Meyer, Gersten, & Gutkin, 1983; Stein & Goldman, 1980), races/ethnicities (Gunn, Smolkowski, Biglan, & Black, 2002; Kamps et al., 2007; SRA/McGraw-Hill, 2009), and socioeconomic statuses (O'Brien & Ware, 2002). Gersten et al. (1984) argue that these basic instructional principles can be thought of as a protocol for promoting stimulus control and this lack of response to effective instructional practices may be a result of a stimulus control problem.

Effective remediation as a Stimulus-Control issue. According to Gersten et al. (1984), the design principles of DI were created based on the basic behavioral principle of stimulus control. The concept of stimulus control has provided a useful framework for both instruction and intervention (Daly, Hofstadter, Martinez, & Andersen, 2010). Stimulus control is the basic behavioral process that governs academic responding (Daly & Murdoch, 2000). Stimulus control refers to the occurrence or non-occurrence of a behavior according to the presence or absence of a particular antecedent stimulus. When the antecedent stimulus is present, behavior is more likely. When it is absent, behavior is less likely. For skill building, stimulus control occurs through stimulus discrimination training, which involves providing a reinforcing consequence only in the presence of a specific antecedent stimulus, the S^D (Skinner, 1969). If the student's behavior occurs in the presence of some other antecedent stimulus (S-delta), it is not reinforced (Miltenberger, 2016). The antecedent stimulus becomes a discriminative stimulus (S^D) that evokes the correct response. As such, a behavior is said to come under stimulus control when there is a greater likelihood that the behavior will occur in the future while in the presence of the S^D , but not in the presence of S-delta. Math encompasses many skill repertoires that can be developed through the process of stimulus discrimination training. For example, a student's oral response to a visually presented multiplication problem behavior should be under the stimulus control of that multiplication problem. If the student responds correctly to the problem, he or she receives reinforcement for that response. If the student responds incorrectly to the multiplication problem, he or she will not receive reinforcement. The presence of an academic performance problem indicates that the target S^D (e.g., a multiplication problem on a flash card) has not developed

appropriate stimulus control over the student's academic responding (i.e., a correct oral response; Kupzyk, Daly, Ihlo, & Young, 2012). Accordingly, an academic performance problem in math can be conceptualized as a behavior deficit, meaning that the academic response is not occurring as frequently as it should following the S^D ; the response may not even be occurring at all (Daly et al., 2010).

The goal of academic intervention is to increase academic responding in the presence of instructional material (i.e., the desired S^D ; Daly et al., 2010; Greenwood, 1996; Heward, 1994). Academic intervention is essentially stimulus discrimination training applied to curricular objectives for which stimulus control is weak (Daly, Lentz, & Boyer, 1996). The learning trial is at the heart of all academic intervention and is a key contributor to academic learning (Daly et al., 2010; Heward, 1994; Skinner, Fletcher, & Henington, 1996). The learning trial is a synonym for the three-term contingency (antecedent-behavior-consequence) and consists of an instructional antecedent, a student response, and a consequence that either corrects an incorrect response or reinforces a correct response (Daly et al., 2010). Thus, when viewed as a behavior deficit, the existence of academic performance problems indicates that the instructional antecedents and consequences for responding are not appropriately matched to the student's proficiency level. As such, the learning trial can be used to identify the mismatch and establish a functional relationship between the instructional antecedent that should evoke a response and the student's academic responding (Daly et al., 2010).

The Instructional Hierarchy. The Instructional Hierarchy (IH; Haring, Lovitt, Eaton, & Hansen, 1978) is a useful heuristic for structuring and maximizing the efficiency of learning trials. The IH is a dynamic teaching model that calls for close

monitoring of the student's proficiency level with the skill being taught (Martens, Daly, Begeny, & VanDerHeyden, 2011). Proficiency improves as the student goes from accuracy to fluency, to generalization, and finally adaptation (Daly et al., 1996). During initial skill development, proficiency monitoring focuses on *how* accurately or fluently a skill is performed. As skill development progresses, proficiency is measured in terms of the breadth of conditions under which the skill can be performed—all of those circumstances in which the skill can be usefully applied (Martens et al., 2011). Different instructional strategies are used over the course of skill development to promote greater proficiency. In initial skill development, responding is often inaccurate and slow. Accuracy improves when practice is accompanied by modeling and prompting. As accuracy improves and error rate decreases, fluency can be improved through repeated practice, timed trials, feedback, and positive reinforcement for improved rate of responding. Once responding is both accurate and fluent, generalization can be programmed through modeling, repeated practice, and reinforcement across all the contexts necessary for skill mastery (Daly et al., 1996). The literature suggests that the use of these strategies can be highly effective at promoting skill acquisition across multiple academic areas, including reading, writing, and math (e.g., Ardoin & Daly, 2007; Espin & Deno, 1989; Lalli & Shapiro, 1990; Skinner, McLaughlin, & Logan, 1997).

One intervention designed to increase and promote accurate responding is Cover-Copy-Compare (CCC; Grafman & Cates, 2010; Skinner, Turco, Beatty, & Rasavage, 1989; Skinner, Bamberg, Smith, & Powell, 1993). CCC has been widely researched across multiple academic areas for many decades. In fact, the first study of CCC

examined its effectiveness on spelling accuracy (Hanson, 1978). CCC is a self-management intervention that can be used to address multiple basic math skills. With this intervention, students are provided with a model of how to respond to an instructional item on a worksheet. After inspecting it, the student then covers the problem with the correct answer, copies the response, and then compares the written response the original model. If the student's response is incorrect, he or she fixes the mistake prior to moving on to the next stimulus. In effect, CCC provides multiple learning trials with modeling, multiple opportunities to respond, immediate corrective feedback, and error correction (Rathvon, 2008; Skinner, et al., 1997).

Though CCC has been shown to be efficacious across multiple academic areas (e.g., reading, spelling), few studies have examined its efficacy in the area of math. Nevertheless, CCC has been shown to improve math accuracy (Lee & Tingstrom, 1994; Mong & Mong, 2010; Mong & Mong, 2012; Poncy, Skinner, & O'Mara, 2006; Stading, Williams, & McLaughlin, 1996). In an early study, Lee and Tingstrom (1994) modified CCC for small-group application. A multiple-baseline-design-across-behaviors was used to measure digits correct per min (DCPM) and percent of problems correct for five fifth-grade students. The students were instructed to monitor the amount of time it took for them to complete the CCC worksheets assigned for the day; however, they were allowed to take as long they needed. Improvements in percent of problems correct were found for all participants and four of the five participants showed increases in DCPM from baseline to intervention.

In another study, Stading et al. (1996) investigated the effects of home-based CCC on multiplication facts with an 8-year-old female. A multiple-baseline-design-

across-behaviors was used to measure accuracy. Sessions lasted between 10 and 15 min and the student was instructed to complete as many problems as she could in that amount of time. Baseline accuracy ranged from 0% to 35% of problems correct across multiplication facts. After intervention, accuracy increased across all multiplication facts and ranged between 75% and 100% of problems correct. In these studies, the duration of the sessions was only as long as necessary for the students to achieve accurate responding to the math problems presented and the researchers did not include contingencies to measure or promote increased fluency of responding.

In later studies, CCC has been compared to interventions designed to promote fluency. For instance, Mong and Mong (2010) compared CCC to Math-to-Mastery (MTM), an intervention that requires additional practice for inaccurate and/or slow responding. Using an alternating-treatments design, Mong and Mong (2010) examined DCPM and errors per min (EPM) for three participants. Both CCC and MTM resulted in improvements in DCPM and EPM, but MTM resulted in the greatest improvements for two of the participants. Nevertheless, CCC resulted in improvements in DCPM and EPM more quickly than MTM. This finding suggests that CCC may be a more efficient strategy for improving math accuracy, but that it may not be sufficient to address slow responding.

In another study, Mong and Mong (2012) compared CCC to MTM and taped problems in a study investigating brief experimental analysis (BEA) methods, an assessment strategy for evaluating the effectiveness of interventions for individual students (Daly, Martens, Hamler, & Dool, 1999). Though the primary purpose of the study was to examine a type of BEA, important information can be drawn from the

results regarding the efficacy of CCC in comparison to interventions that included a fluency component. During the BEA, CCC was found to be the “best” intervention for only one of the three participants. An alternating-treatments design was then used to validate the BEA results and demonstrated similar effects. CCC resulted in improvements in DCPM and EPM for all three participants, but was best for only one in comparison to taped problems and MTM. MTM produced the greatest gains for the other two participants. This may be due to the fact that MTM included a series of 1-min timed trials in addition to modeling and error correction. These results demonstrate that CCC is an effective method for improving math accuracy. However, literature on CCC also suggests that the intervention itself does not explicitly target fluency, which may result in responding that is largely accurate, but slow.

As stimulus control develops, accurate responding should get faster (Daly et al., 2010). Fluency follows acquisition in the IH whereby responding is not only accurate, but also rapid and proficient (Daly et al., 1996). Thus, interventions designed to improve fluency should be used once accuracy improves and errors decrease. Fluency has been described as a fluid mixture of speed and accuracy and has been associated with terms such as automatic, second nature, and mastery (Binder, 1996). Daly, Martens, Barnett, Witt, and Olson (2007) suggested that in order for fluency practice to be maximally effective, training should include materials that the learner can respond to with high accuracy, brief and repeated practice opportunities, monitoring of performance, and performance criteria for changing to more challenging material. It has been argued that retention, on-task behavior, and endurance improve as fluency improves (Binder, 1996; Lindsley, 1992, 1996; McDowell & Keenan, 2001).

Multiple studies have demonstrated that daily timed trials are effective for developing students' fluency with basic math skills (Lovitt, 1978; Van Houten, 1980, 1984; Miller, Hall, & Heward, 1995). For example, Van Houten and Thompson (1976) found that a series of 1-min timed trials was sufficient enough to increase second grade students' computation fluency by threefold while maintaining accuracy and receiving no feedback. In another study, Miller et al. (1995) examined three interventions designed to improve computation fluency with a classroom of first-grade students. Using an ABABCBC design, they compared the effects of a 10-min work period with next-day feedback, 1-min timed trials with next-day feedback, and 1-min timed trials with self-correction on single-digit addition and subtraction math fact fluency. The math facts consisted of four problem types: addition with sums of less than 10, addition with sums between 10 and 18, subtraction with minuends of less than 10, and subtraction with minuends of between 10 and 18. Students were initially screened on all four problem types and math facts that students did not respond to accurately were excluded from the study. In each condition, students were presented with a packet of seven math worksheets and "next-day feedback" was provided that indicated incorrect answers and the total number of problems attempted at the top of the worksheet. In the 10-min work period condition, students were given 10 min to complete as many math problems in the packet as possible. In the 1-min timed trials, students completed math problems in a series of seven 1-min timed trials with a 20-s intertrial interval, all of which was conducted within a 10-min session. In the 1-min timed trials with self-correction, two 1-min timed trials were conducted. After each trial, the teacher disclosed one problem and answer at a time using an overhead until all of the problems attempted by any of the students had been

read and corrected. Students followed along and wrote an 'X' over incorrect answers. This procedure was then replicated in a special education classroom of 11 students. The results indicated that the rate of problems correct increased while accuracy was maintained with both of the 1-min timed trials conditions, which is consistent with earlier findings. Both the first-grade and special education students demonstrated the highest correct rates and highest levels of accuracy during the timed trials with self-correction conditions. These results support the efficacy of timed trials with immediate corrective feedback for improving computation fluency. Additionally, Miller et al. (1995) ensured that the math facts included were ones to which students were already responding accurately, but slowly, demonstrating the appropriateness of a fluency intervention for skills that are largely accurate, but slow. This study was conducted with a classroom of young students that was managed by the classroom teacher, which raises questions about whether timed trials would work with other populations. Given that older students probably have higher skill levels, it seems reasonable to assume that timed trials might be quite effective.

In sum, the IH provides a simple heuristic that may be useful in making decisions regarding intervention selection. According to the IH, when a high error rate exists, an intervention should include modeling, multiple opportunities to respond, immediate feedback, and error correction. On the other hand, when error rate is low, one may consider using a fluency intervention that includes components such as brief and repeated practice opportunities, monitoring of performance, and performance criteria for changing to more challenging material. Though there is research supporting the efficacy of adapting prompting and error correction strategies for improving academic performance,

few studies have investigated the use of these procedures with typically developing high school students who are struggling in math.

Choice

Typically developing high school students are often given more responsibility in their education (Hill, Bromell, Tyson, & Flint, 2007). As such, it is important to help motivate high school students to improve their academic performance. One simple motivational strategy that may also increase the effectiveness of an intervention is choice.

Motivational effect of choice. Providing students with choices prior to assigning an academic task is a simple way of improving motivation to complete the task. Motivating operations (MOs; Michael, 1982) affect the potency of reinforcement by temporarily altering the reinforcing value of the consequence, making the consequence either less (abolishing operations) or more (establishing operations) reinforcing (Laraway, Sincerski, Michael, & Poling, 2003; Michael, 1982, 2004). Similar to prompting strategies, MOs make the behavior that precedes the presumed reinforcer more or less likely to occur (Kruger et al., 2016). Thus, giving students a choice prior to presenting an academic task may prevent undesired behavior from occurring and increase the likelihood of desired behavior under appropriate conditions (Kruger et al., 2016). Investigators have advanced three potential explanations of choice's MOs effects: (1) choice may make an aversive situation less aversive, (2) choice may develop properties of conditioned reinforcement, and/or (3) choice may reduce the risk of satiation (e.g., Dunlap, Kern-Dunlap, Clarke, & Robbins, 1991; Dyer, Dunlap, & Winterling, 1990; Kern, Mantegna, Vorndran, Bailin, & Hild, 2001; Morgan, 2006; Stenhoff, Davey, Lignugaris-Kraft, 2008).

First, providing choice has the potential for making an aversive situation less aversive to students, which may subsequently improve their behavior. For instance, Romaniuk et al. (2002) conducted a study to determine if the function of problem behavior was related to the efficacy of choice. Functional analyses were first conducted to determine whether each participant's problem behavior was maintained by escape or attention. Then, an ABAB withdrawal design was used to determine whether the choice of instructional task improved problem behavior. Students who displayed attention-maintained behavior did not show a reduction in problem behavior, but students who displayed escape-maintained problem behavior did. These results suggest that choice may have operated as an abolishing operation. It appears that choice may have reduced the aversiveness of the task, removing the need for escaping it (Kruger et al., 2016). On the other hand, these results may also suggest that choice served as an establishing operation. When presented with two or more options, the student may have selected the academic task associated with the greater amount of reinforcement, temporarily increasing the potency of positive reinforcement while mitigating the aversive features of the task demands. Therefore, whether as an abolishing operation or an establishing operation, choice may operate by decreasing the aversiveness of task demands.

Second, there may be an additive effect of choice (Kruger et al., 2016). Specifically, because choice is always paired with higher preference stimuli (relative to other available concurrent stimuli), the pairing may create a conditioned reinforcement effect (Fisher, Thompson, Piazza, Crosland, & Gotjen, 1997; Kern et al., 2001). For example, Dunlap et al. (1994) found that a choice condition was superior to a non-choice condition at increasing appropriate behavior and decreasing problem behavior while

holding type of task constant. Several other studies have shown that simply choosing the sequence of tasks can lead to improvements in responding (Jolivette, Wehby, Canale, & Massey, 2001; Kern et al., 2001; Moes, 1998; Ramsey, Jolivette, Patterson, & Kennedy, 2010). Behavioral improvement resulting from choice alone suggests that the inclusion of choice may strengthen the already existing reinforcing properties of the task selected from concurrent, competing alternatives (Kruger et al., 2016).

Third, choice may reduce the risk of satiation. Allowing students to select academic tasks provides them with the opportunity to control how conditions are altered (Umbreit & Blair, 1996; Vaughn & Horner, 1997), which results in greater variation across sessions. Their choices may be governed in part by fluctuations in satiation and deprivation states, which reduces the risk of satiation with the task itself or the reinforcing consequences of the task. Although the actual mechanism(s) that make choice work in a given situation have not been isolated, it is clear that providing students with choice holds great potential for improving task engagement, which, when it leads to productive practice, may improve academic performance. Choice allows students to organize the instructional context in such a way that yields a better relative consequence than would otherwise be produced if there was no opportunity for choice. In other words, a student is more likely to choose to do something that results in greater reinforcement than something that is less preferred when offered a choice, likely decreasing aversive features of the task demand that may be momentarily present (Kruger et al., 2016). Thus, choice as an antecedent intervention component may be a useful strategy for helping motivate high school students to improve their academic performance and can be applied in a variety of ways. Students can be given a choice of reinforcer for improving academic

performance. It can also be used to give students a choice of tasks to complete. Or, it can be used to offer a choice of instructional tasks. Each will be discussed in turn.

Choice of reinforcer. Using choice to directly target programmed contingencies involves offering the student a choice of contingent consequences (i.e., reinforcers) immediately prior to assigning the task. Choice of reinforcer allows students to select the most potent reinforcer for their academic behavior when the task is assigned (Fisher et al., 1997; Kruger et al., 2016). Providing students with a choice of reinforcer has been shown in the literature to increase both assignment completion and accuracy (Cosden, Gannon, & Harding, 1995; Schmidt, Hanley, & Layer, 2009; Tiger, Hanley, & Hernandez, 2006).

Choice of task. Another way to use choice as an antecedent strategy is to allow the students to select the instructional task. Students are often asked to complete multiple tasks within one class period. Allowing students to select the sequence in which they complete the academic task has been shown to result in increased task engagement, time on task, task completion, and accuracy, while reducing off-task, disruptive, and problem behavior (Cosden et al., 1995; Dunlap et al. 1994; Dunlap et al., 1991; Dyer et al., 1990; Kern et al., 2001; Kern et al., 1998; Moes, 1998; Powell & Nelson, 1997; Ramsey et al., 2010; Romaniuk et al., 2002; Shogren, Eaggella-Luby, Bae, & Wehmeyer, 2004; Umbreit & Blair, 1996; Vaughn & Horner, 1997). For example, Jolivette et al. (2001) examined the effects of choice of task sequence on task-related and social behavior of three students diagnosed as having an emotional or behavior disorder. An ABA design embedded within a multiple-baseline across subjects design was used. During the choice condition, the teacher provided students with the opportunity to choose which math

assignment to complete first out of three assignments. Once the student completed the selected assignment, he was then able to select the next assignment to be completed. During the no-choice condition, the order of assignments to be completed was prescribed by the teacher. The results indicated that the choice condition resulted in higher levels of task engagement and lower levels of off-task and disruptive behavior for all students compared to the no-choice condition.

Kern et al. (2001) also examined the effects of task choice on reducing problem behavior. Participants varied in age (5, 11, and 15 years) and problem behavior (aggression, noncompliance, throwing objects, and property destruction), and the setting varied for each participant (inpatient facility or in the classroom). An ABAB design was used and conditions were counterbalanced across participants. During the choice condition, the participants were presented with three vocational or domestic tasks to complete and were asked to select the order in which they wanted to complete them. Participants could also opt to change tasks at any time. During the no-choice condition, the participants were required to complete the tasks in a randomly selected order. For one participant, there was an increase in engagement and a reduction in problem behavior during the choice condition, while for the other two participants there was only a reduction of problem behavior during the choice condition. The results indicate that choice may be effective at increasing task engagement and reducing problem behavior.

Each of these studies included a variety of academic tasks and either the opportunity for participants to choose which task they prefer (e.g., Dunlap et al., 1994) or the order in which they completed the tasks (e.g., Kern et al., 2001). Although the tasks presented to the participants were non-preferred tasks that had previously evoke problem

behavior or low levels of desired behavior, choice of task proved to be an effective antecedent intervention strategies for increasing academic engagement while decreasing problem behavior.

Choice of instructional strategy. A unique application of choice that capitalizes on its motivational value is choice of instructional strategy. One can offer the student a choice of the instructional strategies to be used to learn a skill. The student may be more motivated to practice appropriately, especially if the practice results in reinforcing consequences. Three studies have explored student choice of instructional strategies. Carson and Eckert (2003) compared the effects of student-selected math computation fluency interventions with empirically selected interventions with three 4th-grade students. The study was conducted in two phases and an alternating treatments design was used in each phase. In the initial assessment phase, the students were exposed to four initial interventions and a baseline condition (one single-digit addition probe) at random for two to three sessions each. The four interventions included contingent reinforcement, goal setting, feedback on digits correct, and timed-sprints. The student-selected and empirically selected interventions were identified after the initial assessment phase. To determine the student-selected intervention after exposure, the researchers verbally discussed each of the intervention procedures with the students, and then asked the students to select the intervention that they thought was best for solving math problems. Finally, the students were asked to rank order the remaining interventions. The empirically selected intervention was defined as the intervention that produced the highest DCPM when compared to baseline during the initial assessment phase. Next, the choice assessment phase was conducted in which the empirically selected intervention,

the student-selected intervention, and the baseline conditions were repeatedly administered within an alternating treatments design.

All three students selected contingent reinforcement. DCPM in the student-selected intervention were comparable to baseline DCPM for all three students. However, the empirically selected interventions produced greater gains in DCPM than the student-selected intervention. These findings indicate that students may not select the most effective interventions when given an opportunity to choose without proper guidance and support. Notably, these results may be limited, as student choice may have been heavily influenced by the strong motivational pull of a tangible reinforcer in one intervention that was absent in the other conditions. Therefore, although choice can have beneficial effects, there may be a need to include a specific training condition prior to choice to improve the likelihood that students will select the best individualized intervention. The training component should include not only the procedures for how to do the intervention, but also how to quantitatively determine the effectiveness of an intervention for a student's academics. Further, to maximize motivation contingent reinforcement should be consistently applied throughout based on performance goals, not simply included in one intervention.

Daly, Garbacz, Olson, Persampieri, and Ni (2006) overcame this limitation by examining the combined effects of choice of instructional strategies with rewards for oral reading fluency (ORF). A multiple-probe design across tasks (reading passages) was used to examine if two middle-school students could be influenced to choose *whether* and *how* to be instructed while measuring academic performance. The outcomes measured were correctly read words (CRW) and errors for 30 sec. A reward contingency was also

offered for improving accurate and fluent reading during the choice condition. Between baseline and treatment, students received a brief explanation of each instructional strategy and practiced each with the guidance of the experimenter. Then, treatment was carried out for three consecutive sessions. Students were told they could receive a tangible reward for meeting a pre-determined goal during criterion passage reading. Prior to attempting to meet their goal, students were given the option of how to be instructed on the corresponding instructional passage. If the student chose to receive instruction, he or she was then presented with instructional strategies from which to choose: modeling, practice, and/or error correction. If the student chose modeling, then the experimenter read the passage out loud to the student. If the student chose practice, then the student read the passage and then received feedback on the amount of time it took, the number of errors, and if he or she would have received his or her reward. If he or she chose error correction, then the experimenter marked errors down and showed the error words to the student, read the words to the student, and prompted the student to read the sentence containing the error words three times.

Both students in the study consistently chose to be instructed rather than not be instructed and increases in ORF were observed. Additionally, both students sampled across instructional strategies but most frequently chose to be instructed using the practice procedure (the strategy that required the most effort on the part of the student). These findings indicate that both students increased their ORF through choosing how to be instructed. Moreover, they suggest that, when given the option of whether or not to practice, students can be influenced to choose the instructional strategy that would provide them with greater opportunities to respond, regardless of the amount of work

required. These results, albeit promising, were modest, which may be due to not knowing if the students were making the “right” choices based on their individual needs.

Moreover, training on the use of instructional strategies occurred in one brief session prior to the initiation of treatment. Further, training simply included how to use each instructional strategy, but not how to make accurate decisions regarding when it is most appropriate to use each strategy. These limitations raise questions about whether gains in academic performance would be more robust if choice was paired with ongoing training that includes how to decide when to use the various strategies based on empirically identified student need.

Daly and Kupzyk (2012) investigated the effects of an individualized, student-selected, parent-delivered reading intervention on ORF. Three 3rd-grade students referred by their teachers due to poor ORF and their parent participated. Prior to treatment, students were exposed to four instructional strategies: listening passage preview, repeated readings, phase drill correction, and flashcard instruction. The experimenter conducted an intervention session for each strategy. After the students were exposed to the five strategies, the CRW data from the individual intervention exposures were graphed and presented to each student. Then, the experimenter reminded each student what he or she did with each strategy and informed the student of his or her scores after exposure to each intervention strategy. The students were then asked to select the intervention strategies that they thought helped them improve their reading, in effect choosing how they wished to be instructed. The experimenter then created an individualized intervention package comprised of the strategies each student selected as most helpful. Following a single parent-training session, the students’ parents delivered the intervention package at home

at least four times a week for 5 weeks using a written protocol of intervention steps. During the intervention phase, an alternating treatments design was used to compare the results of the parent-delivered intervention package to a control condition.

The results suggested that presenting data on performance to the students influenced their selection of the intervention package. Students selected different numbers and types of strategies for their intervention packages. Two of the participants selected the three most effective intervention strategies while one participant chose the first and third most effective. In all cases, validation results showed increases in CRW compared to screening. Positive ORF effects compared to control were found for all students during the parent-tutoring (experimental) phase. However, the design used only allowed for comparison between conditions, not growth over time. In addition, parent implementation integrity was only anecdotal, so it is unclear how much intervention was delivered at home. Implementation of the intervention package was heavily managed by the parents, which raises questions about the appropriateness of this type of intervention with other populations. Given that older students probably have greater amounts of autonomy, it seems reasonable to assume that they might have greater involvement in implementing their own interventions.

Therefore, although research has demonstrated the valuable impact of choice of instructional strategy on academic performance, there appears to be a compelling need for explicit guidance and training prior to offering choice to improve the likelihood that students will select the best individualized intervention. Collectively, these studies offer useful insights into how to promote improvement in academic performance through choice. First, students prefer interventions that include specific reinforcement

contingencies and will engage in repeated practice when positive reinforcement is available. Moreover, the studies that produced the greatest gains in academic performance included providing some degree of information to the students about their own performance, while Carson and Eckert (2003) failed to share the data with the students. This suggests that sharing data with the students while guiding them in how to select interventions may be a good way to facilitate productive practice with instructional assignments.

Yet, one consistent limitation across all of the studies that may have diminished the effects found was the training provided. Though the later studies progressively increased the amount of training provided prior to intervention selection, the brief training sessions may have limited effects relative to ongoing training and data-based progress monitoring. Given the changing levels of proficiency that occur as skills progress toward proficiency, teaching students how to select interventions may be vital to helping them reach the goal of skill mastery. Finally, parents may be helpful to their students in providing productive practice with multi-component intervention packages (Daly & Kupzyk, 2012).

Parent Involvement and Parent Support

Families and schools working together can improve students' academic achievement (Galindo & Sheldon, 2012), which speaks to the importance of promoting increased parental involvement in education. Parent involvement refers to the participation of important caregivers (i.e., parents, grandparents, stepparents, foster parents, etc.) in the educational process in order to promote the academic and social well being of their children and adolescents (Fishel & Ramirez, 2005; Wolfendale, 1983).

There are a variety of benefits to parental involvement. As a whole, when parents are involved, students demonstrate higher achievement, engagement, and better attendance (e.g., Christenson, 1995). In fact, when parents work with their children at home, students experience more favorable outcomes than when they receive school-based tutoring alone (e.g., Jason, Kurasaki, Neuson, & Garcia, 1993).

Unfortunately, parental involvement usually declines between elementary and high school, despite its continued importance at *all* grades (Eccles & Harold, 1993; Epstein, 1987). In addition, adolescents often receive more responsibility, spend considerably less amounts of time with their parents, and share and disclose less information with their parents as they grow and develop (Hill, et al., 2007). There is also increased conflict during adolescence (Hill et al., 2007), the frequency of which is highest during early adolescence; however, intensity of conflict steadily increases throughout the entirety of this developmental period (Arnett, 1999). Though conflict is not always harmful to adolescent development and well being (e.g., Adams & Laursen, 2001), it has the potential to impact the amount of involvement a parent has in his or her adolescent's education. As such, shaping the way in which parents interact with their adolescents regarding their education may prevent negative interactions that diminish parent involvement in education.

Parents are an extremely important resource for adolescents (Hill et al., 2007) and parental involvement in academics helps to ensure that adolescents gain the skills and knowledge necessary to prepare them for higher level occupations and develop career aspirations (Hill, Ramirez, & Dumka, 2003; McDonald & Jessell, 1992; McWhirter, Hacket, & Bandalos, 1998; Young & Friesen, 1990; Young & Friesen, 1992; Young,

Friesen, & Borycki, 1994). For example, a portion of the longitudinal analysis following participants from seventh to eleventh grade conducted by Hill et al. (2004) demonstrated that parental academic involvement, defined as “parents’ work with schools and with their children to benefit their children’s educational outcomes and future success” (p. 1492), in seventh grade operated on career aspirations through multiple paths. Specifically, there was a significant positive relationship between parental academic involvement in seventh -grade and eleventh-grade aspirations. Additionally, seventh-grade parent academic involvement was significantly negatively related to eighth-grade school behavior problems, which had a significant negative relationship with ninth-grade school achievement, which then had a significant positive relationship with eleventh - grade career aspirations. The strongest path was found between ninth-grade school achievement and eleventh-grade career aspirations. Though the model was complex, it is clear that parental involvement has a significant impact on career aspirations in eleventh-grade, both directly and indirectly. This shows the potentially far-reaching positive effects of early parental involvement or deleterious effects of lack of involvement starting as early as middle school.

Given the available research regarding the significance of overall parental involvement in high school academics, it is important to recognize the distinct and valuable differences in the topography of parental involvement with high school academics when compared to parental involvement in elementary academics. Melby and Conger (1996) explored the relationship between adolescent academic performance and the parental behaviors of authoritative parenting and hostility across 4 years. Participants were enrolled in seventh grade with a mean age of 12.6 years during the first year of the

study. Authoritative parenting was defined as high acceptance, supervision, and autonomy granting while hostile parenting was defined as angry and irritable interactions with the adolescent that include responding to misbehavior by yelling, threatening, and physical reprimands. Melby and Conger (1996) found that academic performance at the end of the study was most strongly related to academic performance during the first year of the study. In addition, there was a significant relationship between adolescent academic performance in the first year of the study and parenting during the middle two years of the study for both authoritative parenting behaviors and parent hostility. These parenting behaviors during the middle two years were subsequently related to adolescent academic performance at year four. Authoritative parenting behaviors were found to indirectly affect year one academic performance and year four academic performance. In general, this study demonstrated that early childrearing practices impact later adolescent academic performance. More importantly, any displays of hostile parenting practices decreased adolescents' academic performance irrespective of the strong relationship between grade point average at years one and four. However, the generalizability of the results of this study is limited due to participants being from predominantly White, rural, and intact families. Nevertheless, this study provides evidence to suggest that parents may need additional support to find appropriate ways to be involved in their adolescents' academics to avoid hostile parenting practices like angry and irritable interactions.

Jeynes (2007) conducted a meta-analysis that included 52 studies on parental involvement in student academic achievement in urban secondary education. This meta-analysis explored overall parental involvement, expectations for academic achievement, attendance and participation, communication with their adolescents, homework

monitoring, and parental style (i.e., a supportive and helpful parenting approach). The results indicated that the impact of parental involvement overall was significant for secondary school adolescents. The largest effect sizes in this study emerged for high parental expectations for student academic achievement, though a supportive and helpful parenting approach, communication about school activities, and homework were also statistically significant. This information demonstrates the importance of a supportive and helpful parenting approach and high academic expectations as these factors had a greater impact on student educational outcome than other aspects of parental involvement, such as only providing general household rules and only attending and participating in school functions.

In another meta-analysis, Fan and Chen (2001) also found that the type of parental involvement influenced the strength of the relationship between parental involvement and academic achievement. Specifically, the researchers found that supervision in the home was weakly associated with achievement while parents' aspirations and expectation of academic accomplishments had the strongest relationship with academic achievement. Prior research has also demonstrated that parental academic pressure (defined as the parental exertion of demands and expectations to maintain a high level of performance on their children) can have negative effects on math academic achievement while academic support has positive effects (Koutsoulis & Campbell, 2001).

There are critical limitations to the studies conducted by Jeynes (2007) and Fan and Chen (2001). First, both studies were meta-analyses and the results are limited by the studies included. Studies on middle school and parental involvement included in each of these studies varied by methodology and conclusions drawn. Second, neither study

addressed a specific developmental time period. Rather, Fan and Chen (2001) did not consider developmental stage altogether while Jeynes (2007) collapsed the sample across middle and high school, limiting the conclusions that may be generalized to a high-school population.

Hill and Tyson (2009) conducted a meta-analysis that included 50 studies on parental involvement in middle school. The researchers explored the relationship between academic achievement and three types of parental involvement: home-based involvement, school-based involvement, and academic socialization. Home-based involvement included communication between parents and children about school, homework help, participating in educational activities (e.g., going to museums, libraries, etc.), and creating a supportive learning environment in the home. School-based involvement included attending and/or volunteering at school events (e.g., open houses, etc.), participating in school governance, and communication between parents and school personnel. Academic socialization included “communicating parental expectations for education and its value or utility, linking school-work to current events, fostering educational and occupational aspirations, discussing learning strategies with children, and making preparations and plans for the future” (p. 5).

The results provided additional support for parental involvement by demonstrating a statistically significant relationship between general parental involvement and academic achievement. However, the results also suggested that the *type* of parental involvement matters. Specifically, there was a statistically significant positive relationship between school-based involvement and academic achievement as well as academic socialization and academic achievement while there was not a statistically

significant relationship between home-based involvement and academic achievement. Additionally, the relationship between academic socialization and academic achievement was stronger than the relationship between school-based involvement and academic achievement.

The researchers attempted to identify potential variables that impact home-based involvement in a post-hoc analysis. Particularly, parental help with homework and the parental provision of academically enriching activities (e.g., visiting museums) were explored. The results of the post-hoc analysis demonstrated a statistically significant negative relationship between help with homework and achievement and a statistically significant positive relationship between achievement and the provision of academically enriching activities. Of note, the results of this study are based on a middle-school sample as opposed to a high-school sample.

Nevertheless, the results of this meta-analysis conducted by Hill and Tyson (2009) are important in that they continue to provide support for involvement, particularly *how* parents can be involved to have the greatest impact on achievement. In general, parental involvement should include communication regarding the value of education, fostering of adolescent educational and occupational aspirations, discussion of learning strategies, and preparation for adolescent future through linking educational material to adolescent interests. Additionally, the study indicates that great care must be taken if parents are to be involved with homework completion. The literature has shown that help with homework both fosters and interferes with achievement (e.g., Cooper, 1989, 2007; Hill & Tyson, 2009; Wolf, 1979). However, multiple factors that can be readily accounted for may explain the potential negative relationship between

achievement and help with homework, including a difference in how school and parents present academic information, parental interference with adolescent autonomy, and excessive parental pressure.

Further research has confirmed the negative impacts of parental academic pressure, showing that low levels of parent pressure and high levels of support are linked to high levels of academic achievement (Levpuscek & Zupancic, 2009). Parental involvement has also been found to relate to academic self-efficacy (e.g., Deci & Ryan, 1985; Skinner & Belmont, 1993). Academic self-efficacy is defined as a student's beliefs about his or her ability to learn or perform specific academic tasks (Bandura, 1986, 1997). It has been proposed that students report higher academic self-efficacy when they perceive their parents as placing more emphasis on effort and achievement than when they perceive their parents as putting less value on academic effort and achievement (Marchant, Paulson, & Rothlisberg, 2001). Academic self-efficacy positively correlates with academic achievement directly and indirectly through goal establishment (Schunk & Pajares, 2002; Zimmerman & Bandura, 1994).

Parental involvement has also been tied to students' mastery goal orientation. Mastery-goal orientation refers to a student's motivation to develop new skills or gain additional knowledge through engagement in schoolwork (Ames & Archer, 1988; Gonzalez, Doan Holbein, & Quilter, 2002). This is different from an ability goal orientation, in which the student's goal is to either demonstrate an ability to perform a particular skill or avoid the demonstration of lack of ability. Instead, students with a mastery-goal orientation tend to define success in relation to effort and progress made in accomplishing the task. Simply put, students with a mastery-goal orientation tend to find

engagement in the academic process reinforcing whereas students with an ability-goal orientation tend to find high marks reinforcing.

Prior research has linked parental involvement to the development of student goal orientation. For example, Levpuscek and Zupancic (2009) examined the influence of parental involvement on the development of goal orientation with eighth-grade students in Slovenia. Perceived parental academic pressure was found to be negatively associated with (a) students' math achievement and (b) mastery-goal orientation within the math domain. Perceptions of parental academic support were positively related to mastery-goal orientation toward math, but were negatively related to the final grade. These results further demonstrate that the type of parental involvement (parental pressure versus parental support) is important to mastery goal orientation, sense of academic self-efficacy, and math academic achievement.

Other specific patterns of parenting behaviors and their relation to adolescent adjustment have been studied. For example, the type of control (i.e., psychological control and behavioral control) that parents exert over their adolescents has been found in the literature to influence adolescent development (Galambos, Barker, & Almeida, 2003). Behavioral control refers to the management of an adolescent's behavior through firm and consistent discipline whereas psychological control refers to the management of an adolescent's behavior through psychological methods such as induction of guilt and the withdrawal of love. Research has demonstrated that higher behavioral control and lower psychological control contribute to higher academic competence (Eccles et al., 1997; Gray & Steinberg, 1999). Galambos et al. (2003) further explored the influence of the various types of control by examining their relationship with externalizing and

internalizing adolescent behaviors. The results showed a significant negative relationship between behavioral control and rate of increase in externalizing behaviors. In particular, less behavioral control was associated with a greater rate of increase in externalizing adolescent behavior. Greater psychological control showed a significant positive relationship with externalizing problems; however, this was likely impacted by the significant interaction between both types of control on externalizing behavior. The link between the combination of psychological and behavioral control and externalizing behavior seems to suggest that when parents exert too much control over their adolescent's behavior, the adolescents are more likely to escape control through externalizing behaviors.

A study conducted by Simpkins, Bouffard, and Dearing (2009) also demonstrated the influential relationship between parental involvement and adolescent behavior. The highest levels of adolescent academic achievement and the lowest levels of problem behavior were found for adolescents whose parents were engaged in their education, provided cognitive stimulation, and were involved in the community. Conversely, adolescents whose parents exhibited excessive levels of control by being highly restrictive and establishing a higher than average number of rules had the lowest levels of academic achievement (Simpkins et al., 2009). This information is critical, as it demonstrates the need for parents to avoid seeking either too little control or excessive control of adolescents' behavior while at the same time exhibiting other behaviors indicative of support (e.g., providing cognitive stimulation; Eccles et al., 1991; Mounts, 2001; Simpkins et al., 2009). Instead, parents should establish a stimulating home environment (i.e., providing educational materials, engaging in educational activities with

adolescents) coupled with a moderate level of structure (i.e., rules). Moreover, participating in quality communication with teachers to prevent academic or behavior problems, providing structure at home, scaffolding adolescent independence, and linking education to future success have all been associated with a reduced rate of decline in grade point average (Wang, Hill, & Hofkens, 2014).

However, it is important to distinguish between parents' home-based educational involvement (i.e., participation in educational activities at home) and school-based educational involvement (i.e., participation in activities at school, such as volunteering or governance, as well as communication with school personnel). Toren (2013) examined the relationship between these two bases and adolescent self-efficacy and academic achievement. He sought to test three hypotheses. First, he hypothesized that home and school involvement affect self-evaluation (i.e., the perception of one's own worth) and academic achievement differently in that the effect of home-based involvement on self-evaluation is positive while the effect of school-based involvement is negative. Second, it was hypothesized that home- and school-based parental involvement are linked to academic achievement indirectly via self-evaluation, indicated by scholastic competence and global self-worth (i.e., overall satisfaction with one's self as a person). Finally, he hypothesized that girls' self-evaluation would be lower when compared to boys' self-evaluation.

With a sample of 397 Jewish seventh-graders drawn from a junior high school in an urban middle-class residential area of Israel, Toren (2013) collected data on parental involvement, students' own perceptions of their competence, and school grades in English, Hebrew, and mathematics. For girls, the relationship between home-based

parental involvement and both scholastic competence and global self-worth was significant, indicating that greater home-based involvement increased greater scholastic competence and global self-worth. The results differed somewhat for boys. Specifically, there was a significant positive relationship between home-based parental involvement and scholastic competence, which was significantly positively related to academic achievement. Parental volunteering was significantly positively related to academic achievement and global self-worth, the latter of which was significantly negatively related to academic achievement. Notably, the strongest path for both boys and girls was demonstrated between academic achievement and scholastic competence, the latter of which also had a significant relationship to home-based parental involvement for both boys and girls.

These results demonstrate that parents' educational involvement plays an important role in adolescents' self-evaluation and academic achievement and may suggest that achievement is strongest for home-based parental involvement that includes discussion of learning strategies, linking material from school to students' interests and goals, and making preparations and plans for the future to promote goal setting and attainment (Hill & Tyson, 2009; Toren, 2013). It is important to note that this study was conducted in Israel with middle school-aged students.

While the available literature provides clear evidence for the importance of an overall increase in parental involvement, there are multiple parent variables that impact the quality of parental involvement that must be considered when promoting parental involvement, including parental self-efficacy, perceptions of invitations for involvement, and parental perceived life context (Hoover-Dempsey, Bassler, & Brissie, 1992; Hoover-

Dempsey & Sandler, 1995, 1997; Sheridan & Kratochwill, 2007; Walker, Wilkins, Dallaire, Sandler, & Hoover-Dempsey, 2005). Parents' perceived self-efficacy in their ability to help their children succeed in school allows them to believe their involvement activities can positively influence their child's learning and academic performance (Ames, 1993; Grolnick, Benjet, Kurowski, & Apostoleris, 1997; Hoover-Dempsey et al., 1992; Hoover-Dempsey & Sandler, 1997; Sheridan & Kratochwill, 2007; Swick, 1988), which predisposes them to be more actively involved in their children's education. Parental self-efficacy has been identified in the literature as critical for parents to maintain their engagement and involvement (Comer, 1995; Sheridan & Kratochwill, 2007). Prior research has demonstrated that providing parents with explicit training in how to be involved in their children and adolescents' academics may have a positive impact on parental self-efficacy (e.g., Jones & Prinz, 2005; Sanders & Woolley, 2005; Sofronoff & Farbotko, 2002).

Another important variable relating to parental involvement is parents' perceptions of invitations for involvement from their child, their child's teacher, and their child's school (Sheridan & Kratochwill, 2007). Parents' decisions to be involved in their adolescents' academics are influenced by the extent to which opportunities and expectations for involvement present themselves. Parents are more likely to be involved if their involvement is expressly desired by their adolescents and teachers. This finding may be particularly important when fostering parental involvement with adolescents. Balancing healthy autonomy with the need to recruit parental support may not be easy to do for many adolescents. It would seem that empowering adolescents to make effective

choices while assisting them to recruit necessary support may be the most fruitful method for inviting constructive parental involvement.

A final psychological variable is perceived life context, which refers to parents' perceptions of the resources available to them for promoting involvement, such as time and energy, and the skills and knowledge related to involvement (Sheridan & Kratochwill, 2007). Factors such as time, energy, and skills may be viewed by parents as barriers to involvement (Gettinger & Waters-Guetschow, 1998) and have been identified as influencing the level and type of involvement (Lareau, 1989; Leitch & Tangri, 1988). There is evidence to suggest that parents can be involved and engaged in meaningful ways when they are actively assisted in becoming involved, such as providing them with the necessary resources (e.g., childcare, transportation, etc.) and education to alleviate the impact of the previously mentioned barriers (Dauber & Epstein, 1993).

The previously identified variables appear to influence parental involvement in education in unique ways. Walker et al. (2005) found that these variables together explained 19% of the variance in parents' school-based involvement and 33% of the variance in parents' home-based involvement. The strongest predictor of parents' home-based involvement was identified as perceptions of specific invitations from the child to be involved in his or her schooling while the biggest predictor of school-based involvement was parents' self-efficacy. Further, perceived life context was a strong positive predictor of school involvement for parents with reportedly higher levels of time, energy, skills, and knowledge. In other words, parents who believed they had the resources necessary to be involved were more likely to be involved in school-based activities (e.g., attends special events at school, PTA meetings, field trips, etc.).

Conversely, for parents who reported lower levels of time, energy, skills, and knowledge, perceived life context was a strong positive predictor of involvement in home-based activities like homework (Walker et al., 2005; Sheridan & Kratochwill, 2007). This result is particularly important because it suggests that even when parents believe that they lack the resources necessary to be involved at school, they are still likely to be involved in home-based activities (e.g., helping with specific skill practice, supervising homework, helping the adolescent study for exams, etc.). Taken together, these findings point to the need to carefully configure programs that account for these factors to promote parent support and involvement in adolescent education.

Parent support. Given the importance of home-based parental involvement, a carefully configured parent support program that includes well supported parent involvement strategies and addresses barriers to involvement may be an effective way for improving math academic achievement (e.g., Toren, 2013). Since adolescents in the United States spend only 30% of their waking hours inside of school (Sheridan & Kratochwill, 2007), promoting parent support is an efficient way to motivate and engage students in structured mathematics activities outside of school. Promoting parent support has also been shown to result in improvements in learner self-efficacy (Powell-Smith, Stoner, Shinn, & Good, 2000) and positive parent-child interactions (Thurston & Dasta, 1990). Parents also benefit because they gain confidence in how to support the learning of high school students outside the classroom.

The Task Force on Evidence-Based Interventions in School Psychology found promising evidence to support the promotion of parent involvement at home to address school-based math and reading concerns (Fishel & Ramirez, 2005). Fishel and Ramirez

reviewed 24 studies from between 1980 and 2002 and examined the methodologies and effect sizes for each study. The most promising intervention identified was one that improved mathematics achievement and self-concept in African American fourth- and fifth- graders at risk for mathematics problems by combining peer with parent tutoring (Heller & Fantuzzo, 1993). Though the effect sizes were large (range, 0.86 to 1.63) and the methodology was rated as strong by the reviewers, the study included specific participant populations (limiting the generalizability), did not include reliable measures of mathematics, nor were data collected from multiple sources.

In a review of over 40 articles, Toomey (1993) concluded that studies with an explicit “parent training” component (parents received modeling of appropriate behaviors and were monitored and received guided practice) were more successful at prompting parent support than studies that did not include a parent-training component. Without guidance and support, parents are likely to only encourage their adolescents to spend more time practicing math skills. Although simply encouraging math practice outside of the school day is a good thing, it is not likely to produce improvements in mathematics skills and therefore insufficient in meeting their needs. Parent support interventions for adolescents must offer appropriate encouragement and support without becoming overbearing or punitive. Strategies like prompting, offering rewards for practice, providing an appropriate and consistent setting in the home for the student to complete his or her homework that has adequate lighting and is free from distractions, offering feedback on overall engagement/completion of practice, and promoting academic goal attainment can create the kind of supportive environment that is conducive to improved learning and social interactions (Cancio, West, & Young, 2004; Salend & Schliff, 1989).

Cancio et al. (2004) explored the use of a self-management and parent participation homework intervention to improve mathematics homework completion and accuracy. Participants included six students between the ages of 11 and 15 and at least one parent or legal guardian. Parents received a 1-hr training session in their home to familiarize them with the self-management homework plan and provide them with education on the importance of parent participation and parent training. Parents also received a notebook that outlined the intervention protocol, and role-plays of the homework plan were conducted. Students received one training session that lasted less than an hour to address the specific steps of the homework plan. Parents and students both individually monitored the students' treatment integrity with the homework plan. The students received points at home when their treatment monitoring results matched those of their parents. The points could then be exchanged for rewards from a menu. Parents provided points based on their subjective opinion of the extent to which their adolescent was engaged in the math homework plan. Students received points in the classroom for completing their daily math assignments and turning them in to their classroom teacher along with the parent-checklist. Using a multiple-baseline design across participants, Cancio et al. (2004) monitored percent of homework completion and percent homework accuracy. They found immediate improvements in homework completion and accuracy after the introduction of the intervention package for all participants. Average completion during baseline was 2% and rose to 92% during intervention. Additionally, homework accuracy increased from 2% during baseline to 89% during intervention. However, despite the promising results, there are a few notable limitations of this study. Specifically, the researchers did not collect maintenance data so

the long-term effects of this program are unknown. Data were also not collected regarding the generalizability of this homework program to general mathematics skill acquisition in the classroom.

Other studies have confirmed the positive impact of self-management interventions paired with parent support on homework completion and accuracy (e.g., Callahan, Rademacher, & Hildreth 1998; Glomb & West, 1990; Miller & Kelley, 1994; Olympia, Sheridan, Jenson, & Andrews, 1994). Callahan et al. (1998) examined the effects of combined self-management and parent participation on homework completion and quality with sixth-through eighth-grade students at risk for school failure. The combined intervention resulted in increased homework completion and homework accuracy for the majority of participants. Average homework completion during baseline was 33.2% and improved to 69.4% during intervention while homework accuracy during baseline was 25.9% and improved to 62.0% during intervention. Further, Callahan et al., (1998) found that parent participation differentially impacted homework completion and accuracy. Higher levels of parent participation were found to be associated with higher levels of homework completion and accuracy, while lower levels of parent participation were associated with lower levels of homework completion and accuracy.

Based on the literature, several conclusions seem appropriate. First, when parents are involved in education and work with their children from home, students experience higher achievement, greater engagement, better attendance, increased career aspirations, and fewer behavior problems than when they receive school-based tutoring alone (Christenson, 1995; Hill et al., 2004; Jason et al., 1993). Even though parental involvement is clearly crucial to academic achievement, decades of research have

demonstrated that there must be a balance in the behaviors that parents exhibit when involved in adolescent education. Supervision and behavioral control are important and necessary elements to this balance (Galambos et al., 2003; Marchant et al., 2001; Melby & Conger, 1996), but they are not sufficient. Parents should strive to avoid yelling, threatening, physical reprimands, and being too restrictive in their rule setting (Melby & Conger, 1996; Simpkins et al., 2009). Instead, parents should pair setting general house rules with high acceptance, autonomy granting, and academic expectations. Additionally, parents should regularly communicate with their adolescents about school activities and homework in such a way that includes discussion of learning strategies, linking material from school to students' interests and goals, and making preparations and plans for the future to promote goal setting and attainment (Hill & Tyson, 2009; Jeynes, 2007; Toren, 2013).

Therefore, interventions attempting to promote parent support for adolescents must offer appropriate encouragement and support without becoming overbearing or punitive. Parents can accomplish this by providing educational materials and engaging in educational activities with their adolescents (Eccles et al., 1991; Mounts, 2001). Using strategies like prompting, offering rewards for practice, providing an appropriate and consistent setting in the home for the student to complete his or her homework that has adequate lighting and is free from distractions, offering feedback on overall engagement/completion of practice, and promoting academic goal attainment can create the kind of encouraging and supportive environment that is conducive to improved learning and social interactions (Cancio et al., 2004; Salend & Schliff, 1989).

Purpose of the Current Study

High school students must adequately master a broad range of mathematics skills by the time they graduate (NCTM, 2013). Additionally, they are expected to have greater autonomy and responsibility in their own learning. Motivational strategies may be particularly useful in fostering the development of autonomy and responsibility at the high school level. Choice is one such motivational strategy that might be particularly useful. Presenting students with a choice prior to the provision of an academic task can prevent disruptive behavior from occurring and increase academic engagement and task completion (Cosden et al., 1995; Dunlap et al. 1994; Kruger et al., 2016; Ramsey et al., 2010; Romaniuk et al., 2002).

Yet, although choice has great potential for increasing academic work, students must be knowledgeable regarding which strategies are most helpful to them. As such, students require specific guidance and training in intervention selection and use to maximize the benefits of the academic intervention, especially when their skills are not strong (e.g., Carson & Eckert, 2003; Daly & Kupzyk, 2012). Further, given the diversity of individual student learning histories, needed strategies will differ across students and change within students over time as skill proficiency improves. There is a paucity of research on choice of instructional strategies. What has been done is limited to elementary and middle school-aged children. Choice of instructional strategies may be even more effective with high school students who are generally more knowledgeable and autonomous than younger students. Therefore, research on strategies for teaching students how to choose intervention components would be a useful contribution to the literature.

Identifying where one's own skill deficits lie in order to choose appropriate intervention components can be a difficult task for many high school students, especially those who are already behind in the curriculum. Therefore, high school students still need support to improve their academic performance. Parental support in high school academics may be helpful in providing guidance in intervention selection and use. Parent involvement has been shown to result in more positive attitudes towards school, increased attendance, and improved academic achievement (Christenson et al., 1992; Epstein, 1987; Greenwood & Hickman, 1991). Further, more parental support that includes praise, encouragement, and help with homework, has been shown to be the best predictor for adolescents' grades in school (Deslandes, 1996). In terms of specific instructional strategies, parents can help their adolescents with programs that include a combination of prompting, rewards for practice, feedback, and support for goal attainment in an appropriate and consistent setting in the home. Unfortunately, despite the potential positive effects, parental involvement usually decreases after elementary school (Epstein, 1987). In addition, parents may lack the skills needed to help their high school students.

The purpose of the study was to examine the effects of high school students' independent, remedial, home-based math practice while receiving parent support on math computation fluency. The multi-component intervention package encompassed both home-based remedial practice and parent support. For the home-based remedial practice component, students were trained in math computation fluency interventions and how to select them appropriately and then encouraged to engage in repeated practice at home using the interventions. For the parent support component, the experimenter worked with

the parents to create a structured time and place for student remedial practice, and to encourage the student through positive feedback. The study was designed to address two research questions. First, what are the effects of this multi-component treatment package on the students' computation fluency and accuracy? Second, what are the effects of this multi-component treatment package on students' reported self-efficacy and mastery goal-orientation?

A multiple-baseline-across-participants design was used to examine the effects of training high school students to choose and use effective intervention strategies on their math academic performance in combination with parent support that included rewards, environmental manipulation and monitoring, and feedback on math computation fluency and academic engagement both at home and at school. The sequence of phases was as follows: baseline, parent training, intervention implementation, and maintenance. In the parent-training phase, parents were provided with a 1-hour-long training session regarding the importance of parental involvement and instructed in how to promote academic achievement and engagement. In the intervention phase, students were provided with access to two evidence-based interventions, CCC and timed fluency trials, and taught how to make ongoing decisions regarding which intervention to use at both home and school. Parents received training on how to support their adolescents in practicing and ongoing decision making at home. It was hypothesized that training students to select math interventions and encouraging them to practice at home with parental support would increase students' math fluency and accuracy as well as their reported self-efficacy and mastery goal orientation related to math.

CHAPTER 2

Method

Participants

Participants were recruited from one urban public high school located in a diverse Midwestern school district. The student body (49.1% female) from this district was comprised of 67.7% White, 13.1% Hispanic/Latino, 6.3% Black or African American, 4.5% Asian, 0.7% American Indian/Alaska Native, and 0.1% Native Hawaiian/Pacific Island individuals in the 2015-2016 school year. Participants who volunteered to participate in the study and wanted to work on their math performance, had high rates of math class attendance, had an identified skills-deficit in math, and had at least one parent or guardian willing to participate were included in the study. Approval for this study was obtained from the Human Subjects Institutional Review Board.

The first step of the recruitment process involved meeting with the participating school's administrators to obtain their approval for the study. Following their approval, the researcher met with interested math teachers to provide an overview of the study, review the consent form, and answer questions. These teachers then identified students in their classrooms who exhibited poor math computation skills and would benefit from participation in the study. Teachers contacted the primary caregivers (i.e., parents, guardians, etc.) of nominated students to determine if the primary caregivers were willing to be contacted by the researcher. If they were willing to be contacted, the researcher met with interested primary caregivers to provide an overview of the study, review the consent form, and answer questions. Student assent was then obtained. Follow assent, screening occurred to ensure that inclusionary criteria was met. In other words, screening

occurred to determine that a performance-deficit was not present and that math performance was low compared when compared to same-grade peers.

Three students (two females and one male) were included as participants in this study. Names listed throughout were pseudonyms provided to each participant. One ninth-grade student (Rachel, a 14-year-old White female), one tenth-grade student (Dustin, a 16-year-old African American male), and one eleventh-grade student (Renee, a 17-year-old Multiracial female) participated. All participants received special education services for a Specific Learning Disability (SLD) in reading, writing, and math. Mothers of the three referred students who met the inclusion criteria participated. Rachel's mother was 56-years-of-age and identified herself as White, Renee's mother was 39-years-old and identified herself as Biracial, and Dustin's mother was 41-years-old and identified herself as African American.

Settings

Home. Prior to the study, each family committed to providing a space at home for the adolescent to practice his or her math skills. The family was encouraged to provide a setting that had appropriate lighting and was free from distractions (e.g., television, radio, other children playing, etc.). Parents were trained to implement the intervention in their homes during the parent support phase (see procedures). A majority of the intervention activities during this phase took place in the students' homes (e.g., supervision, feedback, self-management activities).

School. All baseline, student training, and parent training sessions as well as assessment during the home-based practice phase were conducted in an available hallway at the public high school proximal to the students' math classrooms. An appropriately

sized desk and two chairs were placed in the hallway for all sessions. The author and trained school psychology doctoral students were responsible for the implementation of the screening, baseline, student training, parent training, and parent support procedures. The individuals with whom participants worked were encouraged to locate the table and chairs in a setting that ensured minimal distractions.

Materials

Reward Menu. A reward menu was used as part of programmed reinforcement (Appendix A). The menu was one standard size paper on which eight stimuli were written. The stimuli written on the reward menu included activities (e.g., Sudoku, UNO®, Would You Rather?TM, charge phone, phone time, drawing, and listening to music), tangibles (e.g., gift card), and edibles (e.g., soda, chips). A corresponding point value was written alongside each stimulus to indicate the number of points needed to earn that particular reward (e.g., gift card=30 points).

Worksheets.

Screening worksheets. Single-skill worksheets, Aimsweb® Mathematics Concepts and Applications (M-CAP) worksheets, and Aimsweb® Mathematics Computation (M-COMP) worksheets were used to assess each participant's proficiency with math component and composite skills (e.g., addition, subtraction, multiplication, division). Aimsweb® Mathematics Concepts and Applications (M-CAP) and Aimsweb® Mathematics Computation (M-COMP) worksheets are combined-skill worksheets that were used to identify components of typical math curriculum that had not yet been mastered by the participants. Based on the data gathered from these worksheets, individual skills were targeted for additional screening for each participant. For example,

further screening on one-digit-by-one-digit multiplication problems (e.g., 2×4) and two-digit-by-one-digit multiplication problems (e.g., 10×2) was warranted for one participant (Dustin), further screening on one-digit-by-one-digit division problems (e.g., $4 \div 2$) and two-digit-by-one-digit division problems (e.g., $10 \div 2$) was warranted for Renee, and further screening of subtraction of positive and negative integers (e.g., $-4 + -5$) was warranted for Rachel. These single-skill worksheets were generated using interventioncentral.com and Excel[®], and consisted of approximately 30 randomly generated single-skill problems (e.g., one-digit-by-one-digit addition problems, one-digit-by-one-digit multiplication problems, etc.).

Instructional worksheets. Two types of instructional worksheets were used throughout the training and home-based practice phases (see experimental procedures): Cover-Copy-Compare (CCC) worksheets and Timed-fluency (TF) worksheets. Two difficulty levels for each instructional worksheet type were used. The difficulty levels were identified using baseline levels of responding. After the baseline phase, completed problems were divided into two problem difficulty levels: easy and hard. To do so, the frequency with which a particular problem appears throughout baseline was tallied. Then, the number of times that particular problem was completed correctly was tallied. The number of times the problem appears was divided by the number of times that problem was completed correctly. This number was then multiplied by 100 to obtain a percentage. “Easy” problems was defined as individual problems completed with at least 85% accuracy during all baseline sessions while “hard” problems was defined as individual problems completed with less than 85% accuracy during all baseline sessions.

CCC worksheets were single-difficulty worksheets that consisted of approximately 10 randomly generated problems written on one standard size paper (Appendix B). The problems on this type of worksheet were either “easy” or “hard” problems. The worksheet was divided into three columns. The left column contained the problems with their corresponding answers. The middle and right columns contained sections for participants to write down the problem and answer. A place for parent initials was located on the bottom right-hand corner of the worksheet.

TF worksheets were also single-difficulty worksheets. (Appendix C) The TF worksheets consisted of approximately 20 randomly generated “easy” or “hard” problems without corresponding answers organized in two columns. A place for parent initials was located on the bottom right-hand corner of the worksheet.

Instructional assessment worksheets. Instructional assessment worksheets were used throughout the student training and home-based practice phases to assess performance improvements on each difficulty level following each student training and parent support session. The instructional assessment worksheets were single-difficulty worksheets that contained approximately 30 randomly generated math problems identified as either “easy” or “hard” problems using the procedures stated above.

Generalization assessment worksheets. Additional worksheets were generated to assess generalization of skills on a weekly basis. These generalization assessment worksheets were combined-difficulty worksheets that contained approximately 30 randomly generated math problems identified as both “easy” and “hard” problems (procedure described above). They contained all of the problems instructed in the previous week arranged in random order on the worksheets.

Performance Feedback Graph. A graph template for graphing participant data and providing performance feedback was provided (Appendix D). Participants filled in appropriate numbers on the vertical and horizontal axes. The participants also plotted daily performance fluency data on the performance feedback graph.

Active Engagement Observation Form. The active engagement observation form was one standard size paper in landscape orientation (Appendix E). The definition of active engagement (AE; see measures) was written across the top. A table was located in the center of the document that includes spaces to mark occurrence of AE for each intervention. Spaces were provided to write the first name of the target student, date, and observer name. Finally, a guide for calculating the percent AE was included at the bottom of the form.

Homework Binder. An indexed homework binder was provided to parents during the parent training session and was divided into three sections. The first section, “effective strategies for improving math computation,” listed the strategies, why each strategy is important, and what each strategy looks like (Appendix F). The second section, “supporting your adolescent,” outlined why supporting adolescent academic development is important and the specific parenting behaviors useful for helping adolescents (Appendix G). The third section contained all of the necessary materials for parents to monitor and support student math practice completion at home: (a) a daily homework log that also served as an integrity sheet (Appendix H), (b) a reward menu, and (c) a written protocol of the steps that parents took to support their adolescents’ practice (Appendix I).

Screening

Screening of participant math performance occurred following teacher nomination of students. The purpose of screening was twofold. First, it was conducted to identify participants with skill (and not performance) deficits (Daly, Martens, Witt, & Dool, 1997). Second, it was conducted to determine participants' math proficiency relative to typical peer performance through benchmark assessments. Thus, screening of participant math performance was conducted in two steps: a performance-deficit analysis was followed by assessments of various computation fluency problem types, which were compared to normative data.

Performance-deficit analysis. The experimenter conducted a performance-deficit analysis using the Reinforcer Validation protocol (Appendix K). To do so, the experimenter administered a single baseline session and then administered multiple sessions using contingent reward on a variable-ratio schedule to identify whether performance increases substantially above baseline. For baseline, the experimenter placed a stack of single-skill math worksheets in front of the student and instructed the student to complete as many math problems as he or she could in 2 min. The number of problems completed correctly in 2 min during this initial session was calculated and recorded. A problem was scored as correct if all of the correct digits were written in the appropriate columns and places. In the subsequent contingent reward sessions, the experimenter placed another stack of single-skill math worksheets in front of the student containing problems of the same type (e.g., single-digit multiplication) but not necessarily all the same problems, arranged in a different order.

The student was then told that he or she could earn a reward this time for completing math problems contingent upon meeting a performance criterion. The criterion number of math problems needed to earn the reward was a randomly selected number between the following two numbers: (1) [the initial session score + 1] and (2) [the initial session score \times 1.5]. Microsoft Excel® was then be used to randomly generate the criterion number. This criterion number was written on an index card and placed facedown in front of the student. The student was then be instructed to complete as many math problems as he or she could in 2 min. The number of problems completed correctly in 2 min during this session was calculated and recorded by the experimenter. A problem was scored as correct if all of the correct digits were written in the appropriate columns and places. The student was then told how many problems he or she completed. This number was compared to the criterion number on the index card by determining which number is larger (the criterion number or the number of problems completed by the student) or if they are equivalent. If the student met or exceeded the performance criterion, he or she was allowed to select a reward from the reward menu. Potential participants who demonstrated increases in performance under the reinforcement contingency would have been excluded from the study, as they would have had performance- and not skill-deficits. The results of these analyses indicated that all three participants suffered from skill deficits, as their performance did not improve under the reinforcement contingency.

Benchmark assessments. The experimenter administered benchmark assessments to determine each student's skill level in comparison to same-grade peers. Aimsweb® Mathematics Concepts and Applications (M-CAP) and Aimsweb®

Mathematics Computation (M-COMP) were used to make this comparison. All three versions available for each M-CAP and M-COMP were administered and the median score obtained for each participant was retained. Rachel obtained a median score of 9 on the M-CAP and a median score of 17 on the M-COMP, placing her at the 36th and 41st percentiles, respectively. Renee obtained a median score of 3 on the M-CAP and the M-COMP, placing her at the 5th and 3rd percentiles, respectively. Dustin obtained a median score of 3 on the M-CAP and a 6 on the M-COMP, placing him at the 5th and 6th percentiles, respectively.

Math Skill Selection

Math skill selection occurred following participant screening. To begin the process of identifying academic skills warranting intervention, the experimenter had the students' teachers identify math skills with which the students have been having difficulty. Based on this information in combination with results from the M-CAP and M-COMP, math worksheets were created for every skill the teachers identified. Each skill was assessed using a 2-min probe. During the screening sessions, the experimenter gave the student a pencil and a math worksheet placed face down. The experimenter informed the student that he or she will have 2 min to complete as many problems as possible and that if he or she cannot not answer a problem, he or she should skip it and go on to the next problem. Following this explanation, the experimenter instructed the student to begin working. As the student worked on the math problems, the experimenter sat quietly and worked on another activity. At the end of the session, the experimenter told the student that time is up and collected the math worksheet. The experimenter administered

the remaining worksheet(s) using the same procedures outlined here until all of the skills were assessed.

The experimenter first presented the math worksheet that contained the most difficult problems and continued to administer math worksheets in descending order of difficulty level (i.e., worksheets that contained harder math problems were administered ahead of worksheets that contained easier math problems). After all of the screening worksheets were administered or if the student displayed fatigue, the experimenter returned the student to his or her classroom. Multiple sessions were necessary for each student. Skills identified for intervention were: (a) addition and subtraction of positive and negative integers (Rachel), (b) multiplication facts 0-9 (Dustin), and (c) division facts 0-9 and 2-digit-divided-by-one-digit, no regrouping (Renee).

In addition to screening participants' math performance, the experimenter asked the participant to identify a list of activities and stimuli for which he or she would be willing to work in an unstructured interview. These stimuli included, but were not limited to, edibles (e.g., chips, granola bars, soda), tangibles (e.g., gift card), or activities (e.g., Sudoku, UNO®, Would You Rather?TM, charge phone, phone time, drawing, and listening to music). Participants were then asked to rank order the items and activities they would be willing to work for to allow for the assignment of point values. In other words, the higher preference the item, the greater the point value needed to obtain that item during the home-based practice phase. Once participants identified the list of potential rewards, the experimenter had the adolescent's parent(s) approve the available rewards. The approved rewards were then placed on the participants' individualized reward menu.

Independent Variable

The independent variable in this study was a multi-component intervention package that included a home-based remedial practice component and a parent support component. The home-based remedial practice component included prior training in the selection and use of instructional strategies (described below) and repeated practice at home. The parent support component included having parents create a structured environment for remedial practice, and encouragement through the provision of positive feedback.

Instructional Strategies

Cover-Copy-Compare (CCC). In CCC (Skinner et al., 1993, 1997), the experimenter said to the students, “[This] is a strategy that will help you fix your mistakes. This strategy is most helpful when you are making a lot of errors.” The CCC worksheets were made available to the participants and they were instructed to study the math fact model provided in the left column of the sheet. They then folded over the left side of the paper and, in the column directly to the right of the model, copied from memory the math fact and the answer. The students then uncovered the model and compared it to their responses. If he or she had written the math problem and answered it correctly, he or she then moved to the next item. If the participant had written or answered it incorrectly, the student re-covered the model and attempted to write and answer it again from memory in the column to the right of the first blank column and again checked the correctness of the copied item. This procedure continued until the 5 min work period ended or until the student choose to switch interventions.

Timed-fluency trials (TFT). The experimenter said to the student “[This] is a strategy that helps you get faster. To use this strategy, you will use a timer to see how many problems you can complete in 1 min. After 1 min is done, count the number of problems you completed. Then, do it again to try and beat your last score. It means you are getting faster if you beat your last score. This strategy is most helpful when you are not making errors; it is not helpful if you are making errors. You might practice and learn the wrong thing.” The TF worksheets were then made available to the students.

Participants were instructed to begin the timer and complete as many problems as possible within 1 min. After 1 min elapsed, students stopped the timer and recorded the number of problems completed on a record sheet. This procedure was repeated until the 5-min work period ended or until the student choose to switch interventions. Each time the student repeated these procedures, he or she looked at his or her most recent score and compared that score to his or her prior scores to determine if he or she completed more problems within 1 min. If she or she completed more problems than the last score, then it was considered that he or she “got faster.”

Dependent Variables

Math Academic Performance. Math academic performance encompasses math computation fluency and math accuracy, the primary dependent variables of the study.

Math Computation Fluency. Math computation fluency was defined as digits correct per two min (DCPM), errors per two min (EPM), and total problems correct (TPC). In each session, participants were given either a generalization assessment worksheet or an instructional assessment worksheet and instructed to complete problems for 2 min. Results were scored as DCPM by calculating the number of digits completed

correctly. A digit was scored as correct if the correct digit was written in the appropriate column and place. All of the correctly completed digits were counted to obtain each student's correct number of digits per 2 min for each math worksheet. Results were scored as EPM by calculating the number of digits completed incorrectly. A digit was scored incorrect if the digit was written in the incorrect column and/or place or was not written at all. All of the incorrectly completed digits were counted to obtain each student's errors per 2 min. Results were scored as TPC per 2 min (TPC2M) by first calculating the number of problems completed correctly within 2 min. A problem was scored as correct if all of the correct digits were written in the appropriate columns and places. All of the correctly completed problems were counted and recorded.

Math Accuracy. Math accuracy was defined as the percentage of TPC from total problems attempted. This was calculated based on the daily and generalization assessment worksheets described above. Percentage of TPC was calculated by dividing TPC by the number of problems attempted. The resulting number was then multiplied by 100 to obtain a percentage.

Math Self-Efficacy. Two scales of the Patterns of Adaptive Learning Scales (PALS; Midgley et al., 2000), Mastery Goal Orientation (Revised) and Academic Efficacy, were used (Appendix J). The original items in the English version of the measure are phrased in terms of general class work. Given the focus of this dissertation is on math only, the items were rephrased to measure domain-specific (i.e., math) goals and perceptions. Students responded using a 5-point Likert-type scale (1=*not at all true* to 5=*very true*).

The Mastery Goal Orientation (Revised) scale approximates a students' mastery goal orientation in an achievement setting (e.g., math class). This scale contains five items. Midgely et al. (2000) reported high internal consistency of the scale ($\alpha=0.85$). The Academic Self-Efficacy scale approximates students' perceptions of their capability to do class work. This scale also contains five items. Midgely et al. (2000) reported good internal consistency of this scale ($\alpha=0.78$). Levpuscek & Zupancic (2009) assessed internal consistency of the two scales combined, which was strong ($\alpha=0.87$).

Survey administration was conducted according to the guidelines outlined by the authors of the PALS. Specifically, the measure was administered by trained data collectors at the participants' school prior to the initiation of baseline. Students were informed that the measure is not a test, there are no right or wrong answers, and that there responses would be kept confidential. A sample question was included at the beginning of the measure to introduce the use of the Likert-type scale. All instructions and items were read aloud to each participant.

Experimental Design and Procedures

A multiple-baseline-across-participants design was used in this study to examine the impact of training high school students to select their own individualized interventions while giving them parental support on improving math academic performance. With this design, experimental control is achieved when a visible change in the level or trend of the dependent variable (e.g., math computation fluency) occurs in a staggered fashion across baselines (Kazdin, 2011).

Baseline. In this phase, participants' baseline math-computation fluency and accuracy were assessed by administering one combined-skill probe for 2 min to establish

current skill level prior to the introduction of intervention. Participants did not receive training on how to select or utilize the various intervention strategies available to them. Additionally, no materials, feedback, or training were provided to parents.

Student Training Phase. The training phase occurred in the participating student's school. During the training phase, participants were exposed to CCC and TFT interventions (Appendix L). At the beginning of each session in this phase, the intervention strategies were introduced and the participants were provided with guidelines derived from the Instructional Hierarchy (Ardoin & Daly, 2007; Haring et al., 1978) for how to select a strategy based on their most recent performance for a particular difficulty level. Specifically, the experimenter recommended that CCC be used when error rates are high and TFT when error rates are low. One difficulty level (i.e., "easy" or "hard") was used per session, and was alternated across sessions. The participants were shown the graph of their daily performance data to determine whether CCC or TFT was needed. After reviewing the data, participants were prompted to identify which intervention strategy they believed would be most helpful for them based on their daily performance data. Specifically, the experimenter asked, "Based on your graph, which strategy do you think will be most helpful for you today?" If the participant responded with an answer consistent with the recommendations, the experimenter provided praise. If the participant responded with an answer inconsistent with the recommendations, the experimenter restated the recommendations, saying, "Remember, a lot of errors may mean that you need modeling and error correction (CCC). Few errors mean you may need practice (TFT)."

Participants were then provided the opportunity to practice for 5 min using either or both of the intervention strategies available. They were also told that they could practice as much or as little as they wanted using any of the methods they want. AE was measured at this time to monitor student choice and use of the intervention strategies. Immediately after the completion of the 5-min practice time, an instructional assessment worksheet was administered daily to measure skill acquisition for the difficulty level instructed in that session. Participants then graphed the data gathered from the instructional assessment worksheets (i.e., TPC and EPM) under the guidance of the experimenter. The results were reviewed in the following training phase session.

Once a week, a generalization assessment worksheet that contained both easy and hard problems (both difficulty levels) to assess generalized performance was administered. The training phase lasted until participants consistently demonstrated valid decision-making regarding which intervention was most appropriate based on their performance. When the student made the decision to use CCC when error rates were high and TFT when error rates were low at least five days in a row, this phase was terminated.

Parent Training Session. Once stability in decision-making was observed during the training phase, parent training occurred. Parent training occurred in a single session after the completion of the training phase either at school, dependent on experimenter and parent availability. The experimenter conducted individual training sessions with each parent. Each training session took approximately 1 hour. During this session, parents were provided with a rationale for supporting their adolescents in implementing a math intervention in the home. The lead experimenter then explained the process for selecting intervention strategies, and provided the homework binder to the parent. Additionally, the

intervention procedures were modeled for the parent to provide her with a basic understanding of both interventions, thus allowing for parental detection of correct intervention implementation for both strategies.

Home-based Practice Phase. The home-based practice phase occurred following the parent training session. This phase was intended to promote parental involvement in adolescent education as well as generalization of decision-making skills taught to participants in the training phase. During this phase, assessment of skills and reinforcement occurred at school with the experimenter. Intervention practice and parent support occurred at home with participating students' parents (Appendix M).

School. The participants met three to five times per week with the experimenter at school, at which point they turned in their completed intervention materials and received feedback on their "homework." Specifically, if participants turned in their completed intervention materials from the previous night with parent initials and the corresponding daily homework log, they received points that could be exchanged for items or activities on the reward menu on the upcoming "assessment day" or they could save up their points to exchange for higher-valued items on a later "assessment day." If participants did not bring the previous stated materials to the experimenter, they were informed that they did not earn points for the day, but that they would have the opportunity to earn points the next day.

Additionally, the experimenter conducted an assessment. Instructional assessment worksheets were administered in each session to monitor skill acquisition within a particular difficulty level on which math computation fluency and accuracy were measured. Participants then graphed the data gathered from the instructional assessment

worksheets (i.e., TPC or EPM) under the guidance of the experimenter to determine whether CCC or TFT was needed. After reviewing the data, participants were prompted to identify which intervention strategy would be most helpful for them based on their daily performance data. Specifically, the experimenter asked, “Based on your graph, which strategy do you think will be most helpful for you today?” If the participants responded with an answer consistent with the recommendations, the experimenter provided praise. If the participants respond with an answer inconsistent with the recommendations, the experimenter restated the recommendations, saying, “Remember, lots of errors may mean that you need modeling and error correction (CCC). Few errors mean you may need practice (TFT).” Finally, participants were then provided with the intervention materials (i.e., CCC and TFT worksheets) necessary for the subsequent evening. One difficulty level (i.e., “easy” or “hard”) of intervention materials was used per evening session, which was alternated across evening sessions. They were then informed that they could practice as much or as little as they would like at home and that the practice could potentially improve their chances of receiving a higher-valued reward on the next assessment day.

Once a week an “assessment day” day occurred. In this session, a generalization assessment worksheet that contained both easy and hard problem types were administered in which math computation fluency and accuracy was measured. After completion of the generalization assessment worksheet, the number of points the participant earned from turning in his or her homework materials throughout the week was calculated. Participants were then told that they could exchange their points for a

reward from the reward menu or that they could save up their points to exchange for a higher-valued item on a later “assessment day.”

Home. During each session at home, participants practiced using the interventions and parents supported and monitored participant intervention use with the assistance of the homework binder protocol. The protocol contained within the homework binder prompted parents to ask their adolescents to share with them what was discussed during the school session with the experimenter to facilitate a conversation about learning strategies and school activities. Specifically, parents were prompted to ask questions such as, “how did your math session go at school today?”, “what did your math data suggest?”, or “what strategy do you think will be most helpful to you today?” The protocol then guided parents to prompt their adolescents to begin their 5-min math practice time.

During the math practice time, the homework binder protocol instructed parents to monitor their adolescents’ use of the available intervention strategies (i.e., CCC or TFT) with the homework log. Each day, parents were prompted to check whether or not their adolescents chose to practice and which intervention(s) they used while documenting the length of time the adolescents spent practicing their math. Parents were also prompted to monitor their adolescent’s use of the interventions to determine that the interventions were being used with fidelity. Once the participant completed his or her math practice, the protocol then directed parents to provide feedback to the participant on his or her engagement with the intervention materials. Specifically, if the adolescent spent any time using the interventions during the math work time, the parents were prompted to praise their adolescent based on their engagement and a statement pairing the intervention used with their corresponding rule (i.e., “You worked really hard today! You used CCC, which

is a great way to work on becoming more accurate.”). Parents were instructed to also provide praise if participants utilize the intervention consistent with the feedback reported to the parents at the beginning of the session. If the adolescent did not use the intervention consistent with the reported feedback, the parents were instructed to restate the recommendations, saying, “Remember, lots of errors may mean that you need modeling and error correction (CCC). Few errors mean you may need practice (TFT).” The homework binder protocol then instructed parents to inform their adolescents that they will have the opportunity to practice more math problems to try and improve their math performance the following day.

Interobserver Agreement. During each session of the study, the experimenter scored the math worksheets. Four independent observers scored a random sample of 30% of the completed math worksheets to obtain IOA for math digits correct and TPC. Agreement for math digits is defined as both observers recording a digit as correct or incorrect. A disagreement for math digits is defined as any discrepancy between observers in relation to the same math digit (e.g., one observer scored a digit in the ones column for a particular problem as correct whereas the other observer scored the same digit as incorrect). IOA was calculated by dividing agreements by the number of agreements plus disagreements and multiplying the result by 100% to arrive at a percentage. Agreement for TPC was defined as both observers recording a problem as correct or incorrect. A disagreement is defined as any discrepancy between observers in relation to the same math problem (e.g., one observer recorded the problem as correct while the other observer scored the problem as incorrect). IOA was calculated by dividing agreements by the number of agreements plus disagreements and multiplying

the result by 100 to arrive at a percentage. The mean IOA for math digits correct was 83% (range, 76% to 88%) and the mean IOA for TPC was 79% (range, 76% to 82%).

For the purposes of obtaining interobserver agreement (IOA), the experimenter and an independent observer were present during 27% of the training phase sessions to simultaneously record active engagement. Agreements were defined as both observers recording the same response (i.e., presence or absence of active engagement) within each observation interval. IOA is calculated by dividing the total number of agreements by the total number of agreements plus disagreements and multiplying that number by 100 to obtain a percentage. The mean IOA for active engagement was 97% (range, 90% to 100%).

Procedural Integrity

All sessions in the baseline phase were audiotaped. An independent observer listened to a random sample of 30% of the recorded baseline sessions and recorded whether the experimenter implemented the steps correctly using the baseline protocol that outlined every step of the session. To calculate procedural integrity, the total number of steps implemented correctly was divided by the total number of steps according to the protocol. The result was then multiplied by 100 to arrive at a percentage. The mean procedural integrity for the baseline phase was 97% (range, 80%-100%).

Procedural integrity for the treatment condition (treatment integrity) was measured in the same way. All experimental sessions in the student training and home-based practice phases were audiotaped. An independent observer listened to a random sample of 30% of the recorded baseline, training, home-based practice, and maintenance sessions and recorded whether the experimenter implemented the steps correctly using

treatment protocols that outlined every step of the session. To calculate treatment integrity, the total number of steps implemented correctly was divided by the total number of steps according to the protocol. The result was then be multiplied by 100 to arrive at a percentage. The mean treatment integrity for the study across all experimental phases was 92% (range, 71% to 100%). The mean treatment integrity for the baseline phase was 97%, 96% for the student training phase and 89% for the home-based practice phase.

Active Engagement (AE). As another indicator of treatment integrity, AE was measured to approximate participant responsiveness (Dane & Schneider, 1998; Hagermoser Sanetti & Kratochwill, 2009; Power, Blom-Hoffman, Clarke, Riley-Tillman, Kelleher, & Manz, 2005). Participant responsiveness is defined as “the extent to which the participant implements essential intervention strategies as planned” (Hagermoser Sanetti & Kratochwill, 2009, p. 458). AE was measured only during the student training phase at school to quantify student use of interventions once an intervention was chosen in a training session. As participants only had access to the interventions (i.e., CCC or TF trials) during the experimental conditions, baseline AE was not obtainable. AE was objectively defined as the use of an available intervention during the intervention implementation time and included looking at the intervention materials, physically manipulating instructional materials according to directions, writing math problems, or verbally answering math problems (indicated by movement of mouth). This was recorded at 10-second intervals using a momentary time-sampling format for the entire 5-min intervention session 3 to 5 times a week at school. Intervention AE was reported as

percent of intervals for each intervention (CCC and TF), which provided an estimate of the duration of the behavior as a percentage of time.

The results for AE are presented in Table 1. All participants demonstrated high levels of total active engagement during the student training phase. Rachel's average total active engagement was 100%, Renee's average total active engagement was 95.4% ($SD=3.04$), and Dustin's average total active engagement was 80.4% ($SD=36.17$). Differences in active engagement between "easy" and "hard" problems were observed for both Renee and Dustin. Both exhibited higher levels of engagement when completing problems identified as "easy" in comparison to problems identified as "hard." Renee's average "easy" active engagement was 97% ($SD=0$) while her average "hard" active engagement was 93% ($SD=4.24$). Dustin's average "easy" active engagement was 97.7% ($SD=4.04$) while his average "hard" active engagement was 54.5% ($SD=54.44$). These results indicate that they were more engaged with easier than with harder items. Additionally, the data suggest that all three participants consistently demonstrated understanding of which intervention should be used within five sessions, as evidenced by verbal report of which intervention strategy he or she should use based on his or her graphed error rates on three consecutive sessions. Additionally, two of three participants (Renee and Dustin) demonstrated valid intervention use within five sessions, as evidenced by high TFT active engagement with "easy" problems and high CCC active engagement with "hard" problems at the end of the student training phase. These results suggest that after sampling both interventions and repeated exposure to the guideline "when you're making a lot of errors, Modeling and Error Correction is most helpful and

if you're are making very little errors, Practice is most helpful," Renee's and Dustin's use of intervention changed to align with their verbal choice.

Data Analysis

Visual inspection. The primary method of data analysis was visual inspection of the graphed math computation fluency (i.e., DCP2M and TPC) and accuracy data. Specifically, data was graphed and examined for changes in trend (i.e., noticeable increase or decrease in student responding over time), level (i.e., increases or decreases in student responding upon intervention implementation), and variability (i.e., the stability of student responding over time) within and across baseline, student training, and home-based practice phases (Kazdin, 2011).

Structured criteria for visual inspection. The differences between conditions was examined using the conservative dual-criteria method (CDC; Fisher, Kelley, Lomas, 2003). The CDC is used to examine the significance of behavior change during the intervention implementation phase (i.e., home-based practice phase) compared to baseline by determining if a sufficient number of intervention data points exceeded the baseline mean and trend lines based on the binomial distribution. CDC has been established by research as a valid method for detecting treatment effects compared to other methods, including the general linear model and other statistical evaluation methods (Fisher et al., 2003; Stewart, Carr, Brandt, & McHenry, 2007). Specifically, Fisher et al. (2003) found that using traditional nonoverlap methods to estimate effect size, such as split-middle lines, resulted in high Type I error rates. Additionally, most nonoverlap methods are insensitive to trend (Parker, Vannest, & Davis, 2011). As such, CDC was used in this study because it was believed to better account for variability within and

across phases and the likelihood of gradual behavior change over time with an intervention package of this type than other single-case design effect size metrics.

CHAPTER 3

Results

Math Computation

Fluency. The results for the digits correct per 2 min (DCP2M) and errors per 2 min (EP2M) data are displayed in Figure 1 and Table 2. Visual inspection of Rachel's rate of DCP2M and EP2M reveals differentiated patterns of responding between baseline and home-based practice phase. During baseline, results for DCP2M and EP2M were stable or perhaps even beginning to trend in the undesired direction. Following the initiation of the home-based practice phase, Rachel's DCP2M results displayed a decreasing trend with a degree of variability, whereas her EP2M results demonstrated an increasing trend. It was suspected that these undesirable trends may have been due to differential difficulty level even within "easy" and "hard" problems, and was hampering her progress. As such, during the following sessions (and phases as indicated in the Figure), the experimenter had her practice within even more narrow ranges of difficulty level. Therefore, problems originally assigned to the "easy" condition were broken down further as easy, moderate, and hard difficulty levels. Likewise, problems originally assigned to the "hard" condition were broken down further as easy, moderate, and hard difficulty levels. This was done to present her with a narrower range of problem types (e.g., easier problems from the "easy" set) during practice sessions and sequencing all the problem types so that she was exposed to the full range of problems over the course of the treatment phase. As a result, Rachel received intervention for six difficulty levels: Hard (Easy), Easy (Easy), Hard (Medium), Easy (Medium), Hard (Hard), Easy (Hard). From this point on, practice was conducted sequentially across all six difficulty levels

(Figure 1). Specifically, practice was conducted with each difficulty level for one week (i.e., four to five sessions) prior to changing difficulty levels. No alterations, however, were made to how skills were measured (and reported in the Figure). An increasing trend in DCP2M and a decreasing trend in EP2M emerged following this change in how Rachel practiced items.

Differentiated patterns of responding between baseline and home-based practice phase did not occur for Renee (Figure 1 and Table 2, second participant). Visual inspection of Renee's math fluency performance indicates an increasing trend and considerable variability in DCP2M and a decreasing trend (also with considerable variability) in EP2M during baseline. An increasing trend was also apparent for Renee's performance on DCP2M the home-based practice phase. However, an increasing trend in her EP2M occurred and there was a high degree of data overlap between baseline and intervention phases. Two factors are noteworthy about this participant. First, during the administration of baseline combined-difficulty worksheets, Renee expressed fatigue and frustration and began to skip problems she did not know. Doing so introduced a large degree of variability during baseline that mitigates against finding a treatment effect. Second, Renee chose to practice during 95% of sessions. Of the sessions that she chose to practice, however, Renee did not seek parent support in 63% of those sessions.

Dustin's results indicate that no treatment effect was found. A decreasing trend in Dustin's rate of DCP2M and an increasing trend in his rate EP2M are evident. However, although a slightly increasing trend was apparent for Dustin's performance on DCP2M in the home-based practice phase (the same is true for EP2M as well), the results across baseline and the home-based practice phases are completely overlapping. It is important

to note that Dustin's school attendance was inconsistent during the home-based practice phase and that he only chose to complete his math practice at home on 17% of the occasions.

In general, although Rachel's baselines were relatively stable, Renee and Dustin displayed highly variable performance during baseline, which overlapped considerably with results during the treatment phase. On a positive note, however, results during the home-based practice phase reveal increasing trends in DCP2M for all participants. Errors were reduced for Rachel, but remained the same or increased for Renee and Dustin. With a multiple-baseline design, experimental control is demonstrated when behavior changes in a treated baseline while the following baselines remain stable. In spite of the overall increasing changes in performance during intervention, the results indicate that baselines did not remain stable following intervention and that the requisite changes in performance were not large enough during treatment to allow one to conclude that experimental control was achieved.

Total problems correct. The results for total problems correct per 2 min (TPC2M) data are displayed in Figure 2 and Table 2. Results for Rachel's TPC2M during baseline are stable or even decreasing. Following the initiation of the home-based practice phase, Rachel's performance dropped initially, but began to increase when problems were practiced within the more narrow ranges of difficulty level described earlier. However, those performance increases were slow to materialize.

Renee displayed considerable variability in both baseline and home-based practice phases. Furthermore, there is considerable data overlap between both phases, suggesting limited treatment effects. Again, this may have been due at least in part to the

fatigue and frustration effects reported by Renee, and also by the fact that she did not rely on parent support for 63% of the sessions.

Dustin's performance during baseline was initially variable, but eventually stabilized. His performance during intervention did not change and all of the data points are overlapping with the prior baseline phase. It is important to note that Dustin's school attendance was inconsistent during the home-based practice phase and that he only chose to complete his math practice at home 17% of opportunities. The overall data pattern within and across subjects indicates that treatment effects were limited where they occurred (Rachel) and that there was considerable overlap for all participants between baseline and treatment phases, meaning that experimental control was not achieved.

Accuracy. The results for math accuracy (i.e., TPC2M divided by total problems attempted, multiplied by 100 to obtain a percentage) are displayed in Figure 3 and Table 2. Rachel's accuracy during baseline was stable. During intervention, there was a slow, steady improvement over time. The steady improvement became evident when Rachel worked on narrower sets of problem types. Renee's baseline accuracy was variable and increasing over time, whereas her accuracy during intervention had a slight decreasing trend. All of the data in the home-based practice phase overlapped with the baseline data points. Dustin also displayed highly variable performance during baseline. The same was true for the intervention phase. All but one of the data points in the intervention phase (the first data point) overlapped with baseline. It is noteworthy that Dustin chose to complete his math practice at home on only one occasion, which corresponded with the intervention session that resulted in an abrupt increase in accuracy to 100% following the introduction of the home-based practice phase. Dustin chose to not complete his math

practice at home on all following intervention sessions. Overall, although Rachel demonstrated some improvement during intervention, the other participants did not, and experimental control was thus not achieved.

Individual Participant Intervention Results of the Student Training and Home-Based Practice Phases

The results described in this section represent math computation fluency, total problems correct, and accuracy data gathered for each participant from instructional assessment worksheets, as opposed to the generalization assessment worksheets, across student training and home-based practice phases. Thus, these data represent change in math academic performance not readily apparent in the multiple-baseline design. Rather, these results represent the data that were plotted by the participants and used to assess performance improvements on each difficulty level trained following each student training and home-based practice session. The data are differentiated by difficulty level (i.e., “easy” and “hard”), which is not readily observable in the multiple-baseline design. These data were also used by participants and the experimenter to make decisions regarding which intervention each participant should have used when practicing at home. As such, these data provide important additional information regarding math academic performance on each difficulty level in relation to the intervention (i.e., CCC versus TFT) used. Further, the number of sessions conducted in the student training phase represents the number of sessions required for each participant to demonstrate understanding of specific intervention procedures as well as how to select an intervention based on his or her graphed data. Given the purpose of the student training phase, insufficient data were collected to determine trends for all participants.

Rachel.***Math computation fluency (DCP2M, EP2M, and TPC) by difficulty level.***

DCP2M and EP2M results for both “easy” and “hard” difficulty levels are displayed in Figure 4 and TPC2M results for all “easy” and “hard” difficulty levels are displayed in Figure 5. An increasing trend in both “easy” and “hard” DCP2M was evident during the home-based practice phase, though there was also an increasing trend in “easy” EP2M. Data during this phase did not exceed student training data. Given this, the difficulty levels were altered to increase intervention specificity as previously described, and is henceforth referred to as the modified home-based practice phases.

During the modified home-based practice phase, immediate improvements in performance were observed for all skills within difficulty levels following the introduction of intervention except for the “easy/easy” skill. Immediate decreases in EP2M for both “easy” and “hard” difficulty levels were observed. EP2M remained low across all modified home-based practice phases except the “easy/medium” phase in which “hard/hard” EP2M increased initially, but then immediately decreased (it is important to note that during this phase, the “hard/hard” problem type was not receiving intervention, so inconsistent performance would be expected). Additionally, an overall increasing trend was observed across all modified home-based practice phases and performance exceeded that of the student training phase. Finally, performance during the return to the original home-based practice phase exceeded that of the first implementation of that phase, demonstrating overall fluency performance improvements for both “easy” and “hard” difficulty levels. These results suggest that breaking skills down to their smallest component skills and providing intervention to those component skills may lead

to generalized performance improvements in composite skills (Binder, 1996; Johnson & Layng, 1992).

Accuracy by difficulty level. Accuracy results for both “easy” and “hard” difficulty levels are displayed in Figure 6. During the modified home-based practice phase where intervention specificity was increased, immediate improvements were observed for both “easy” and “hard” accuracy. Additionally, these improvements maintained across the modified home-based practice phases except for “easy/medium”, where there was initially low accuracy percentages in “hard/hard” accuracy. However, it is important to note that during this phase, the “hard/hard” problem type was not receiving intervention, so low accuracy in performance would be expected. Finally, performance during the return to the original home-based practice phase exceeded that of the first implementation of that phase, suggesting generalized performance improvements in accuracy for both “easy” and “hard” problem types.

Renee.

Math computation fluency (DCP2M, EP2M, and TPC2M) by difficulty level.

DCP2M and EP2M results for both “easy” and “hard” difficulty levels are displayed in Figure 7 and TPC2M results for both “easy” and “hard” difficulty levels are displayed in Figure 8. Insufficient data was collected during the student training phase to establish trends in her performance; however, there was clear distinction in rate of DCP2M and EP2M between “easy” and “hard” difficulty levels. It is important to note that data had to be pro-rated for the final student training session due to a shortage of instructional assessment worksheets.

During the home-based practice phase, there was an increasing trend in “easy” TPC2M and DCP2M while “easy” EP2M remained low and stable. Though there was overlapping “easy” DCP2M and TPC2M data between student training phase and home-based practice phase initially, data eventually exceeded that of the home-based practice phase. There was also a slightly increasing trend in “hard” DCP2M and TPC2M during the home-based practice phase. However, there was no change in level from the student training phase to the home-based practice phase and there was an increasing trend in “hard” EP2M and an increase in variability across phases. These results are remarkable as they demonstrate performance improvements that are not readily apparent in the multiple-baseline design. It appears that home-based practice led to improvements in “easy” math computation fluency that are not visible in the combined results (Figures 7 and 8).

Accuracy by difficulty level. Accuracy results for both “hard and “easy” difficulty levels are displayed in Figure 9. Not enough data were collected during the student training phase to establish trends in his performance; however, there was clear distinction in accuracy between “easy” and “hard” difficulty levels. During the student training phase, the second “hard” accuracy data point was below that of the first “hard” data point while the “easy” accuracy data remained consistent. The stability in the accuracy of the “easy” difficulty level maintained during the home-based practice phase. It is important to note that a ceiling effect may have been present as behavior cannot exceed 100% accuracy. A decreasing trend with increasing variability was observed for accuracy on the “hard” difficulty level. These results are notable, as they demonstrate significant performance improvements in the “easy” difficulty level that are not apparent in the

multiple-baseline design, suggesting possible differential efficacy as a function of the difficulty level of the skill being taught.

Dustin.

Math computation fluency (DCP2M, EP2M, and TPC2M) by difficulty level.

DCP2M and EP2M results for both “easy” and “hard” difficulty levels are displayed in Figure 10 TPC2M results for both “easy” and “hard” difficulty levels are displayed in Figure 11. Not enough data was collected during the student training phase to establish trends in his performance; however, there was clear distinction in rates of TPC2M, DCP2M, and EP2M between “easy” and “hard” difficulty levels.

During the home-based practice phase, there was an increasing trend in “easy” TPC2M and DCP2M while there was a decreasing trend in “easy” EP2M. However, there was considerable overlapping “easy” TPC2M and DCP2M data between student training phase and home-based practice phase and data did not exceed that of the home-based practice phase. There was a decreasing trend in “hard” TPC2M, DCP2M, and EP2M during the home-based practice phase. Again, there was considerable overlapping data across phases. These results also indicate performance improvements not observed in the multiple-baseline design, suggesting differential efficacy in relation to the difficulty level of the skill being taught when students are provided with structure and support as opposed to when they are not.

Accuracy by Difficulty Level. Accuracy results for both “hard and “easy” difficulty levels are displayed in Figure 12. Insufficient data were collected during the student training phase to establish trends in her performance; however, there was clear distinction in accuracy between “easy” and “hard” difficulty levels. Notably, the final

“easy” and the final “hard” accuracy data points in this phase fell below that of the prior data points. During the home-based practice phase, there was a slight increasing trend in the “easy” difficulty level. It is important to note that a ceiling effect may have been in place as behavior cannot exceed 100% accuracy. A decreasing trend with a high degree of variability and data overlap across phases was observed for accuracy on the “hard” difficulty level.

The Conservative Dual Criteria (CDC) Results

In addition to visual inspection, the CDC method (Fisher, 2003) was used to provide further evidence of the effects of the intervention package during the home-based practice phase for DCP2M and TPC2M. For Rachel, at least 14 out of 26 data points needed to fall above both criterion lines to be statistically significant for both DCP2M and TPC2M. Based on this method, Rachel demonstrated a significant difference between the baseline and the home-based practice phases, as 15 points fell above both lines for both DCP2M and TPC2M. Consistent with visual inspection, Renee and Dustin showed a lack of change between phases for both DCP2M and TPC2M as none of their scores fell above both criterion lines (13 out of 19 needed to be significant for Renee and 6 out of 6 needed to be significant for Dustin).

Intervention Choice and Use During Home-Based Practice

Permanent product data gathered during the home-based practice phase provide results regarding choice and use of instructional strategies during the home-based practice phase. Data from permanent products (i.e., completed intervention materials) indicated that Rachel engaged in at-home practice for 81.5% of scheduled opportunities, Renee engaged in at-home practice 95.0% of scheduled opportunities, and Dustin

engaged in at-home practice 33.3% of scheduled opportunities. All caregivers returned completed Homework Logs when possible, though the number of steps completed on the Homework Logs varied. Rachel's parent completed 100% of steps on the Homework Log, Renee's caregiver completed an average of 97.8% of steps ($SD=6.67$, range, 80% to 100%) on the Homework Log, and Dustin's parent completed an average of 80% of steps ($SD=0$) on the Homework Log. Data gathered from the returned Homework Logs completed by parents indicated that when at-home math practice was completed, Rachel sought parent support 86.4% of the time, Renee sought parent support 63.2% of the time, and Dustin sought parent support 100% of the time. Additionally, data gathered from both intervention materials provided by participants and the Homework Logs completed by parents indicated that all participants used the appropriate intervention (i.e., the intervention that should have been used based on participants' graphs) 100% of the time.

Math Academic Self-Efficacy

Academic self-efficacy results are displayed in Figure 13. Rachel's average self-efficacy score during baseline was 2.8 ($SD=0.447$) and her post-intervention math academic self-efficacy average score was 3.8 ($SD=0.837$). Renee's average self-efficacy score during baseline was 3.0 ($SD=1.581$) and her post-intervention math academic self-efficacy average score was 3.4 ($SD=1.817$). Dustin's average self-efficacy score during baseline was 3.4 ($SD=1.517$) and his post-intervention math academic self-efficacy average score was 3.8 ($SD=1.095$). Overall, all three participants' average math academic self-efficacy scores improved somewhat from baseline to post-intervention, suggesting improved perceptions of their competence to do their math work. However, only Rachel's self-efficacy score exceeded the 95% confidence interval, suggesting that the changes for

Renee and Dustin were not significant. Furthermore, none of the participants' average scores exceeded that of the average score obtained by Midgley et al. (2000) when conducting psychometric analyses.

Mastery Goal Orientation

Mastery goal orientation results are displayed in Figure 14. Rachel's average mastery goal orientation score during baseline was 4.6 ($SD=0.548$) and her post-intervention mastery goal orientation average score was 4.8 ($SD=0.447$). Renee's average mastery goal orientation score during baseline was 3.2 ($SD=0.836$) and her post-intervention mastery goal orientation average was 4.6 ($SD=0.548$). Dustin's average goal orientation score during baseline was 3.8 ($SD=0.447$) and his post-intervention mastery goal orientation average score was 3.8 ($SD=0.447$). Overall, Rachel's and Renee's average mastery goal orientation scores increased from baseline to post-intervention while Dustin's remained unchanged. Rachel's and Renee's average scores exceeded that of the average score obtained by Midgley et al. (2000) when conducting psychometric analyses at post-intervention. However, it is important to note that Rachel's post-intervention score is within 1 standard error of measurement of her baseline score, suggesting no significant difference in mastery goal orientation from pre- to post-intervention.

Social Validity

Behavior Intervention Rating Scale (BIRS). Social validity was measured using a modified version of the BIRS (Elliot & Treuting, 1991; Martens et al., 1985). The results are displayed in Figure 15. Rachel's average rating across items was 5.27 (range, 4 to 6), indicating strong intervention acceptability. Rachel's mother provided an average

rating of a 6, also indicating strong intervention acceptability. Renee's average rating across items was 4.87 (range, 4 to 6), indicating strong intervention acceptability. Renee's mother provided an average rating of 5.73 (range, 2 to 6), also indicating strong intervention acceptability. Dustin's average rating across items was 4.8 (range, 3 to 6), indicating strong intervention acceptability. Dustin's mother provided an average rating of 5.87 (range, 4 to 6), also indicating strong intervention acceptability. Overall, these results indicate that all participants and their parents rated the intervention package as highly acceptable.

CHAPTER 4

Discussion

The purpose of the study was to examine the effects of high school students' independent, remedial, home-based math practice while receiving parent support on math computation fluency. The multi-component intervention package encompassed both home-based remedial practice and parent support. For the home-based remedial practice component, students were trained in math computation fluency interventions and how to select them appropriately and then encouraged to engage in repeated practice at home using the interventions. For the parent support component, the experimenter worked with the parents to create a structured time and place for student remedial practice, and to encourage the student through positive feedback. The study was designed to address two research questions. First, what are the effects of this multi-component treatment package on the students' computation fluency and accuracy? Second, what are the effects of this multi-component treatment package on students' reported self-efficacy and mastery goal-orientation?

Using a multiple-baseline design, three high school students were taught to differentiate intervention strategies according to proficiency levels (accuracy versus fluency) and then encouraged to practice the interventions at home with parent support. Parents were trained to provide support to their students to encourage them to practice using programmed rewards, progress monitoring, and performance feedback. The results indicated that, although there were some performance increases, there were no visible increases in performance in most cases and experimental control was not established. The multi-component intervention package produced limited effects on generalized math

computation fluency and accuracy. Additionally, the results of the study indicated that though there were some improvements in math academic self-efficacy, the improvements made were only significant for one participant (Rachel). Some improvements were also made for mastery goal orientation; however, the improvements were only significant for one participant (Renee). These results do not confirm the hypotheses that training students to select math interventions and encouraging them to practice at home with parental support would increase students' math fluency and accuracy as well as their reported self-efficacy and mastery goal orientation related to math.

In spite of the limited effects on math computation fluency and accuracy, there do appear to have been some beneficial effects. For example, all participants reliably chose the most effective intervention strategies (differentiating efficacy across difficulty levels) within five training sessions. Also, all parents demonstrated high levels of parent support when provided with the necessary materials following the parent training session. Though only one participant—Rachel—showed improvements in math computation fluency and accuracy on the generalization assessment worksheets, two out of the three participants (Rachel and Renee) showed significant improvements in math academic performance on the instructional assessment worksheets. The effectiveness of the program appeared to be greatest for students who received high levels of structured parent support and the appropriate skills were targeted for training. With respect to the latter finding, there was some evidence that participants increased their performance on instructional assessments, which were carried out at different difficulty levels (a distinction that cannot be discerned in the generalized assessment data). There was also some (but limited) evidence of improvements in math academic self-efficacy from pre- to post-intervention. Regarding

attitudes, both parents and participants showed positive attitudes towards the home-based remedial math practice and parent support intervention package, indicating that this intervention package was highly acceptable.

The limited effects on generalized math computation fluency appear to be due to multiple factors, including treatment complexity, treatment integrity, participant motivation, and time constraints related to the academic year. The intervention package examined in this study was highly complex, limiting the conclusions that may be drawn regarding individual components of the package. Participant treatment integrity may be another factor that limits the effects on generalized math computation fluency.

Specifically, Renee and Dustin inconsistently sought parent support throughout the home-based practice phase. Additionally, participant motivation may have presented as a barrier to generalized math computation fluency. Despite all participants indicating a desire to improve their math performance, all participants did not engage in at-home math practice during scheduled opportunities, and some participants (Renee and Dustin) demonstrated minimal at-home math practice and/or obtained minimal parent support. Moreover, all participants anecdotally expressed increasing frustration and disinterest in participation as the end of the school year neared. Likewise, the approaching end of the academic year artificially limited the number of sessions that were conducted with participants. Given that the intervention package examined in this study was intended to improve an academic skill, it is expected that performance improvement would be slow and require multiple practice opportunities. Thus, it is unclear if performance improvements may have been observed on the generalization assessment worksheets had

more sessions been conducted. The implications of these results are discussed in greater detail in the following sections.

Intervention Design and Instructional Procedures

This study attempted to identify high school students' skill deficits and help them choose effective intervention strategies to remediate these deficits. Adolescent academic skill deficits were conceptualized as resulting from a stimulus control problem (e.g., Gersten et al., 1984). Thus, remediation included the process of stimulus discrimination training, which consisted of increasing academic responding in the presence of instructional material for which stimulus control is weak (i.e., the desired S^D ; Daly et al., 2010; Greenwood, 1996; Heward, 1994). The participants learned different instructional strategies and given guidance and feedback about when they would be appropriate to use. This may be the first study to use these procedures with typically developing high school students who are struggling in math. Given that prior research indicated that CCC is a useful intervention in improving math accuracy (Lee & Tingstrom, 1994; Mong & Mong, 2010; Mong & Mong, 2012; Stading et al., 1996) it was theorized that CCC would be a useful intervention to use for problems identified as "hard." Similarly, prior research has supported the use of TFT as a useful intervention for improving math computation fluency (e.g., Lovitt, 1978; Van Houten, 1980, 1984; Miller et al., 1995) and was subsequently hypothesized to be a useful intervention for implementing with "easy" problems. As noted earlier, the students learned within five sessions how to differentiate interventions according to difficulty level.

Though an increase in math computation fluency and accuracy was not observed across all participants on the generalization assessment worksheets, the individual results

of each participant's math computation fluency and accuracy parsed out by difficulty level on the instructional assessment worksheets suggest that CCC and TFT have the potential to be effective under the right conditions. Two of the three participants (Rachel and Renee) demonstrated improvements in math computation fluency (DCP2M and TPC) while accuracy remained stable on "easy" problems following training and during the home-based practice phase. All participants demonstrated appropriate intervention choice 100% of the time during the home-based practice phase, indicating that they utilized TFT when error rates were low, as taught. It is not surprising then that fluency of the "easy" skills improved while accuracy did not change, as TFT was intended to target skills for which accuracy was already high but fluency was low (e.g., Miller et al., 1995). These findings may lend some support for the effectiveness of TFT in improving math computation fluency of typically developing high school students. However, given the complexity of the current intervention package, it is unclear to what extent improvements in math computation fluency can be explained by appropriate use of TFT alone. CCC, the intervention for hard problems, produced limited effects. Although all participants demonstrated appropriate intervention choice 100% of the time, CCC seemed to provide little benefit for "hard" problems in spite of prior studies supporting its use (Lee & Tingstrom, 1994; Mong & Mong, 2010; Mong & Mong, 2012; Stading et al., 1996). This finding runs counter to previous research supporting CCC. However, the limited results for CCC may have been due to poor treatment integrity. Given that CCC is a self-administered intervention and that intervention occurred at home, it is unclear if participants used the intervention they should have. For example, participants may not have corrected their errors after reviewing the answer, thus continuing to practice

answering the problem incorrectly. Participants may also not have attempted to answer the problem prior to reviewing the answer. CCC may also be administratively burdensome, involving multiple worksheets and turning pages. Future studies should examine other intervention strategies (e.g., Taped Problems; Poncy, Skinner, & Jaspers, 2007; Poncy, Jaspers, Hansmann, Bui, & Matthew, 2015) to determine whether they may be more efficient and effective for home tutoring than those used in the current study.

However, the results regarding the effectiveness of CCC and TFT on math computation fluency and accuracy taken together may highlight an important conceptual issue related to stimulus control that warrants further exploration in future studies. Specifically, the increasing trend across the intervention phase for Rachel is notable in that her computation fluency and accuracy improved dramatically after the “easy” and “hard” skills were separated and trained in isolation, a strategy referred to by Wolery, Bailey, and Sugai (1988) as “slicing back.” In Rachel’s case, it appears that she was not able to form the proper discriminations when problems of different difficulty level requiring different interventions were presented, but was able to do so when repeated practice was provided with one skill only, suggesting that her skill deficit may have been even greater than originally conceived. By the end of the intervention phase, however, she did appear to benefit from sessions containing both “easy” and “hard” problems, suggesting that appropriate levels of stimulus control and generalization had been achieved at this point. It may be that both Renee and Dustin had the same difficulty, albeit at less severe levels. If this was the case, they may have benefited more from the change to the intervention package too.

The results of this study may highlight the importance of appropriate skill identification (i.e., screening) and measurement. Aimsweb M-CAP and Aimsweb M-COMP were used as a comprehensive measurement of each participant's proficiency with math component and composite skills (Johnson & Layng, 1992) to inform which skills would be targeted for additional screening. Though national high school norms were available for these measures, the measures themselves were created based on 8th grade curricula. So, the individual skills targeted for additional screening may not have been the most appropriate or relevant for all participants given the complexity of the skills included on these measures for high school students. For example, responding to the problem $20=9x+2$ requires understanding of addition, subtraction, multiplication, and division as well as the bidirectional relationship between addition and subtraction and multiplication and division. Further screening on one-digit-by-one-digit multiplication problems (e.g., 2×4) and two-digit-by-one-digit multiplication problems (e.g., 10×2) may have been conducted for a participant based on their response to that problem when further screening on one-digit-by-one-digit division problems (e.g., $4\div 2$) and two-digit-by-one-digit division problems (e.g., $10\div 2$) may have been warranted. Future studies teaching high school students how to select and use instructional strategies like those used here should examine this issue of differentiating component skills (Johnson & Layng, 1992) and assuring that students have adequate prerequisite skills (or addressing those skills; Howell & Nolet, 2000) before proceeding to the home-based practice phase, which will almost always provide less consistent guidance and feedback.

Choice of Instructional Strategy

The results of this study extend the current literature on choice of instructional strategy by providing evidence that may suggest high school students *can* be taught to choose instructional strategies. This is particularly important given that adolescents are capable of playing a more active role in their educational decision-making (Hill & Tyson, 2009).

In this study, participants were provided with guidelines for selecting instructional strategies based on the IH (Appendices F and L). Participants were then taught how to graph and interpret their own data (Appendix D). They then received direct instruction in how to use their data to select an instructional strategy based on the guidelines provided through modeling, repeated practice, and feedback (praise and/or error correction). All participants selected the appropriate intervention to use at every opportunity during student training phase and maintained consistency in valid decision-making throughout the home-based practice phase, indicating that high school students can be influenced to choose empirically derived instructional strategies and implement them correctly, which extends the current literature in this area (Carson & Eckert, 2003; Daly & Kupzyk, 2012; Daly et al., 2006).

This finding is important because it demonstrates that high school students can be influenced to engage in remedial math practice when there are concurrent, competing opportunities to engage in other, perhaps more pleasurable, activities. In particular, all three participants demonstrated high levels of active engagement at school during the student training phase when given the opportunity to do as much or as little work as they would like. Additionally, two out of three participants—Rachel and Renee—chose to use

the selected intervention at home the majority of the time. Whereas prior research demonstrates overall low rates of academic homework completion by high school students (Wilson & Rhodes, 2010), all participants in this study not only engaged in some level of additional at-home math practice, they also engaged in additional at-home practice when provided the option to *not* practice.

There are several reasons why this may have been the case. First, offering the participants a choice of whether or not to practice and what to practice may have made an aversive situation (i.e., homework completion) less aversive, removing the need to escape it in the home environment (Romaniuk et al., 2002). Second, it is possible that the reinforcement contingencies based on individualized preference assessments carried out prior to the study and choice of consequence during practice sessions may have been sufficiently strong to compete with whatever other concurrent reinforcers may have been available during the practice time. The combination of the use of high-preference consequences and choice in this situation may have further established practicing as being more reinforcing (Kruger et al., 2016).

Third, prior research on parent involvement with homework completion has been shown to promote academic achievement in some circumstances and hinder it in others (Callahan et al., 1998; Cooper, 1989, 2007; Hill & Tyson, 2009; Wolf, 1979). All participants in the current study engaged in some level of at-home math practice, even when given the option to not practice. It is possible that the specific type of parental support available in this study strengthened the contingencies favoring practice at home through variables like contingent social attention, performance feedback, and contingent access to desired consequences.

Unfortunately, the limited effects on generalized computation performance mean that these positive effects on the high school students' choices just described did not result in improved stimulus control with math computation, the ultimate goal of the study. The procedures for this study were complex and a parent-managed intervention might not be strong enough to help remediate students with significant skill deficits. Future studies could examine students with less severe skill problems, using more typical high school classroom exercises. Future studies might also, however, target students with significant skill deficits but provide more extensive training and supervision of results to establish actual performance increases (adjusting the interventions as necessary) before having students practice at home with parent support.

Parent Involvement and Support

This study sought to promote parental support through the use of an explicit parent training component whereby parents received guidance on how to provide educational materials and engage in educational activities with their adolescents by implementing strategies like prompting, offering rewards for practice, providing an appropriate and consistent setting in the home for the student to complete his or her homework that has adequate lighting and is free from distractions, offering feedback on overall engagement/completion of practice, and promoting academic goal attainment (Cancio et al., 2004; Eccles et al., 1991; Mounts, 2001; Salend & Schliff, 1989; Toomey, 1993).

The data available from completed Homework Logs (Appendix H) demonstrate that all caregivers provided high levels of support throughout the home-based practice phase when given the opportunity to do so by their adolescents. The literature suggests

that parents' decisions to be involved in their adolescents' academics are influenced by the extent to which opportunities and expectations for involvement present themselves (Sheridan & Kratochwill, 2007), which is further supported by the results found in this study. The structured parent support outlined during the home-based practice phase prompted parents to record specific activities to track implementation. Parents did this for the most part, as evidenced by parents completing a majority of the steps on the Homework Log. Interestingly, the only step on the Homework Log that was not completed by Renee and Dustin's caregivers was providing feedback to their adolescent on their engagement in the home-based math practice. The fact that Rachel, who did consistently receive this feedback using behavior specific praise and brief comments about the students' choices (e.g., "I noticed that you used 'Timed Practice,' which is a great way to get faster. Remember, lots of errors may mean that you need 'Modeling & Error Correction.' Few errors may mean you need 'Timed Practice.'"), had the greatest improvements in math computation fluency may provide tentative evidence for the importance of this particular component.

Unfortunately, parents were not surveyed directly about why they did or did not follow intervention steps. Nonetheless, given the previous research on the relationship between feedback and academic engagement (Galambos et al., 2003; Marchant et al., 2001; Melby & Conger, 1996; Simpkins et al., 2009), future studies should examine the possible relationship between parental feedback and constructive guidance on academic performance. Future studies should also conduct detailed component analyses to identify the most effective components of parental support as well as barriers that may adversely affect parental support.

Technology may be useful in future studies to gain information regarding treatment integrity in the home environment. Telehealth consultation (Coutts, 2015; Coutts, Holmes, Smith, & Sheridan, 2013; Machalicek et al., 2016) may be very helpful in this regard. Additionally, focus groups or interviews could be conducted with parents to gather additional information regarding their beliefs associated with this type of parent involvement and support. Moreover, research has demonstrated that parents tend to have higher levels of involvement and engagement in their child's education when they have positive, well-developed perceptions of their own efficacy (Ames, 1993; Grolnick et al., 1997; Hoover-Dempsey et al., 1992; Sheridan & Kratochwill, 2007; Swick, 1988); consequently, future studies should explore the relationship between parental self-efficacy and their willingness to provide feedback to their adolescents on home-based math practice.

Math Academic Mastery Goal Orientation and Self-Efficacy

Parent support and involvement has been linked to development of and improvement in adolescent academic self-efficacy (e.g., Deci & Ryan, 1985; Skinner & Belmont, 1993) and mastery goal orientation (e.g., Levpuscek & Zupancic, 2009). It was hypothesized that training students to select math interventions and encouraging them to practice at home with parental support would increase students' reported self-efficacy and mastery goal orientation in relation to math. The results of the study indicated that one participant improved in average mastery goal orientation from pre- to post-intervention and that all three participants' average math academic self-efficacy scores improved from pre- to post-intervention. However, only one participant's self-efficacy score exceeded the 95% confidence interval. Though these results demonstrate

improvements, the improvements do not appear to be statistically significant when considering the 95% confidence interval. Thus, this hypothesis was not confirmed.

In this study, Renee improved her average mastery goal orientation from pre- to post-intervention. Two of three participants demonstrated improvement on the item “One of my goals in math is to learn as much as I can.” Prior research indicates that students with a mastery goal orientation tend to find engagement in the *academic process* more reinforcing than receiving high marks (Ames & Archer, 1988; Gonzalez et al., 2002). It may have been unrealistic to expect that participation in the current study would improve the students’ grades. It is possible, however, that the practice and improvements associated with that practice (however limited they were) helped Renee to improve her mastery goal orientation to some degree while making engaging in practice more reinforcing.

The results of the present study indicated that all three participants’ average math academic self-efficacy scores improved from pre- to post-intervention, though only Rachel’s self-efficacy score exceeded the 95% confidence interval. This suggests that Rachel’s beliefs regarding her ability to learn or perform math tasks was more positive following intervention (Bandura, 1986, 1997). Notably, all participants’ ratings on the items “I can do even the hardest math if I try” and “Even if the math work is hard, I can learn it” improved following intervention. The consistent improvements in math academic self-efficacy across participants continue to lend support to the existing literature regarding the relationship between parental support and involvement and academic self-efficacy. Prior research indicates that students report greater academic self-efficacy when parents are perceived as placing more emphasis on effort and achievement

(Marchant et al., 2001). Taken together these results are consistent with the prior research suggesting that that the type of parental involvement (parental pressure versus parental support) is important to mastery goal orientation, sense of academic self-efficacy, and math academic achievement (Levpuscek & Zupancic, 2009). The sample size is too small and the effects too limited to conclude anything for sure. However, the current results should encourage researchers to examine the relationship between these variables more closely as stronger intervention packages are delivered and stronger skill increases are achieved.

Treatment Acceptability

When examining the use of an intervention in natural contexts, such as the home environment, it is critical to assess treatment acceptability. If the intervention is not found to be acceptable, participants are less likely to use it even if it is effective (e.g., Witt & Elliot, 1985; Shapiro, 1987). Therefore, the study sought to determine whether teaching students to choose instructional strategies and use them with parental support would lead to favorable acceptability ratings for parents and students. It was hypothesized that parents and students would rate the procedures and strategies as socially valid following conclusion of the study. The results support this hypothesis. Both participants and their parents rated the intervention package highly, as evidenced by high ratings on the BIRS, suggesting overall strong intervention acceptability of this intervention package. Studies on treatment acceptability have largely focused on parents, teachers, and elementary-aged students (e.g., Eckert et al., 2017); however, no studies to date were found that have explored adolescent acceptability of academic interventions and parent support. Nevertheless, these data remain consistent with prior research on the acceptability of

academic intervention and parent support programs (e.g., Eckert et al., 2017; Gortmaker et al., 2007; Kupzyk, 2012).

Remarkably, all three participants responded Strongly Agree to the item, “This type of parental support and practice was a fair way to handle my academic problem,” suggesting that the parental support and individualized practice components involved in this intervention package were crucial to acceptability. The high levels of acceptability are particularly noteworthy in light of the limited outcomes in skill improvements achieved in this study. The strong intervention acceptability paired with improvements in participant math academic self-efficacy may suggest that this intervention package provided appropriate balance between parental involvement and support and adolescent autonomy, even if it did not remediate the skills as originally hypothesized. Specifically, it may have struck an appropriate balance between low levels of parental pressure and high levels of parental support (Levpusek & Zupanic, 2009). One potential concern, however, is that if stronger intervention strategies than those used in this study are needed, the interventions will be even more complex and cumbersome. It is possible that the efficiency of the intervention package contributed to favorable perceptions even in the face of limited outcomes. Future research should examine how to achieve the right balance of treatment strength and intensity and acceptability. As noted earlier, it is possible that a more extended phase of direct supervision of the student by a school-based expert who is prepared to make adjustments might help students to settle on the most effective strategy before transporting it to the home for practice.

The information gathered from acceptability questionnaires may also be helpful for making future modifications. The items receiving the lowest ratings are revealing. In

this study, parent and students gave the lowest rating to the item, “This type of parental support and practice is consistent with those I have used before” (adolescent mean rating=4, parent mean rating=2.7), indicating that, while the adolescents believed that they had received parental support of this type before, parents believed otherwise. The disparity in ratings between participants and their parents is not surprising given that tangible parental involvement during high school is relatively uncommon. Given that all participants were enrolled in a remedial math class, it is possible that adolescents had indeed received similar academic interventions prior to enrolling in this study, just not with the kind of parent support that was given in this case. Parents’ low rating of this item suggests that they felt that they had not previously delivered this kind of support before.

The other item rated lowest, but still positively, by both parents and participants was, “My [adolescent’s] academic problem was severe enough to warrant use of this type of parental support and practice” (adolescent mean rating=4.3, parent mean rating=5.3). This finding is interesting given that two of the three participants (Rachel being the exception) performed below the 25th percentile on both the AIMSweb M-CAP and M-COMP based on AIMSweb normative data at baseline, indicating significant difficulties in math. This finding reveals that participants and their parents may have underappreciated the severity of their math problems. Although the importance of math computation fluency and parent support was discussed during the parent training, it is possible that this topic was not sufficiently emphasized. Additionally, the same education should also be provided to adolescents to help them better understand their own skills deficits, which may also lead to a greater understanding of how to make appropriate choices regarding instructional strategies. Thus, future studies would do well to increase

the educational component of math interventions by providing a broader context of the curriculum and adjust where the students' skills lie in that curriculum, especially because high school students will be moving on soon either to more demanding real-world contexts like work, vocational training, and/or college.

Limitations

Several limitations should be considered when interpreting the results of the current study. First, because stable baselines were not established, valid, positive conclusions in support of the hypotheses cannot be given. This arose from moving participants into intervention too quickly due to time constraints imposed by the approach of the end of the school year. For this very reason, maintenance data were not collected. Thus, the extent to which Rachel maintained gains in math computation fluency following her participation in the study is unclear. Second, IOA results for DCP2M and TPC2M were lower than desired, suggesting inconsistency between data collectors and independent coders. This is a significant limitation in that it is unclear to what extent behavior change, or lack of change, is due to scoring errors.

Third, as previously discussed, the nature and severity of the skill deficits might have attenuated the treatment effects, particularly for Rachel and Renee. It appears that they needed further adjustments to the instructional strategies to strengthen the intervention. Further analysis during the intervention phase revealed that slicing back to a smaller number of problem types was a promising adjustment. But, it may have been too little, too late for producing the kind of generalized performance increases that were sought. Relative increases in performance in the instructional assessments do suggest, however, that there were indeed some improvements. Future studies should use even

more extensive screening procedures for identifying skill deficits and perhaps conduct brief experimental analyses to empirically test intervention components even before student training is initiated (Daly et al., 2010).

Fourth, although the researcher made efforts to provide an appropriate balance between parental involvement and support and adolescent autonomy, factors related to the parent-child relationship may have confounded the results to some degree. Prior research suggests that parental involvement and support is not consistently associated with achievement (Hill & Tyson, 2009). That may have been true in this study as well. For example, Renee often reported not wanting to provide her mother with the materials necessary to prompt parental involvement due to alleged psychosocial stressors. In another example, Dustin reported that his mother experienced illness that made it difficult for her to support him in practicing at home, particularly with prompting and monitoring his intervention use. These examples highlight the continued need to address perceived life context (i.e., parents' perceptions of the resources available to them for promoting involvement, such as time and energy, and the skills and knowledge related to involvement; Sheridan & Kratochwill, 2007), which have been identified as influencing the level and type of involvement (Gettinger & Waters-Guetschow, 1998; Lareau, 1989; Leitch & Tangri, 1988).

Fifth, there may be important participant variables that were not taken into account within the context of the current study. In particular, participants represented three different grades, two different sexes, and two different races. The heterogeneity of participant sample makes it difficult to determine which participant variables may have had an impact on the results obtained. For example, prior research has demonstrated that

the relationship between parental involvement and global self-worth (i.e., self-efficacy) differs between boys and girls (e.g., Toren, 2013). Additionally, the relationship between parental involvement and academic achievement has been found to differ depending upon participant-identified ethnicity (e.g., Fan & Chen, 2001; Hill et al., 2004; Hill & Tyson, 2009; Seyfried & Chung, 2002). Future studies should more closely examine variables related to diversity to provide an understanding of how these variables may impact adolescent math academic achievement, parental involvement in adolescent academics, and parental involvement on adolescent academic achievement.

Finally, the current study was carried out in both home and school. The experimenter was minimally involved in the home-based conditions. As such, external validity was emphasized, likely at the expense of internal validity. Specifically, participants were required to choose an intervention that they would practice at home and given the opportunity to choose whether or not to practice. All participants chose to not practice at home at one time or another; however, Dustin chose to not practice at home the majority of the time during the time allocated to practice. Doing so likely impeded his ability to benefit from the interventions offered. This also suggests that while providing a choice of which intervention to use may serve as an establishing operation, it may not be sufficient to promote actual use the intervention in some situations. Moreover, though Rachel and Renee engaged in practice at home, it is unclear to what extent the interventions were used with fidelity as the researcher did not gather information from parents or participants regarding how the interventions were used in the home environment. Thus, similar results may not have been obtained if sessions were

conducted under optimal conditions of administration and/or if the experimenter exerted greater control over them.

Conclusion

This study appears to be the first of its kind in its attempt to determine if high school students can improve their math computation fluency when taught to choose empirically derived instructional components for math computation and subsequently given parental support to implement the intervention(s) of their choice. Given the lack of experimental control and the aforementioned limitations, the results of this study must be interpreted with caution. However, this study highlighted the importance of 1) identifying appropriate instructional antecedents and consequences for establishing stimulus control, 2) providing adolescents with instruction on intervention use, 3) allowing students to choose intervention components, 4) establishing an appropriate balance between parental involvement and support and adolescent autonomy, and 5) determining acceptability of all participants (e.g., parent and adolescent) involved.

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Table 1

% Math active engagement (AE) during student training phase by participant

		<i>M</i>	Standard Deviation
	Total AE	100	0
Rachel	Easy AE	100	0
	Hard AE	100	0
	Total AE	95.4	3.05
Renee	Easy AE	97	0
	Hard AE	93	4.24
	Total AE	80.4	36.17
Dustin	Easy AE	97.7	4.04
	Hard AE	54.5	54.44

Note: Data presented in this table are descriptive. Data are organized by three levels of AE by each participant. Total AE represents overall AE across problem difficulty levels while Easy AE and Hard AE represent AE for each problem difficulty level.

Table 2

Math fluency and accuracy at baseline and parent support phases by participant

		Baseline Phase	Parent Support Phase
Rachel	DCP2M <i>M (SD)</i>	49 (2.65)	57.32 (15.06)
	EP2M <i>M (SD)</i>	18.33 (7.51)	4.88 (3.18)
	TPC <i>M (SD)</i>	20.67 (0.58)	25.94 (7.64)
	Accuracy <i>M (%) (SD)</i>	66.33 (8.14)	86.53 (10.77)
Renee	DCP2M <i>M (SD)</i>	21.64 (7.93)	31.42 (8.40)
	EP2M <i>M (SD)</i>	7.71 (3.60)	12.26 (3.87)
	TPC <i>M (SD)</i>	18.21 (6.76)	24.59 (6.28)
	Accuracy <i>M (%) (SD)</i>	75.07 (11.59)	73.05 (6.22)
Dustin	DCP2M <i>M (SD)</i>	25.65 (9.12)	16.17 (9.75)
	EP2M <i>M (SD)</i>	12.82 (5.14)	8.00 (5.33)
	TPC <i>M (SD)</i>	13.53 (6.33)	9.17 (4.92)
	Accuracy <i>M (%) (SD)</i>	58.36 (16.99)	70.50 (17.21)

Note: Data presented in this table are descriptive. Data represent mean and standard deviation of dependent variables organized by participant and phase.

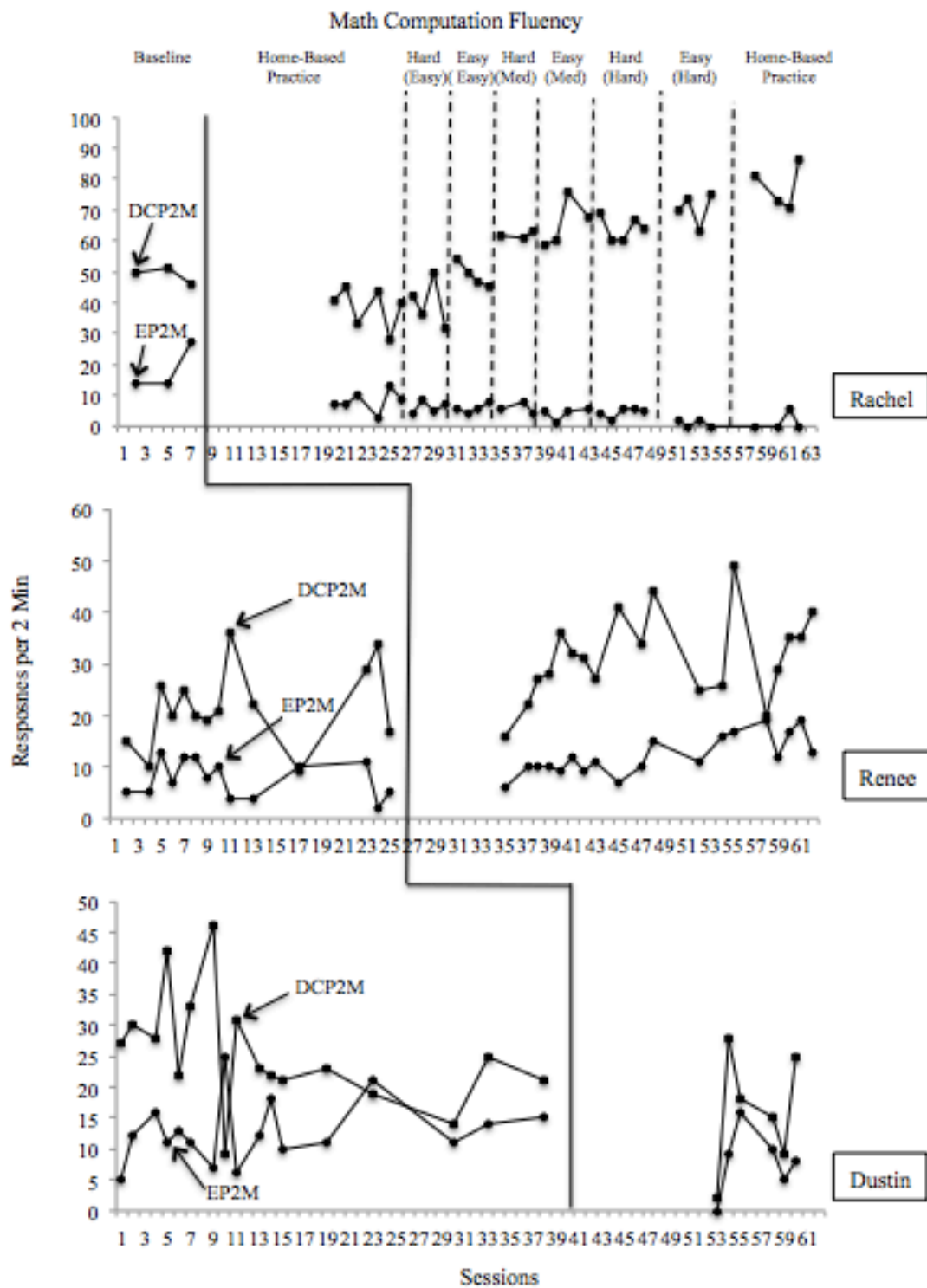


Figure 1. Digits correct per 2 min (DCP2M) and errors per 2 min (EP2M) across participants

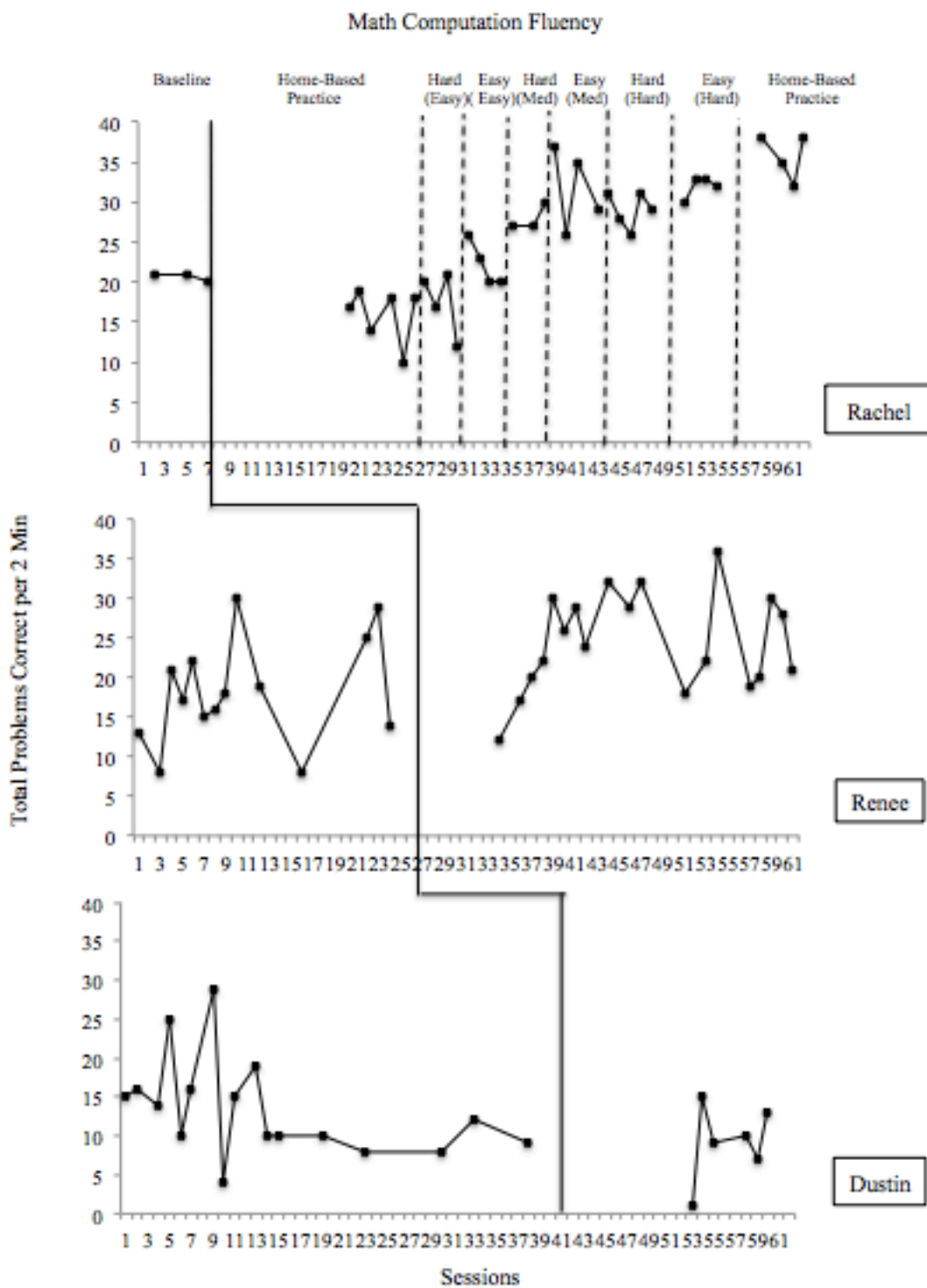


Figure 2. Total problems correct per 2 min (TPC2M) across participants.

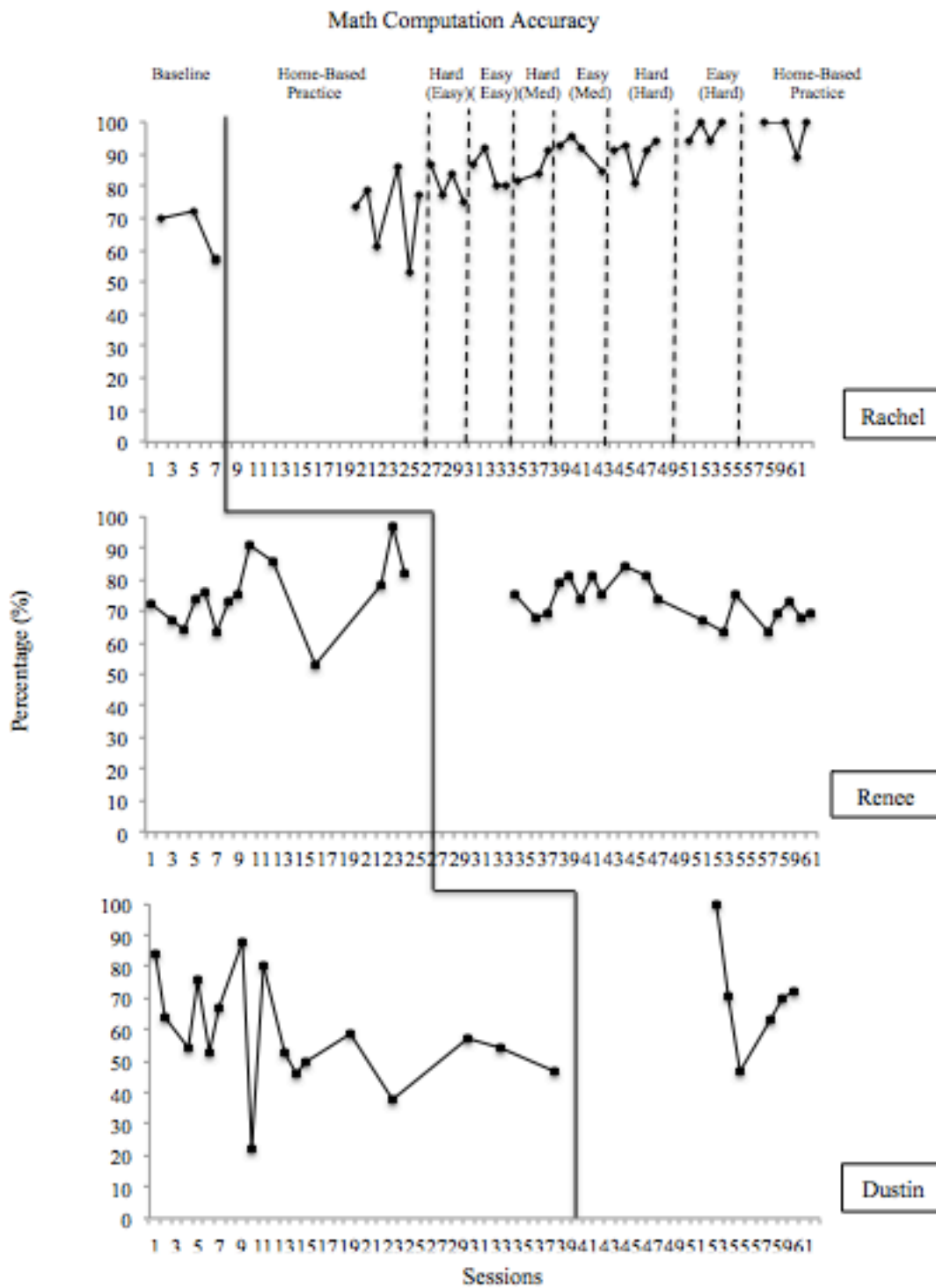


Figure 3. Percent accuracy across participants.

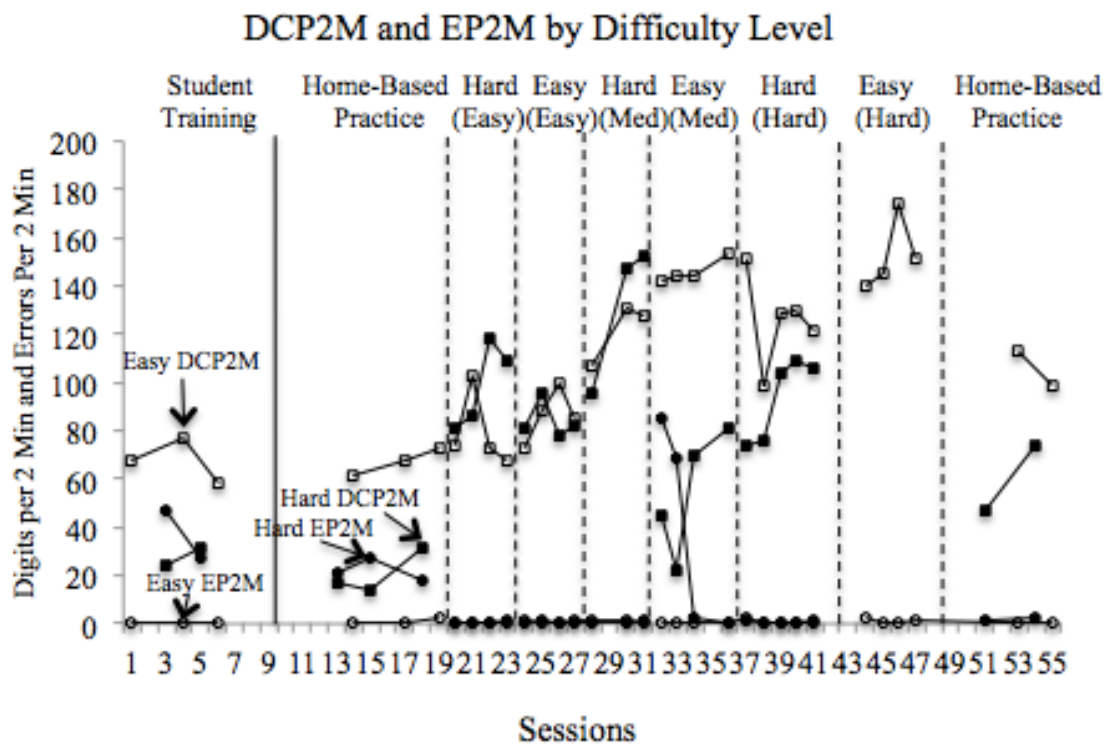


Figure 4. Digits correct per 2 min (DCP2M) and errors per 2 min (EP2M) by difficulty level for Rachel during the student training and home-based practice phases.

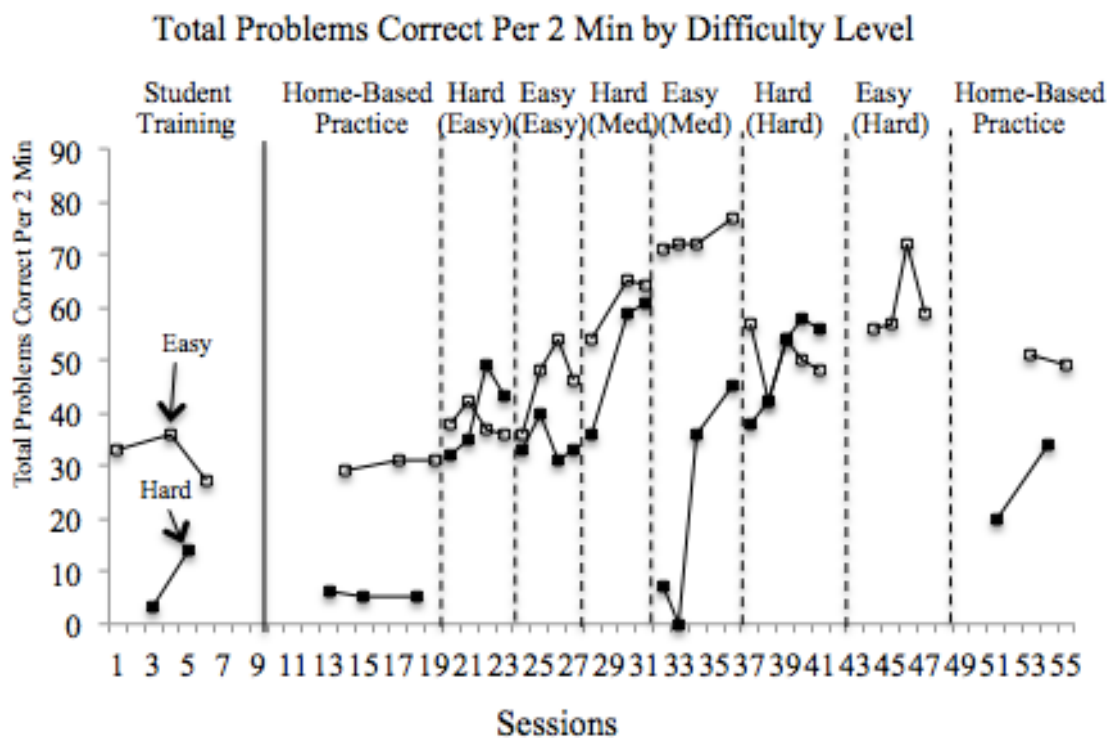


Figure 5. Total problems correct per 2 min by difficulty level for Rachel during the student training and home-based practice phases.

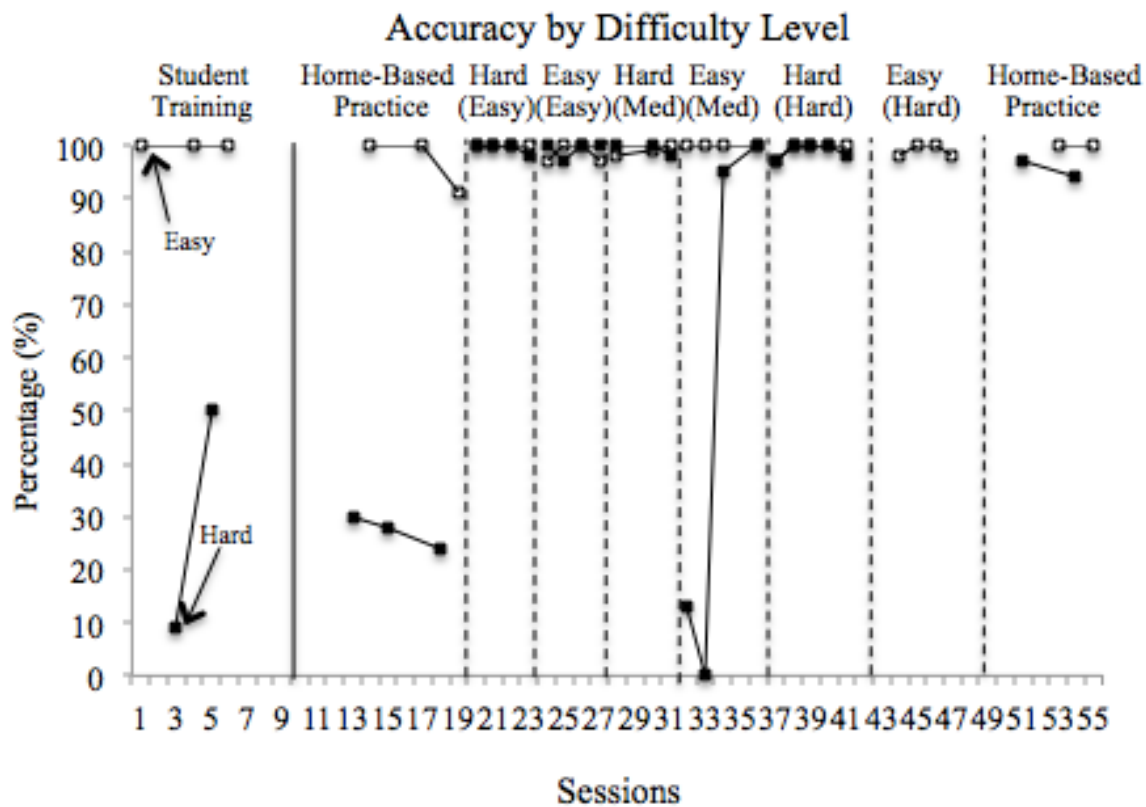


Figure 6. Percent accuracy by difficulty level for Rachel during the student training and home-based practice phases.

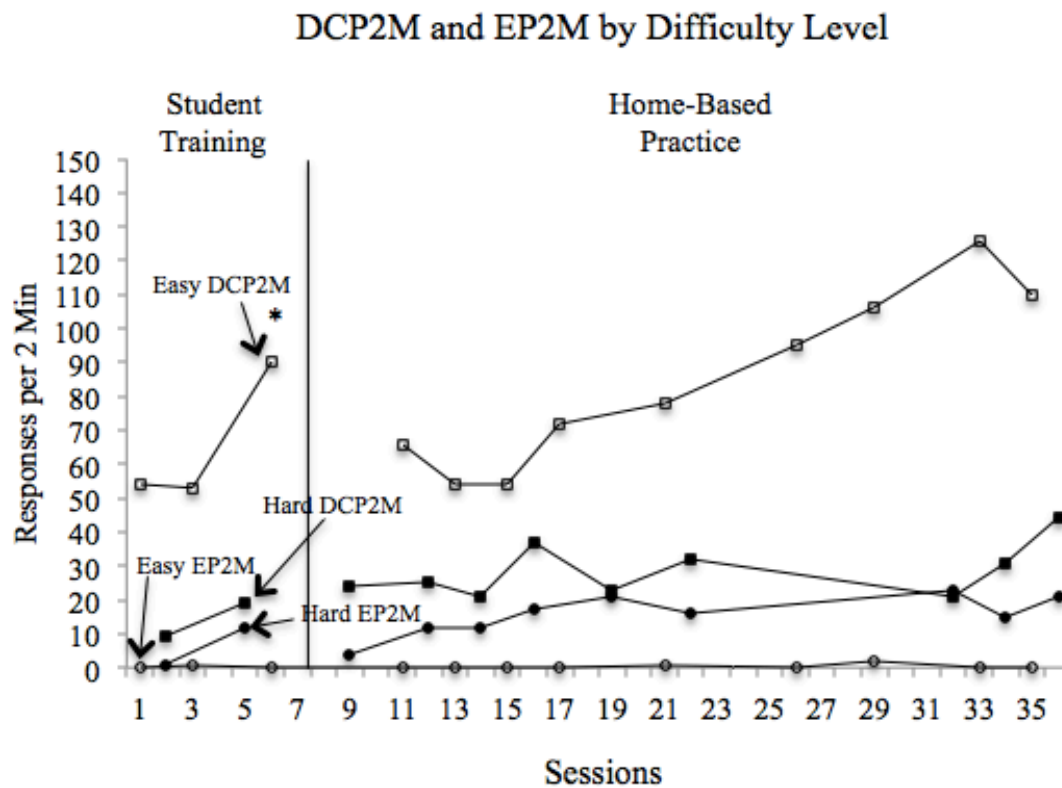


Figure 7. Digits correct per 2 min and errors per 2 min by difficulty level for Renee during the student training and home-based practice phases. Note: the asterisk (*) indicates pro-rated data.

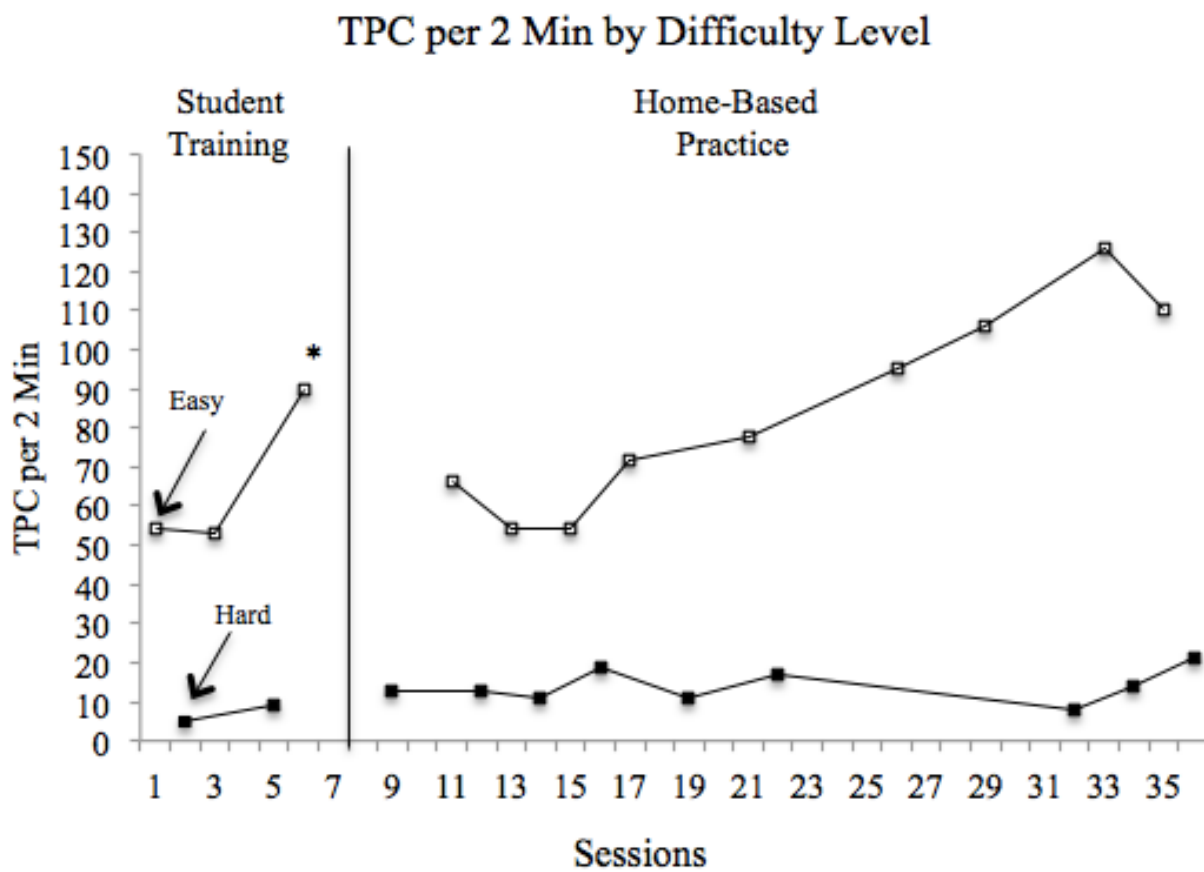


Figure 8. Total problems correct per 2 min by difficulty level for Renee during the student training and home-based practice phases. Note: the asterisk (*) indicates pro-rated data.

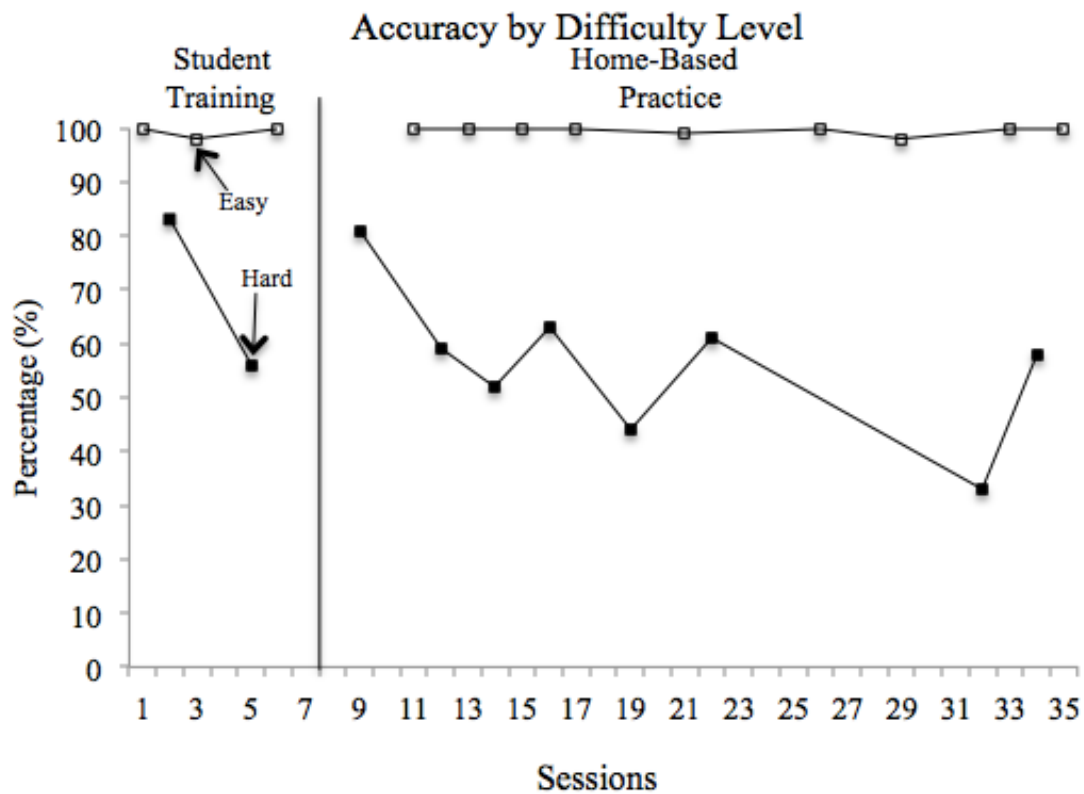


Figure 9. Percent accuracy by difficulty level for Renee during the student training and home-based practice phases. Note: the asterisk (*) indicates pro-rated data.

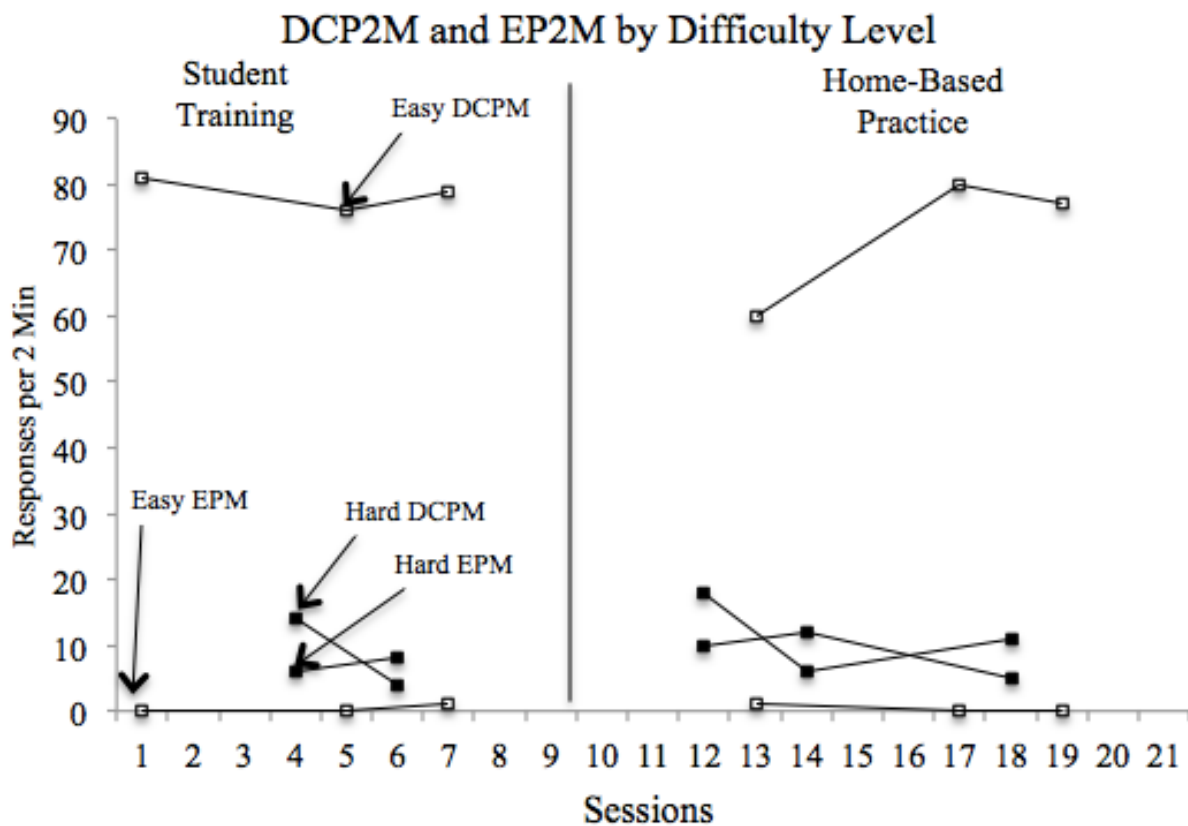


Figure 10. Digits correct per 2 min (DCP2M) and errors per 2 min (EP2M) by difficulty level for Dustin during the student training and home-based practice phases.

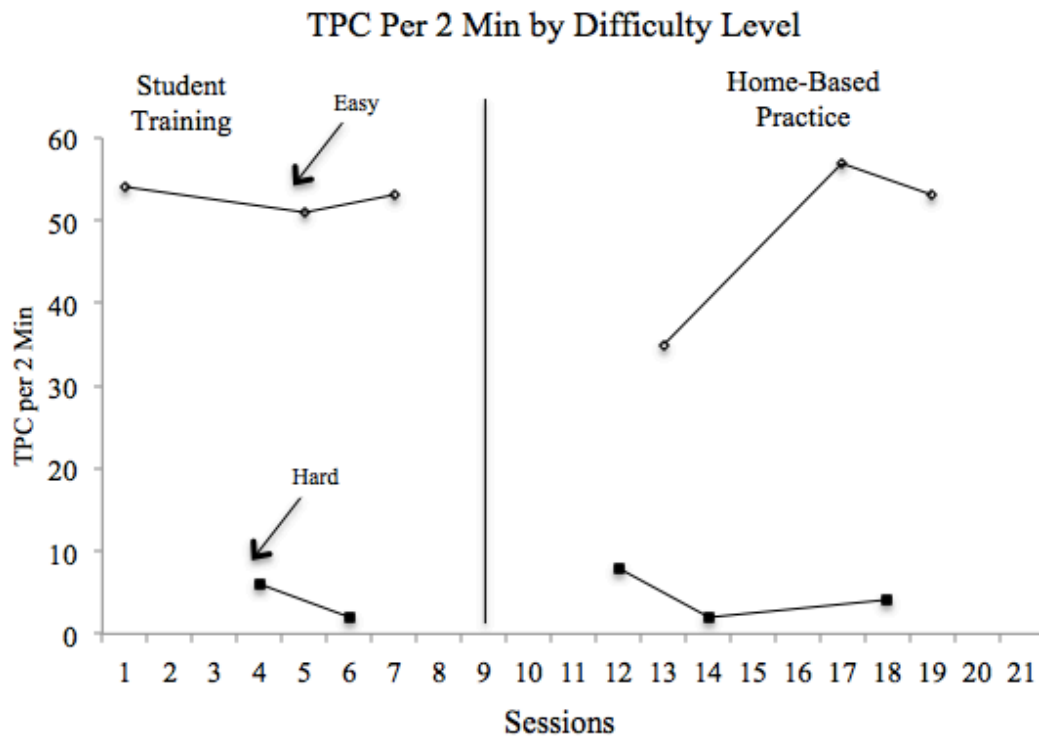


Figure 11. Total problems correct per 2 min (TPC2M) by difficulty level for Dustin during the student training and home-based practice phases.

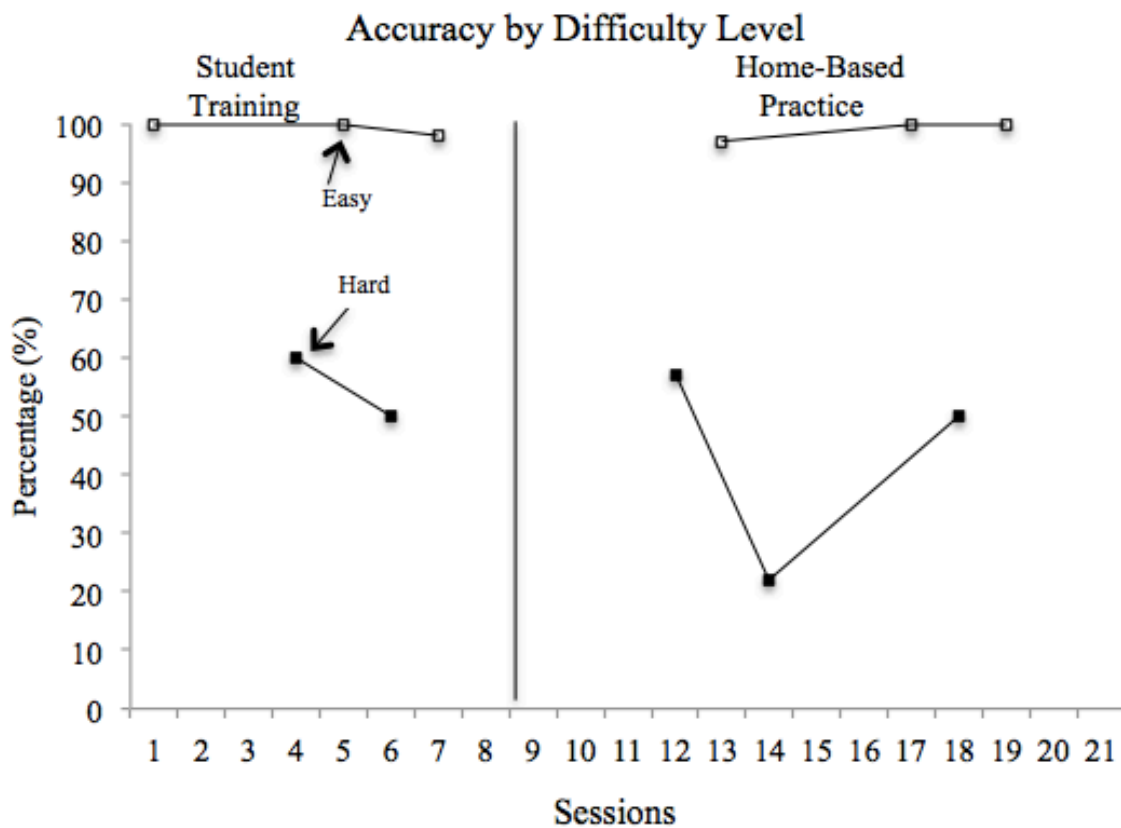


Figure 12. Percent accuracy by difficulty level for Dustin during the student training and home-based practice phases.

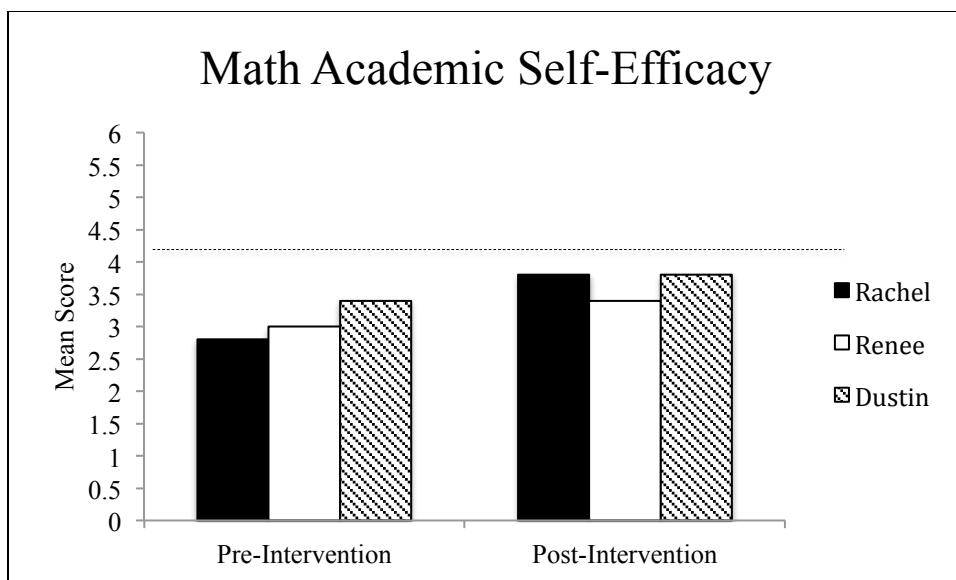


Figure 13. Mean pre- and post-intervention math academic self-efficacy score for each participant. The dashed line represents the average score obtained by Midgley et al. (2000) when conducting psychometric analyses.

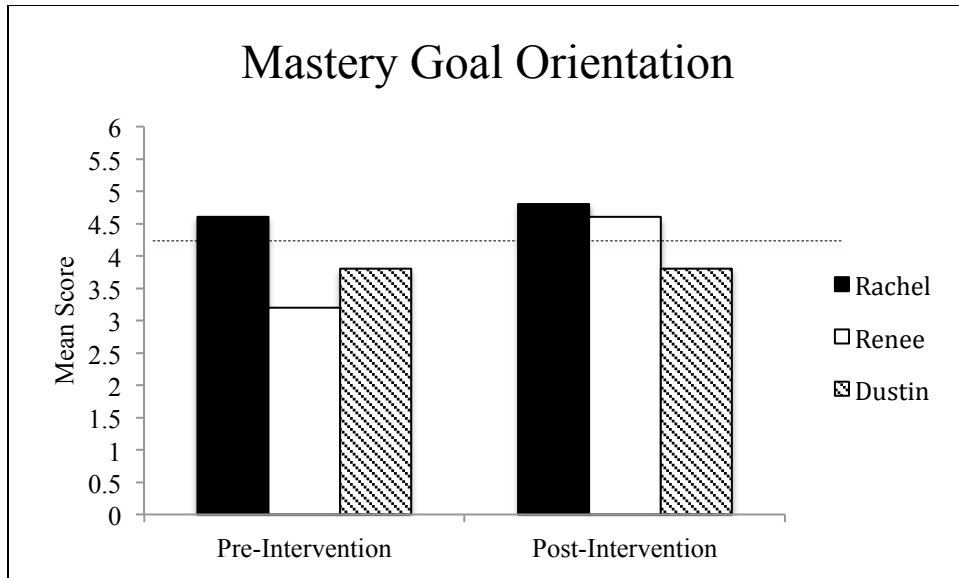


Figure 14. Mean pre- and post-intervention mastery goal orientation score for each participant. The dashed line represents the average score obtained by Midgley et al. (2000) when conducting psychometric analyses.

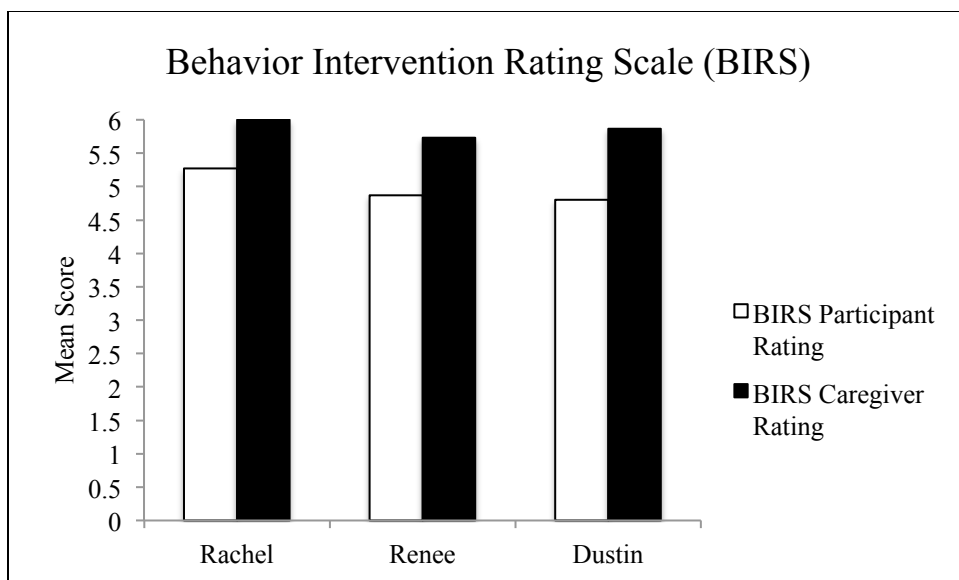


Figure 15. Mean Behavior Intervention Rating Scale (BIRS) scores provided by participants and their caregivers.

Appendix A**Sample Reward Menu**

SUDOKU 1 point	5 MINUTES OF COLORING 1 point
1 GAME OF UNO 2 points	“FANCY” PEN 5 points
HOT CHEETOS 5 points	SPRITE 10 points
PEPSI 10 points	\$5 MCDONALD’S GIFT CARD 15 points

Appendix B

Sample CCC Worksheet

Student: _____	Modeling Error Correction Worksheet	Date: _____
$36 \div 9 = 4$	$36 \div 9 =$	$36 \div 9 =$
$72 \div 9 = 8$	$72 \div 9 =$	$72 \div 9 =$
$24 \div 4 = 6$	$24 \div 4 =$	$24 \div 4 =$
$24 \div 6 = 4$	$24 \div 6 =$	$24 \div 6 =$
$55 \div 5 = 11$	$55 \div 5 =$	$55 \div 5 =$
$15 \div 3 = 5$	$15 \div 3 =$	$15 \div 3 =$
$88 \div 8 = 11$	$88 \div 8 =$	$88 \div 8 =$
$72 \div 8 = 9$	$72 \div 8 =$	$72 \div 8 =$

Appendix C

Sample TFT Worksheet

Student: _____

Timed Practice
Worksheets

Date: _____

$$-6 + -4 =$$

$$-5 + -2 =$$

$$-6 + -8 =$$

$$-4 + -6 =$$

$$-8 + -7 =$$

$$-8 + -9 =$$

$$-3 + -9 =$$

$$-6 + -2 =$$

$$-9 + -2 =$$

$$-3 + -7 =$$

$$-8 + -3 =$$

$$-5 + -5 =$$

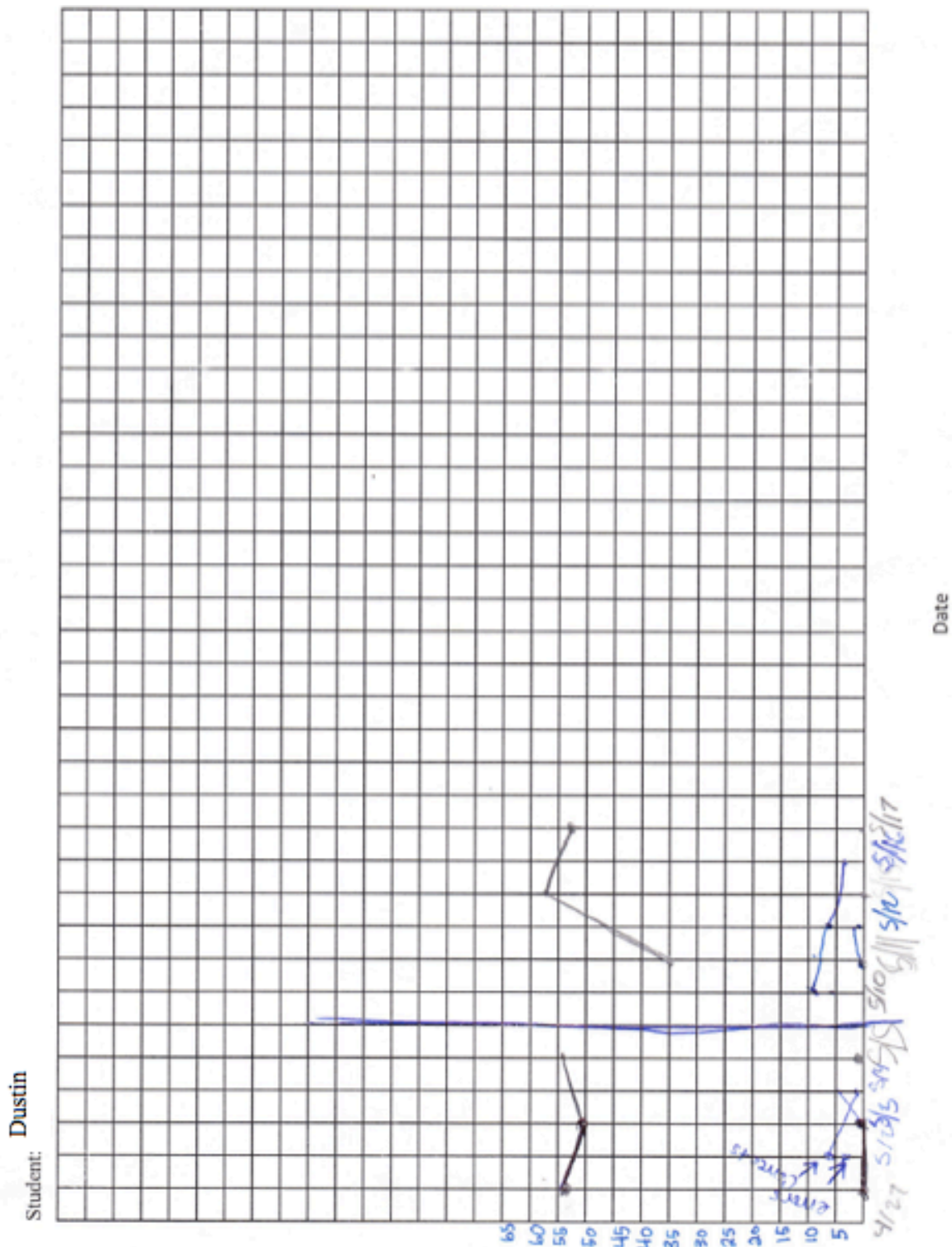
$$-9 + -8 =$$

$$-4 + -8 =$$

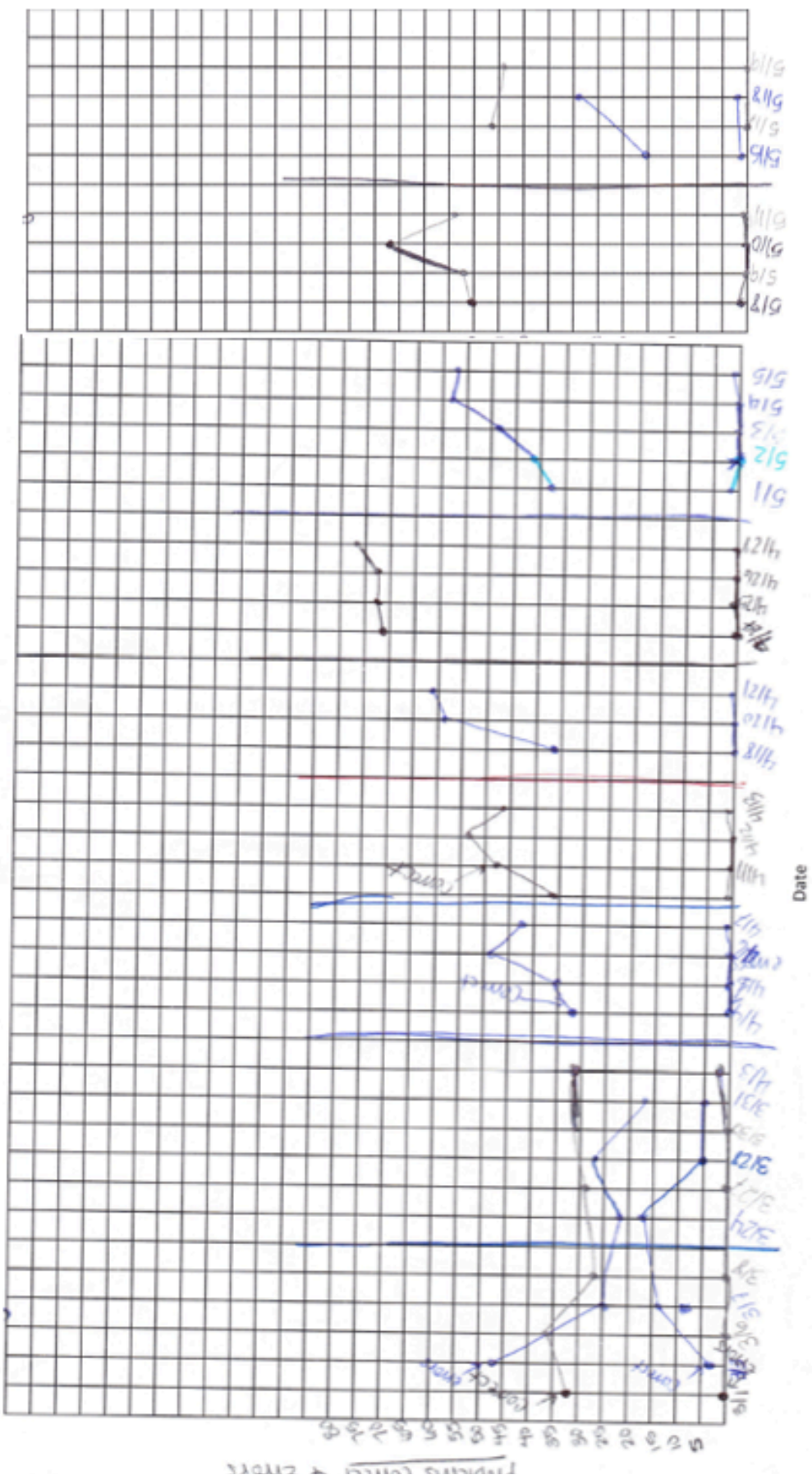
$$-5 + -1 =$$

$$-4 + -8 =$$

Appendix D Participant Graphs

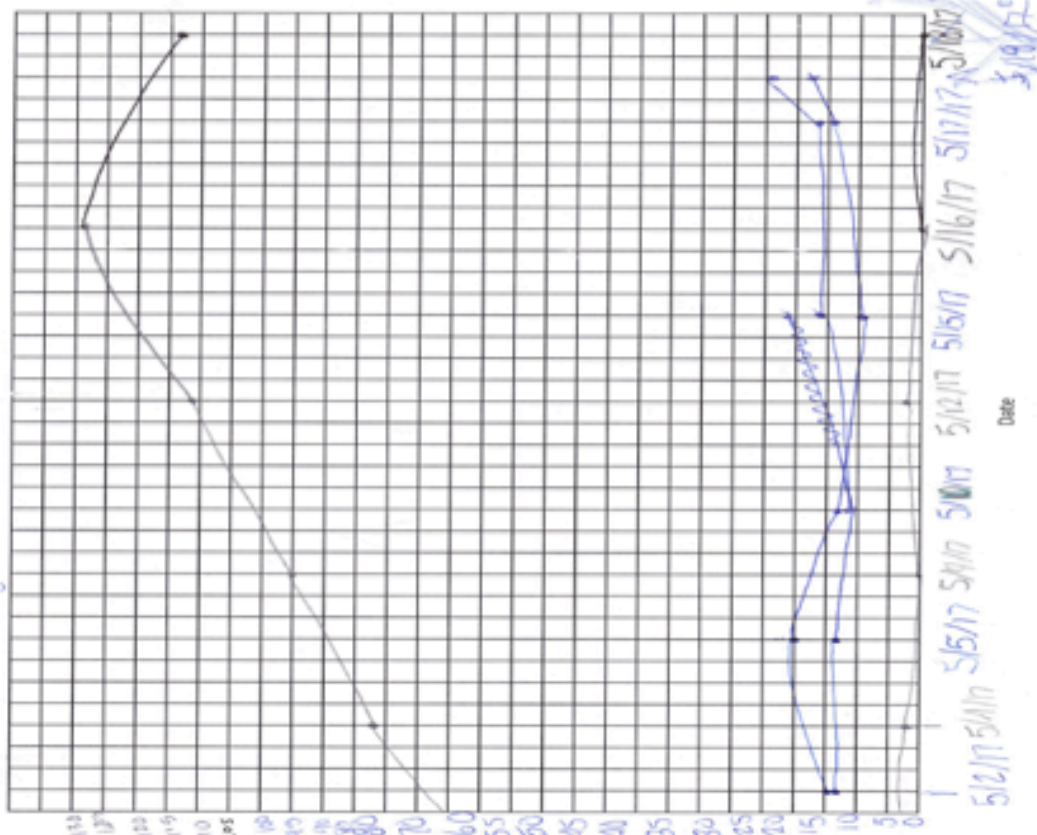
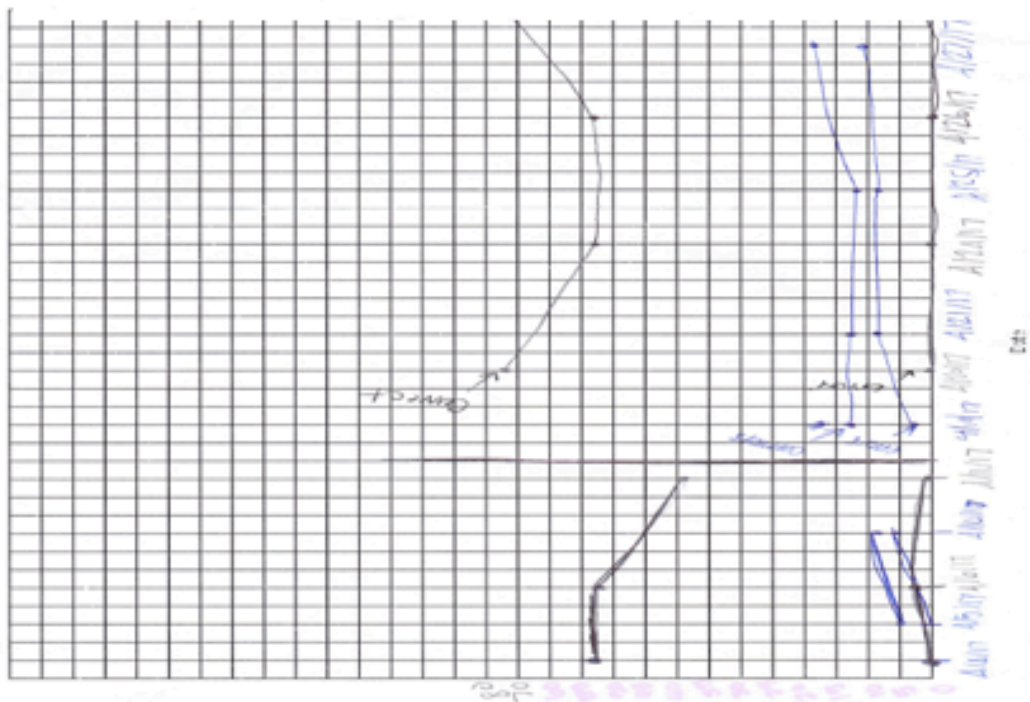


Student Rachel



Renee

Student:



Appendix E

Active Engagement Observation Form

Training Session Observation Form

Student: _____ Date: _____ Observer: _____

Intervention Academic Engagement: The use of any available intervention during the 5-minute time and includes looking at the intervention materials, physically manipulating instructional materials according to directions, writing math problems, or verbally answering math problems (indicated by movement of mouth).

MEC=Modeling & Error Correction; PRAC=Practice (fluency); OT=Off-Task (not engaged in an intervention)

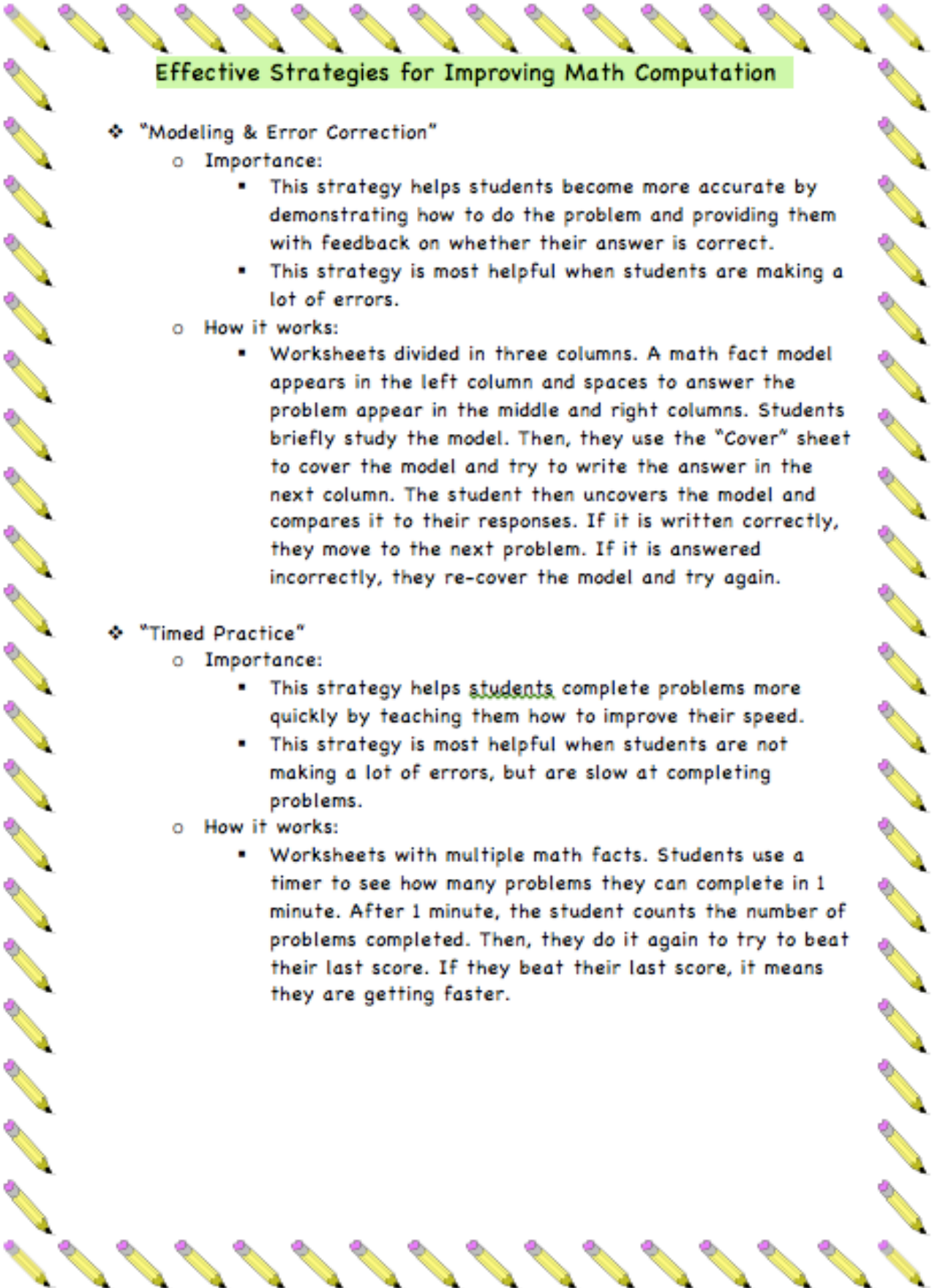
	10	20	30	40	50	1	10	20	30	40	50	2	10	20	30	40	50	3	10	20	30	40	50	4	10	20	30	40	50	5	10	20	30	40	50
MEC																																			
PRAC																																			
OT																																			

Sum MEC Intervals= _____ Total MEC Intervals/30 Observation Intervals= _____ % MEC IAE

Sum PRAC Intervals= _____ Total PRAC Intervals/30 Observation Intervals= _____ % PRAC IAE

Sum OT Intervals= _____ Total OT Intervals/30 Observation Intervals= _____ % OT IAE

Appendix F



Effective Strategies for Improving Math Computation

❖ "Modeling & Error Correction"

○ Importance:

- This strategy helps students become more accurate by demonstrating how to do the problem and providing them with feedback on whether their answer is correct.
- This strategy is most helpful when students are making a lot of errors.

○ How it works:

- Worksheets divided in three columns. A math fact model appears in the left column and spaces to answer the problem appear in the middle and right columns. Students briefly study the model. Then, they use the "Cover" sheet to cover the model and try to write the answer in the next column. The student then uncovers the model and compares it to their responses. If it is written correctly, they move to the next problem. If it is answered incorrectly, they re-cover the model and try again.

❖ "Timed Practice"

○ Importance:

- This strategy helps students complete problems more quickly by teaching them how to improve their speed.
- This strategy is most helpful when students are not making a lot of errors, but are slow at completing problems.

○ How it works:

- Worksheets with multiple math facts. Students use a timer to see how many problems they can complete in 1 minute. After 1 minute, the student counts the number of problems completed. Then, they do it again to try to beat their last score. If they beat their last score, it means they are getting faster.

Appendix G

Supporting Your Adolescent

- * Benefits of parental involvement:
 - o Higher academic achievement
 - o More time on task
 - o Better school attendance

- * Parents are extremely important for helping their adolescents succeed! They can help make sure that adolescents gain the skills necessary for future success as adults in the work force.

- * Helping your adolescent requires a balance between supervision and allowing for independence.
 - o DON'Ts: yell, threaten physical reprimands, be too restrictive in rule setting, or pressure them into activities or ways of doing things.
 - o DO's:
 - Have high academic expectations
 - Allow for independence/autonomy
 - Set general house rules
 - Communicate regularly about school activities and homework

- * Offering appropriate support without becoming overbearing is very important! Creating an encouraging and supportive environment is the best way for helping your adolescent. Here are good strategies for doing that:
 - o Provide an appropriate and consistent setting for homework completion (e.g., dining room, office)
 - o Provide educational materials
 - o Encourage engagement with gentle prompting (e.g., "Now is the time you can work on math")
 - o Offer rewards for practice (e.g., give points towards a big-ticket item for practicing math)
 - o Discuss learning strategies and link homework to adolescent interests and goals (e.g., "You used a strategy that will help you get faster at math, which can help make counting money at the mall easier")
 - o Offer feedback on overall engagement/completion of practice (e.g. "You worked really hard today!")
 - o Promote academic goal attainment (e.g., "Working on this strategy will help you become more accurate and may make it easier for you to do pass math")
 - o Offer choices and calmly explain what will likely happen for each choice (e.g., "Choosing this strategy will help you get faster; on the other hand, choosing this strategy will help you become more accurate.")

Appendix H

Homework Log

Date: _____

- | | | |
|--|-------|----|
| 1. Did NAME practice using her math interventions? | Yes | No |
| 1a. Did NAME <u>begin</u> math practice on her own? | Yes | No |
| 1b. Did you prompt her to practice her math? | Yes | No |
| 2. How long did NAME practice her math? | _____ | |
| 3. Which intervention(s) did NAME use? | _____ | |
| 4. Was feedback provided to NAME on her engagement in math practice? | Yes | No |
| 5. Did you initial NAME's math worksheets? | Yes | No |



Initials _____

Appendix I

Homework Binder Protocol

Materials Needed:

- Homework Log
- “Modeling & Error Correction” Materials
 - Worksheets
 - “Cover” sheet
- “Practice” Materials
 - Timer
 - Worksheets
 - Record Sheet

Steps:

- 1. Ask NAME to share with you what was discussed during her intervention session at school using questions such as:
 - “How did your math session go at school today?”
 - “What did your math graph tell you?”
 - “Which intervention do you think will be most helpful for you today, Modeling & Error Correction or Timed Practice?”
- 2. Prompt NAME to begin her 5-min math practice time by saying, “*Now you have the chance to practice using your interventions to help you get better at math. Remember, practicing here at home will earn you points that you can trade in for a reward at school.*”

- ❑ 3. Allow NAME to practice her math for as long as she would like. While she is practicing, check on her to make sure she is using the intervention(s) correctly.
- ❑ 4. After NAME is finished practicing her math, ...
 - Praise her if she spent any time practicing (e.g. “I’m proud of you for working on your math,” “You worked really hard today,” “Great job practicing your math”)
- ❑ 5. Comment on the strategy she used: Say,
 - *“I noticed that you used ‘Modeling & Error Correction,’ which is a great way to get more accurate.”* OR
 - *“I noticed that you used ‘Timed Practice,’ which is a great way to get faster.”*
 - Check the note to see which strategy is marked. If she used the right strategy, praise her. If she did not use the right strategy, say, *“Remember, lots of errors may mean that you need ‘Modeling & Error Correction.’ Few errors may mean you need ‘Timed Practice.’*
- ❑ 6. End NAME’s math practice time by telling her she will have the chance to practice more math to try and improve her performance as well as earn more points tomorrow.
- ❑ 7. Complete the Homework Log and initial all completed intervention materials in the bottom right-hand corner. Place all materials in their container to be returned to school the next day.

Appendix J

Math Academic Self-Efficacy and Mastery Goal Orientation Measure

Name: _____ Date: _____

This survey helps me to understand your thoughts as a math student. This is not a test and there are no right or wrong answers. The things you tell me on this survey will be kept confidential; no one at home or school will ever see what you put unless you decide to tell them.

The first question is an example. Please circle the number that best describes what you think.

I like strawberry ice cream	1	2	3	4	5
	NOT AT ALL TRUE		SOMEWHAT TRUE		VERY TRUE

Now for the following questions, please circle the number that best describes what you think.

1. One of my goals in math class is to learn as much as I can.	1	2	3	4	5
	NOT AT ALL TRUE		SOMEWHAT TRUE		VERY TRUE

2. I can do even the hardest math if I try.	1	2	3	4	5
	NOT AT ALL TRUE		SOMEWHAT TRUE		VERY TRUE

3. It's important to me that I improve my math skills this year.	1	2	3	4	5
	NOT AT ALL TRUE		SOMEWHAT TRUE		VERY TRUE

4. One of my goals is to master a lot of new math skills this year.	1	2	3	4	5
	NOT AT ALL TRUE		SOMEWHAT TRUE		VERY TRUE

5. I'm certain I can figure out how to do the most difficult math work.	1	2	3	4	5
	NOT AT ALL TRUE		SOMEWHAT TRUE		VERY TRUE

6. I'm certain I can master the math skills taught in class this year.	1	2	3	4	5
	NOT AT ALL TRUE		SOMEWHAT TRUE		VERY TRUE

7. It's important to me that I thoroughly understand my math work.	1	2	3	4	5
	NOT AT ALL TRUE		SOMEWHAT TRUE		VERY TRUE

8. Even if the math work is hard, I can learn it.	1	2	3	4	5
	NOT AT ALL TRUE		SOMEWHAT TRUE		VERY TRUE

9. It's important to me that I learn a lot of new concepts in math this year.	1	2	3	4	5
	NOT AT ALL TRUE		SOMEWHAT TRUE		VERY TRUE

10. I can do almost all the work in math if I don't give up.	1	2	3	4	5
	NOT AT ALL TRUE		SOMEWHAT TRUE		VERY TRUE

Midgley et al. (2000)

Appendix K

Reinforcer Validation Protocol

Reinforcer Validation: Initial Session

Materials and Preparation

- A stack of single-skill math worksheets placed on the desk so they are readily accessible to the student
- Writing utensils for the student and examiner
- Timer

Procedures

- 1. Present the first worksheet to the student saying, ***“Please complete as many math problems as you can in 2 minutes. Start with the problems on this worksheet. When you complete it, take another worksheet from this pile and work on those problems. Do as many as you can in 2 minutes.”***
- 2. Ask the student if he or she has questions. Explain the task as necessary and when you are confident he or she understands the task, say, ***“You can begin”*** and start the timer. If the student asks for help or seeks your attention, say, ***“Just do your best.”***
- 3. At the end of 2 minutes, say ***“Time is up.”*** Collect the worksheets and **score the number of problems completed.**

Reinforcer Validation: Reward Session (Full Menu)

Materials

- A stack of single-skill math worksheets (the same as baseline)
- Reward Menu containing all eight items from the preference assessment
- Index card with criterion number of math problems to earn a reward (see directions below)
- Writing utensils for the student and examiner
- Timer

Preparation

- To select the criterion number of math problems needed to earn a reward, randomly select a number between the following two numbers:
 - (1) the [baseline score + 1] and (2) [the baseline score * 1.5]
 - Randomization can be done through a random number generator app or Microsoft Excel[®]
- Place the index card face down on the desk in front of both the student and you. Do not allow the student to turn it over until step 5.
- Place the reward menu on the table between the student and you.

Procedures

- 1. Say, ***“You can earn a reward for doing math problems this time. At the end of the session, I will turn over this index card. [POINT TO THE INDEX CARD]. If you complete at least as many problems as the number on the other side of this***

card, you will be able to choose a reward from this menu of activities.” [SHOW THE MENU]

- ❑ 2. Present the first worksheet to the student saying, *“Let’s see if you can earn the reward by completing enough math problems in 2 minutes. Start with the problems on this worksheet. When you complete it, take another worksheet from this pile and work on those problems. Do as many as you can in 2 minutes.”*
- ❑ 3. Ask the student if he or she has questions. Explain the task as necessary and when you are confident he or she understands the task, say, *“You can begin”* and start the timer. If the student asks for help or seeks your attention, say, *“Just do your best.”*
- ❑ 4. At the end of 2 minutes, say *“Time is up.”* Collect the worksheets and **score the number of problems completed.**

Performance Feedback and Reward Delivery

- ❑ 5. Tell the student how many problems he or she completed. Turn over the card and state the number for the student, pointing to the card.
 - Compare the criterion to the number completed by the student, pointing out which is larger (the criterion or the number of problems completed by the student) or if they are equivalent.
- ❑ 6. Give feedback to the student saying:
 - Met or exceeded the goal – *“You met the goal and earned the reward. Good job! Pick your reward from the reward menu.”*

- Did not meet the goal- *“I’m sorry, but you did not meet the goal today. You will get another chance to earn a reward of your choice another time.”*
- 7. Deliver the reward or allow access to the chosen activity if the student met the goal.

Appendix L

Student Training Phase Protocol

Materials

- Directions to student
- Audiocassette recorder
- Timer (Practice)
- Modeling and Error Correction (MEC) Materials
- Fluency (PRAC) Materials
- Student Graph

Preparation

- Ask the student to be seated at the table so that you can give instructions.
- As the student is being seated, turn on the audiocassette recorder. State the date and phase being conducted (e.g., Training Session).

Introducing the Training Session

- 1. Say to the student, ***“Over the next few weeks we are going to work together to choose the best ways to help you get better at math. Each day, we are going to talk about strategies you could use to improve your math, practice math problems on worksheets, do a quick math check, and then graph your performance. Using these math strategies during the week will help you later on during assessment day.”***

Presenting Math Strategies

- ❑ 1. Say, *“Let’s first talk about some helpful strategies and rules for you to use when looking at your math performance.”*
- ❑ 2. Review each math strategy with the student and discuss when these strategies would be useful.
 - Say, *“Modeling and Error Correction [DISPLAY MEC MATERIALS TO STUDENT] is a strategy that will help you fix your mistakes. To use this strategy, you cover up the answer here [POINT]. Then, you look here [POINT] for an example of how to do the problem. Then, you try the problem yourself. Once you’ve completed the problem, you uncover the answer and check to see if you made a mistake. If your answer is correct, you can move on to the next problem. If your answer is incorrect, go back and fix your mistake. This strategy is most helpful if you’re making errors.”*
 - Say, *“Timed Practice [DISPLAY PRAC MATERIALS TO STUDENT] is a strategy that helps you to get faster. To use this strategy, you start the timer and see how many problems you can complete in 1 minute. After 1 minute is done, write down the number of correct problems and the number of errors on this sheet here [POINT]. Then you do it again to try and beat your last scores. This strategy is most helpful when you’re getting the right answers. It is not helpful if you’re making errors.”*
 - Say, *“Sometimes you can use more than one strategy at a time. The important thing to remember is that when you’re making a lot of errors,*

Modeling and Error Correction is most helpful and if you're are making very little errors, Practice is most helpful."

Providing Feedback

- 1. Present the graph to the student with the worksheet(s) they completed from two sessions ago. Say, ***“Now, we are going to look at your previous performance and we are also going to look at how your performance changes over time. Let’s start with your performance from two sessions ago. You’re going to work on the same kinds of problems today. Here is how you did.”***
- 2. Say, ***“Two sessions ago, you got ___ problems correct and you made ___ errors when we checked your performance. Which strategy do you think will help you get better at math?”*** Listen to the student’s response and discuss what strategies will be helpful for improving his/her math skills according to whether his/her response is consistent with the results.
 - If the student has 3 or more errors on the worksheet and:
 - States they should use Modeling and Error Correction, say ***“Exactly! You had a lot of errors today. Modeling and Error Correction helps you reduce errors.”***
 - States they should used Practice, say ***“You had a lot of errors that day. Practice does not help fix errors; it helps speed. Modeling and Error Correction would be a better choice.”***
 - If the student has 2 errors or fewer and
 - States they should use Practice, say ***“Exactly! You did not have a lot of errors. Practice helps you get faster.”***
 - States they should use Modeling and Error Correction, say ***“You did not have a lot of errors that day. Modeling and Error***

Correction does not help with speed. Practice would be a better choice.”

- 3. *“Now let's look at how your performance changes over time. We do this by looking at the lines on your graph.”*
 - Say, *“First, we look at the “corrects” line [POINT]. If the lines are going up like this [DEMONSTRATE FOR STUDENT ON SCRATCH PAPER] that means that you are getting better. If the lines are going down like this [DEMONSTRATE FOR STUDENT ON SCRATCH PAPER], that means we might need to try something different to improve your math performance.”*
 - Say, *“Now we look at the “errors” line [POINT]. If the lines are going down like this [DEMONSTRATE FOR STUDENT ON SCRATCH PAPER] that means you are making less errors. If the lines are going up like this [DEMONSTRATE FOR STUDENT ON SCRATCH PAPER], that means we might need to try something different to improve your math performance.”*
- 4. Say, *“Do you think your math performance is getting better? Why or why not?”*
 - Listen to the student’s response and discuss whether performance improved or not according to whether his/her response is consistent with the results. If the response is not consistent, explain why it was or was not helpful according to the results and then say, *“So, now do you think you’re doing better at math? Why?”* Continue to explain the results until the students’ explanation is consistent with the data.

- If the student's math performance is improving, say ***“What rules have helped you improve?”*** Listen to the student's response.
 - If their response is consistent with the following rule (*when you're making a lot of errors, Modeling and Error Correction is most helpful and if you're are making very little errors, Practice is most helpful*), provide praise.
 - If their response is inconsistent with the rule, say, ***“Lots of errors means you need Modeling and Error Correction. Few errors mean you need Practice.”***

Daily Math Practice

- ❑ 1. Place a stack of math worksheets on the desk so they are readily accessible to the student and the experimenter, but are not directly in front of the student, saying to the student ***“Now you have the opportunity to practice using these strategies for five minutes. After you are finished working on the math problems, we will check how it might have helped you, graph your performance, and discuss strategies you can use in the future based on how you did. I am putting different strategies here so you can easily reach them. Are they close enough for you to reach them?”*** If the student says “no,” reposition the strategy binders and ask the question again. When the student replies “yes,” or the equivalent, proceed to the next step.
- ❑ 4. Review Data Record Sheet to determine the type of feedback provided in at the beginning of the session. Then say, ***“Remember, earlier today we discussed _____ as strategies that would be helpful for you.”***
- ❑ 3. Say, ***“During this time you can do these activities as much or as little as you like. While you practice, I’ll be doing paperwork. We’ll end the practice session after 5 minutes.”***
- ❑ 4. While the student is working, observe the student’s intervention active engagement at 10-second intervals using Momentary Time Sampling. If the student asks for help or seeks your attention, say ***“Just do you best.”***
- ❑ 5. At the end of 5 minutes, say ***“Time is up”*** and collect all the materials s/he used and file them appropriately.

Daily Math Check

- ❑ 3. Take the first worksheet from the stack of worksheets and present it to the student saying, ***“Now we are going to check your performance. All of the problems are multiplication facts [DISPLAY FOR STUDENT]. When I say ‘begin,’ take a worksheet from the stack and begin answering the problems. If you don’t know the answer, give your best guess. If you finish one worksheet, select another one and continue. Do you have any questions?”*** If the student says, “no,” proceed to the next step. If the student says, “yes,” answer all questions that s/he has.
- ❑ 5. Say, ***“Okay, begin”*** and start the timer.
 - Supervise the student’s work completion. If the student stops working on problems at any time before 2 minutes are up, say, ***“Please continue working on problems. Do the next problem.”***
- ❑ 6. At the end of 2 minutes, say, stop the timer and say, ***“Time is up.”***
- ❑ 7. Collect all the work the student completed.

Graphing Math Performance

- ❑ 1. Next say, ***“Now we are going to see how well you did.”*** Calculate the number of problems correct and the number of errors during the Daily Math Check. Say, ***“You got ___ problems correct and you made ___ errors.”***
- ❑ 2. Say, ***“Now we are going to track your performance using a graph to plot your scores.”***
 - Ask the student ***“Do you know where your corrects would go on the graph?”***

- If the student verbally or non-verbally indicates they understand how to graph their scores, say ***“Go ahead and plot your corrects and errors on your graph.”*** Check to make sure the student plotted his/her data correctly.
- If the student does not know where her data go on the graph, provide the student with the following instructions:
 - While pointing to the X-axis, say, ***“This side of the graph shows the number of problems.”*** While pointing to the Y-axis say, ***“This side of the graph shows each day you practice your math problems.”***
 - Say, ***“Now we are going write today’s date here [POINT]. Then, we are going to find the number on this side of the graph [POINT TO THE X-AXIS] that matches the number correct. Take one finger and place it there. Now, take your other finger and put it on the date. Push your fingers toward the center of the graph until they meet like this [DEMONSTRATE HOW TO DO THIS TO THE STUDENT]. Put a dot on the graph where your fingers met.”***
 - ***“Now do this with the number of errors you made.”***
 - If there are multiple data points on the graph, say ***“Now that we have more points on our graph, we are going to connect the ‘correct’ dots by drawing a line like this***

[DRAW THE LINE FOR THE STUDENT]. Now you try with the errors.

- For the first few days of this phase, say, ***“We will now do this every day.”***
- Once the student can accurately plot their own data points say, ***“Now go ahead and plot your corrects and errors on your graph.”***

Ending the Session

- Say, ***“Now, based on your graph, which strategy do you think will help you get better at math the next time we work together?”*** Listen to the student’s response and proceed to the next step.
- 2. Say, ***“Okay. When we meet again next time, we will talk about your math performance from today and you will have the opportunity to practice more math problems to try and improve your performance. You may now go back to class.”***
Allow the student to go back to class.
- 3. Record the following information on the Data Record Sheet:
 - Accuracy (# of problems correct/# of problems attempted x 100)
 - Digits correct per minute (DCPM)
 - Errors per minute (EPM)
 - Intervention Active engagement (AE)
 - The type of feedback provided
 - Session date

- Condition

Appendix M

Home-Based Practice Phase Protocol for Rachel

Materials

- Directions to student
- Audiocassette recorder
- Timer (Practice)
- Modeling and Error Correction (MEC) Materials
- Timed Practice (PRAC) Materials
- Student Graph

Preparation

- Ask the student to be seated at the table so that you can give instructions.
- As the student is being seated, turn on the audiocassette recorder. State the date and phase being conducted (e.g., Parent Support).

Introducing the Training Session

- 1. Say to the student, ***“You are now going to have the opportunity to try using your math strategies at home. Each day, we are going to do a quick math check, graph your performance, and briefly review your strategies.. At the end of each day, I will give you all the materials you will need to practice your math at home. If you bring back your math materials the next day showing that you practiced your math using one of the strategies, you will earn points that you can exchange for a reward. Once a week, you will have the opportunity to exchange your points for a reward from***

the reward menu [POINT]. Using these math strategies at home will help you on Reward Day.”

Combined-Difficulty Assessment

- ❑ 1. Say, ***“Now we are going to check your math performance.”***
- ❑ 2. Place a stack of “Assessment” math worksheets on the desk so they are readily accessible to the student and the experimenter but are not directly in front of the student, saying to the student, ***“I am putting math worksheets here so you can easily reach them. Are they close enough for you to reach them?”*** If the student says “no,” reposition the worksheets and ask the question again. When the student replies, “yes,” or the equivalent, follow the next step.
- ❑ 3. Take the first worksheet from the stack of worksheets and present it to the student saying, ***“All of the problems are ___ facts (DISPLAY FOR STUDENT). When I say ‘begin,’ take a worksheet from the stack and begin answering the problems. Start on the first problem on the left on the top row (POINT). Work across and then go to the next row (DEMONSTRATE WITH HAND GESTURES). If you finish one worksheet, select another one and continue. You can choose to do as much or as little work as you would like or nothing at all. Do you have any questions?”*** If the student says, “no,” proceed to the next step. If the student says, “yes,” answer all questions that s/he has.
- ❑ 4. Say, ***“Okay, begin”*** and start the timer. Supervise the student’s work completion. Make sure the student is working in correct order rather than just

picking out the easy ones. If the student is not working in the correct order, say,

“Remember, work across the row before going on to the next one.”

- ❑ 5. At the end of 2 minutes, say, ***“Stop”*** and collect the worksheet(s). Set them aside to be scored after the session is finished.

Awarding Points (Second session and on)

- ❑ 1. Say, ***“Now we are going to see how many points you have. Did you bring back your materials from last night?”***
 - If the student says yes and shows the materials, proceed to step 2.
 - If the student says no or did not bring materials back, say, ***“Remember, if you bring back your completed materials, you can earn points towards a reward.”*** Then, skip to “Daily Math Check” section of the protocol.
- ❑ 2. Count the number of points based on the materials brought back, write them on the “Points Log,” and say, ***“You now have ____ points that can be exchanged on ‘Reward Day.’”***
 - “Homework Log” = 2 points.
 - Demonstrated use of interventions = 1 point

***Reward Day (check the Data Record Sheet prior to completing this portion of the protocol)*

- ❑ 1. If the data record sheet indicates it is Reward Day, complete this section. If it does not, skip and move on to the “Ending the Session” section.

- 2. Say, *“Today is reward day! You have ____ points. If you would like, you can exchange those points for a reward from this reward menu [POINT]. Or, you can choose to save your points for the next Reward Day. Which would you like to do?”*
 - If the student states they want to exchange their points, allow them access to the reward at the end of this session.
 - If the student states they want to wait until the next Reward Day, say, *“Okay, keep up the good job earning points! We will check again next week!”*

Daily Math Check Based on Current “Difficulty of the Week”

- 1. Check the Data Record Sheet for the difficulty of the week. For this assessment, you are going to use the opposite
 - If it is designated as a “Hard” difficulty week, use materials from the “Daily Math Check-Hard” tab.
 - If it is designated as an “Easy” difficulty week, use materials from the “Daily Math Check-Easy” tab.
- 2. Place a stack of “daily math check” worksheets on the desk so they are readily accessible to the student and the experimenter, but are not directly in front of the student, saying to the student, *“Now we are going to check your math progress so we can add data points to your graph. All of the problems are _____ facts [DISPLAY FOR STUDENT]. When I say ‘begin,’ take a worksheet from the stack and begin answering the problems. If you don’t know the answer, give your best guess. If*

you finish one worksheet, select another one and continue. Do you have any questions?" If the student says, "no," proceed to the next step. If the student says, "yes," answer all questions that s/he has.

- ❑ 2. Say, ***"Okay, begin"*** and start the timer.
 - Supervise the student's work completion. Make sure the student is working in correct order rather than just picking out the easy ones. If the student is not working in the correct order, say, ***"Remember, work across the row before going on to the next one."***
- ❑ 3. At the end of 2 minutes, say, stop the timer and say, ***"Time is up."***
- ❑ 4. Collect all the work the student completed.

Graphing Math Performance

- ❑ 1. Next say, ***"Now we are going to see how well you did."*** Calculate the number of problems correct and the number of errors during the Daily Math Check. Say, ***"You got ___ problems correct and you made ___ errors."***
- ❑ 2. Say, ***"Now we are going to track your performance using a graph to plot your scores."***
 - Ask the student ***"Do you remember where your corrects would go on the graph?"***
 - If the student verbally or non-verbally indicates they understand how to graph their scores, say ***"Go ahead and plot your corrects and errors on your graph."*** Check to make sure the student plotted his/her data correctly.

- If the student does not know where her data go on the graph, provide the student with the following instructions:
 - While pointing to the X-axis, say, ***“This side of the graph shows the number of problems.”*** While pointing to the Y-axis say, ***“This side of the graph shows each day you practice your math problems.”***
 - Say, ***“Now we are going write today’s date here [POINT]. Then, we are going to find the number on this side of the graph [POINT TO THE X-AXIS] that matches the number correct. Take one finger and place it there. Now, take your other finger and put it on the date. Push your fingers toward the center of the graph until they meet like this [DEMONSTRATE HOW TO DO THIS TO THE STUDENT]. Put a dot on the graph where your fingers met.”***
 - ***“Now do this with the number of errors you made.”***
 - If there are multiple data points on the graph, say ***“Now that we have more points on our graph, we are going to connect the ‘correct’ dots by drawing a line like this [DRAW THE LINE FOR THE STUDENT]. Now you try with the errors.”***
 - For the first few days of this phase, say, ***“We will now do this every day.”***

- Once the student can accurately plot their own data points say,
“Now go ahead and plot your corrects and errors on your graph.”
- 3. Say, ***“Based on your scores today, which strategy do you think will help you get better at math?”*** Listen to the student’s response and discuss what strategies will be helpful for improving his/her math skills according to whether his/her response is consistent with the results.
 - If the student has 3 or more errors on the worksheet and:
 - States they should use Modeling and Error Correction, say
“Exactly! You had a lot of errors today. Modeling and Error Correction helps you reduce errors.”
 - States they should used Practice, say ***“You had a lot of errors that day. Practice does not help fix errors; it helps speed. Modeling and Error Correction would be a better choice.”***
 - If the student has 2 errors or fewer and
 - States they should use Practice, say ***“Exactly! You did not have a lot of errors. Practice helps you get faster.”***
 - States they should use Modeling and Error Correction, say ***“You did not have a lot of errors that day. Modeling and Error Correction does not help with speed. Practice would be a better choice.”***
- 4. ***“Now let's look at how your performance changes over time. We do this by looking at the lines on your graph.”***

- Say, *“First, we look at the “corrects” line [POINT]. If the lines are going up like this [DEMONSTRATE FOR STUDENT ON SCRATCH PAPER] that means that you are getting better. If the lines are going down like this [DEMONSTRATE FOR STUDENT ON SCRATCH PAPER], that means we might need to try something different to improve your math performance.”*
- Say, *“Now we look at the “errors” line [POINT]. If the lines are going down like this [DEMONSTRATE FOR STUDENT ON SCRATCH PAPER] that means you are making less errors. If the lines are going up like this [DEMONSTRATE FOR STUDENT ON SCRATCH PAPER], that means we might need to try something different to improve your math performance.”*
- 5. Say, *“Do you think your math performance is getting better? Why or why not?”*
 - Listen to the student’s response and discuss whether performance improved or not according to whether his/her response is consistent with the results. If the response is not consistent, explain why it was or was not helpful according to the results and then say, *“So, now do you think you’re doing better at math? Why?”* Continue to explain the results until the students’ explanation is consistent with the data.
 - If the student’s math performance is improving, say *“What rules have helped you improve?”* Listen to the student’s response.
 - If their response is consistent with the following rule (*when you’re making a lot of errors, Modeling and Error Correction is most*

helpful and if you're are making very little errors, Practice is most helpful), provide praise.

Daily Math Check Based on Upcoming "Difficulty of the Week"

- ❑ 1. Check the Data Record Sheet for the difficulty of the week. For this assessment, you are going to use the opposite

 - If it is designated as a "Hard" difficulty week, use materials from the "Daily Math Check-Hard" tab.
 - If it is designated as an "Easy" difficulty week, use materials from the "Daily Math Check-Easy" tab.

- ❑ 2. Place a stack of "daily math check" worksheets on the desk so they are readily accessible to the student and the experimenter, but are not directly in front of the student, saying to the student, ***"Now we are going to check your math progress so we can add data points to your graph. All of the problems are _____ facts [DISPLAY FOR STUDENT]. When I say 'begin,' take a worksheet from the stack and begin answering the problems. If you don't know the answer, give your best guess. If you finish one worksheet, select another one and continue. Do you have any questions?"*** If the student says, "no," proceed to the next step. If the student says, "yes," answer all questions that s/he has.

- ❑ 2. Say, ***"Okay, begin"*** and start the timer.

 - Supervise the student's work completion. Make sure the student is working in correct order rather than just picking out the easy ones. If the

student is not working in the correct order, say, ***“Remember, work across the row before going on to the next one.”***

- ❑ 3. At the end of 2 minutes, say, stop the timer and say, ***“Time is up.”***
- ❑ 4. Collect all the work the student completed.

Ending the Session

- ❑ 1. Say, ***“Now, based on your graph we looked at earlier, which strategy do you think will help you get better at math when you practice at home?”*** Listen to the student’s response and proceed to the next step.
- ❑ 2. Put together the following materials to hand to participant:
 - Place Easy or Hard (see Data Record Sheet for which difficulty to send home) worksheets in respective MEC or PRAC binders
 - Homework Log
- ❑ 3. Say, ***“Okay. Now I am handing you all of the materials you will need if you choose to practice at home tonight, including the worksheet your parent will need. Remember, if you bring these materials back to me tomorrow, you will earn points that you can exchange for a reward on reward day. When we meet again next time, we will count your points, check your math performance, look at your graph, and maybe earn a reward.”***
 - If it is not Reward Day say, ***“You may now go back to class.”*** Allow the student to go back to class.
 - If it is Reward Day and
 - The student earned a reward, allow them access to that reward.

- The student did not choose/earn a reward, say, “*You may now go back to class.*”
- ❑ 4. Record the following information on the Data Record Sheet:
- “Assessment” Data
 - Accuracy (# of problems correct/# of problems attempted x 100)
 - Digits correct per minute (DCPM)
 - Errors per minute (EPM)
 - “Daily Math Check” Data
 - Accuracy (# of problems correct/# of problems attempted x 100)
 - Digits correct per minute (DCPM)
 - Errors per minute (EPM)
 - The intervention that should have been used
 - Session date

Home-Based Practice Phase Protocol for Renee and Dustin

Materials

- Directions to student
- Audiocassette recorder
- Timer (Practice)
- Modeling and Error Correction (MEC) Materials
- Timed Practice (PRAC) Materials
- Student Graph

Preparation

- Ask the student to be seated at the table so that you can give instructions.
- As the student is being seated, turn on the audiocassette recorder. State the date and phase being conducted (e.g., Parent Support).

Introducing the Training Session

- 1. Say to the student, ***“You are now going to have the opportunity to try using your math strategies at home. Each day, we are going to do a quick math check, graph your performance, and briefly review your strategies.. At the end of each day, I will give you all the materials you will need to practice your math at home. If you bring back your math materials the next day showing that you practiced your math using one of the strategies, you will earn points that you can exchange for a reward. Once a week, you will have the opportunity to exchange your points for a reward from***

the reward menu [POINT]. Using these math strategies at home will help you on Reward Day.”

Combined-Difficulty Assessment

- ❑ 1. Say, ***“Now we are going to check your math performance.”***
- ❑ 2. Place a stack of “Assessment” math worksheets on the desk so they are readily accessible to the student and the experimenter but are not directly in front of the student, saying to the student, ***“I am putting math worksheets here so you can easily reach them. Are they close enough for you to reach them?”*** If the student says “no,” reposition the worksheets and ask the question again. When the student replies, “yes,” or the equivalent, follow the next step.
- ❑ 3. Take the first worksheet from the stack of worksheets and present it to the student saying, ***“All of the problems are ___ facts (DISPLAY FOR STUDENT). When I say ‘begin,’ take a worksheet from the stack and begin answering the problems. Start on the first problem on the left on the top row (POINT). Work across and then go to the next row (DEMONSTRATE WITH HAND GESTURES). If you finish one worksheet, select another one and continue. You can choose to do as much or as little work as you would like or nothing at all. Do you have any questions?”*** If the student says, “no,” proceed to the next step. If the student says, “yes,” answer all questions that s/he has.
- ❑ 4. Say, ***“Okay, begin”*** and start the timer. Supervise the student’s work completion. Make sure the student is working in correct order rather than just

picking out the easy ones. If the student is not working in the correct order, say,

“Remember, work across the row before going on to the next one.”

- ❑ 5. At the end of 2 minutes, say, ***“Stop”*** and collect the worksheet(s). Set them aside to be scored after the session is finished.

Awarding Points (Second session and on)

- ❑ 1. Say, ***“Now we are going to see how many points you have. Did you bring back your materials from last night?”***
 - If the student says yes and shows the materials, proceed to step 2.
 - If the student says no or did not bring materials back, say, ***“Remember, if you bring back your completed materials, you can earn points towards a reward.”*** Then, skip to “Daily Math Check” section of the protocol.
- ❑ 2. Count the number of points based on the materials brought back, write them on the “Points Log,” and say, ***“You now have ____ points that can be exchanged on ‘Reward Day.’”***
 - “Homework Log” = 2 points.
 - Demonstrated use of interventions = 1 point

***Reward Day (check the Data Record Sheet prior to completing this portion of the protocol)*

- ❑ 1. If the data record sheet indicates it is Reward Day, complete this section. If it does not, skip and move on to the “Ending the Session” section.

- 2. Say, ***“Today is reward day! You have ____ points. If you would like, you can exchange those points for a reward from this reward menu [POINT]. Or, you can choose to save your points for the next Reward Day. Which would you like to do?”***
- If the student states they want to exchange their points, allow them access to the reward at the end of this session.
 - If the student states they want to wait until the next Reward Day, say, ***“Okay, keep up the good job earning points! We will check again next week!”***

Daily Math Check

- 1. Place a stack of “daily math check” worksheets on the desk so they are readily accessible to the student and the experimenter, but are not directly in front of the student, saying to the student, ***“Now we are going to check your math progress so we can add data points to your graph. All of the problems are _____ facts [DISPLAY FOR STUDENT]. When I say ‘begin,’ take a worksheet from the stack and begin answering the problems. If you don’t know the answer, give your best guess. If you finish one worksheet, select another one and continue. Do you have any questions?”*** If the student says, “no,” proceed to the next step. If the student says, “yes,” answer all questions that s/he has.
- 2. Say, ***“Okay, begin”*** and start the timer.
- Supervise the student’s work completion. Make sure the student is working in correct order rather than just picking out the easy ones. If the

student is not working in the correct order, say, ***“Remember, work across the row before going on to the next one.”***

- ❑ 3. At the end of 2 minutes, say, stop the timer and say, ***“Time is up.”***
- ❑ 4. Collect all the work the student completed.

Graphing Math Performance

- ❑ 1. Next say, ***“Now we are going to see how well you did.”*** Calculate the number of problems correct and the number of errors during the Daily Math Check. Say, ***“You got ___ problems correct and you made ___ errors.”***
- ❑ 2. Say, ***“Now we are going to track your performance using a graph to plot your scores.”***
 - Ask the student ***“Do you remember where your corrects would go on the graph?”***
 - If the student verbally or non-verbally indicates they understand how to graph their scores, say ***“Go ahead and plot your corrects and errors on your graph.”*** Check to make sure the student plotted his/her data correctly.
 - If the student does not know where her data go on the graph, provide the student with the following instructions:
 - While pointing to the X-axis, say, ***“This side of the graph shows the number of problems.”*** While pointing to the Y-axis say, ***“This side of the graph shows each day you practice your math problems.”***

- Say, *“Now we are going write today’s date here [POINT]. Then, we are going to find the number on this side of the graph [POINT TO THE X-AXIS] that matches the number correct. Take one finger and place it there. Now, take your other finger and put it on the date. Push your fingers toward the center of the graph until they meet like this [DEMONSTRATE HOW TO DO THIS TO THE STUDENT]. Put a dot on the graph where your fingers met.”*
 - *“Now do this with the number of errors you made.”*
 - If there are multiple data points on the graph, say *“Now that we have more points on our graph, we are going to connect the ‘correct’ dots by drawing a line like this [DRAW THE LINE FOR THE STUDENT]. Now you try with the errors.”*
 - For the first few days of this phase, say, *“We will now do this every day.”*
 - Once the student can accurately plot their own data points say, *“Now go ahead and plot your corrects and errors on your graph.”*
- 3. Say, *“Based on your scores today, which strategy do you think will help you get better at math?”* Listen to the student’s response and discuss what strategies will be

helpful for improving his/her math skills according to whether his/her response is consistent with the results.

- If the student has 3 or more errors on the worksheet and:
 - States they should use Modeling and Error Correction, say ***“Exactly! You had a lot of errors today. Modeling and Error Correction helps you reduce errors.”***
 - States they should use Practice, say ***“You had a lot of errors that day. Practice does not help fix errors; it helps speed. Modeling and Error Correction would be a better choice.”***
 - If the student has 2 errors or fewer and
 - States they should use Practice, say ***“Exactly! You did not have a lot of errors. Practice helps you get faster.”***
 - States they should use Modeling and Error Correction, say ***“You did not have a lot of errors that day. Modeling and Error Correction does not help with speed. Practice would be a better choice.”***
- 4. ***“Now let's look at how your performance changes over time. We do this by looking at the lines on your graph.”***
- Say, ***“First, we look at the “corrects” line [POINT]. If the lines are going up like this [DEMONSTRATE FOR STUDENT ON SCRATCH PAPER] that means that you are getting better. If the lines are going down like this [DEMONSTRATE FOR STUDENT ON SCRATCH***

PAPER], that means we might need to try something different to improve your math performance.”

- Say, “Now we look at the “errors” line [POINT]. If the lines are going down like this [DEMONSTRATE FOR STUDENT ON SCRATCH PAPER] that means you are making less errors. If the lines are going up like this [DEMONSTRATE FOR STUDENT ON SCRATCH PAPER], that means we might need to try something different to improve your math performance.”
- 5. Say, “Do you think your math performance is getting better? Why or why not?”
 - Listen to the student’s response and discuss whether performance improved or not according to whether his/her response is consistent with the results. If the response is not consistent, explain why it was or was not helpful according to the results and then say, “So, now do you think you’re doing better at math? Why?” Continue to explain the results until the students’ explanation is consistent with the data.
 - If the student’s math performance is improving, say “What rules have helped you improve?” Listen to the student’s response.
 - If their response is consistent with the following rule (*when you’re making a lot of errors, Modeling and Error Correction is most helpful and if you’re are making very little errors, Practice is most helpful*), provide praise.

Ending the Session

- ❑ 1. Say, ***“Now, based on your graph, which strategy do you think will help you get better at math when you practice at home?”*** Listen to the student’s response and proceed to the next step.
- ❑ 2. Put together the following materials to hand to participant:
 - Place Easy or Hard (see Data Record Sheet for which difficulty to send home) worksheets in respective MEC or PRAC binders
 - Homework Log
- ❑ 3. Say, ***“Okay. Now I am handing you all of the materials you will need if you choose to practice at home tonight, including the worksheet your parent will need. Remember, if you bring these materials back to me tomorrow, you will earn points that you can exchange for a reward on reward day. When we meet again next time, we will count your points, check your math performance, look at your graph, and maybe earn a reward.”***
 - If it is not Reward Day say, ***“You may now go back to class.”*** Allow the student to go back to class.
 - If it is Reward Day and
 - The student earned a reward, allow them access to that reward.
 - The student did not choose/earn a reward, say, ***“You may now go back to class.”***
- ❑ 4. Record the following information on the Data Record Sheet:
 - “Assessment” Data
 - Accuracy (# of problems correct/# of problems attempted x 100)
 - Digits correct per minute (DCPM)

- Errors per minute (EPM)
- “Daily Math Check” Data
 - Accuracy (# of problems correct/# of problems attempted x 100)
 - Digits correct per minute (DCPM)
 - Errors per minute (EPM)
- The intervention that should have been used
- Session date