EFFECTS OF RESPONSE OPTIONS ON THE MATHEMATICS PERFORMANCE OF SECONDARY STUDENTS WITH EMOTIONAL OR BEHAVIORAL DISORDERS

by

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DEDICATION

To my grandparents, Mr. and Mrs. Robert L. Lowry

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ABSTRACT

EFFECTS OF RESPONSE OPTIONS ON THE MATHEMATICS PERFORMANCE OF SECONDARY STUDENTS WITH EMOTIONAL OR BEHAVIORAL DISORDERS

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George Mason University, 2012

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Active participation is the hallmark of instructional accomplishment. Teachers have long sought ways of encouraging more active responding on the part of their students to increase achievement and also to decrease behavioral problems in the classroom. The literature regarding “Opportunities to Respond” (OTR) describes a variety of options including response cards and, more recently, technology-based response systems. Although the technology-based systems are increasingly popular they may exceed the budgetary limitations of many schools. Nevertheless, if technology-based response systems afforded superior engagement and outcomes to similar systems that did not rely on technology, they may be worth the investment. Presently, no evaluations of technology-based response systems compared with other OTR methods appear in the literature. Therefore, the present study examined the effects of response options (traditional responding, response cards, response systems) on the mathematics achievement, participation, and time on-task of secondary students with emotional or behavioral disorders (EBD).

Thirty-three students with EBD attending an urban high school and their teachers participated in the study. Each student completed three, grade level units of instruction that were created to be equivalent difficulty and scripted to control for presentation differences. Using a quasi-experimental crossover design, classrooms were assigned to treatment conditions in random order. Conditions included a traditional responding (hand-raising) condition, a response card condition in which students wrote responses on large wipe-of boards, and a technology-based (Clicker) system in which each student responded to a multiple choice option using an individual selection tool. At the end of each one-week instructional unit, students completed an immediate test of the target material. Additionally, each student also completed a one week delayed test for each unit of instruction. Results indicated that the use of response cards (white boards) and systems (Clickers) both significantly increased student's math achievement, participation as well time on task compared to the traditional hand-raising condition. Further, the use of response cards resulted in significant increases in achievement and response accuracy above those found when using response systems. Social validity data indicated that students and teachers felt they benefited from the use of response cards and Clickers. Limitations, discussions, and implications for practice and future research are presented.

1. INTRODUCTION

This chapter provides an overview of the identification and characteristics of students with emotional or behavioral disorders (EBD). Next, academic, social, and behavioral characteristics of students with EBD are presented. Finally, study objectives and rationale are provided.

Identification of Students with Behavioral Problems

The Individuals with Disabilities Improvement Act (U.S. Department of Education, 2007) defines an "emotional disturbance" as:

(i) The term refers to a condition exhibiting one or more of the following characteristics over a long period of time and to a marked degree that adversely affects a child's educational performance:

(A) Inability to learn not explained by other factors

(B) Inability to have interpersonal peer relationships

(C) Inappropriate behavior or feelings under normal circumstances

(D) Pervasive mood of depression or unhappiness

(E) Tendency to develop physical symptoms or fears

(ii) Emotional disturbance includes schizophrenia. The term does not apply to children who are socially maladjusted, unless it is determined that they have an emotional disturbance under paragraph (c) (4) (i) of the IDEA legislation. An inability to learn that cannot be explained by intellectual, sensory, or health factors.

The Evolving Definition of Emotional Disturbance

Since the passage initial special education legislation, PL 94-142 in 1975, only two changes to the emotional disturbance classification have occurred across reauthorizations. These changes include the development of Autism as a distinct disability category separate from serious emotional disturbance and the 1997 change in category from “serious emotional disturbance” to “emotional disturbance” (Gargiulo, 2012).

While there are few changes to legislation, the classification and definition of emotional disturbance is controversial at best. According to the federal definition, students with social maladjustment or conduct disorders are ineligible for services. At the state level, definitions vary with some denying services to students exhibiting problematic behavior attributed to maladjustment. Additionally, acceptable behaviors and expectations vary across cultures with few recognized across cultural norms (Kauffman & Landrum, 2009). While universal, more severe, behaviors of concern, including mutism, eating feces, and murder, are universally considered atypical. Less prominent externalizing behaviors such as cursing, physical aggression, and sexual deviance can be more challenging to define across cultures (Kauffman & Landrum, 2006).

Professional organizations such as the Council for Behavioral Disorders (CCBD, 1990) advocate for the use of the inclusive term “emotional or behavioral disorders” implying that the category include students with conduct, maladjustment, and behavioral concerns. More recently, CCBD completed a series of studies evaluating the organization's role and status (Peck et al., 2012). Authors suggest study results indicate a need to consider a change in name to be more inclusive of students with emotional disabilities. However, Forness (2011) indicated that many students with internalizing behaviors are currently served through EBD as students exhibit both internalizing and externalizing behaviors. Regardless of organizational name, the term EBD is accepted and widely utilized by researchers and professional organizations.

According to Cullinan (2007), current research does not support the five areas of eligibility identification or the exclusion of students with conduct disorders from the emotional disturbance category. Additionally, Forness and Kavale (2000) attack many of the federal definition terms including long period of time, to a marked degree, pervasive, and inability to learn. Kerr and Nelson (2010) concurred, indicating an inability to learn implies that youth with emotional disabilities are unable to learn. While some argue that changing the federal definition to include youngsters with conduct challenges will cause vast increases in students whom are eligible for services thereby draining federal and state resources. (e.g., Webber & Potts, 2008); others indicate that this group of students is entitled to services and thereby deserving of resources to afford access to education (e.g., Forness & Kavale, 2000; Kauffman, Mock, & Simpson, 2007).

Prevalence of Emotional and Behavioral Disorders

Given the lack of consensus regarding eligibility criteria, identification processes, and varying definitions of behavioral norms, it is not surprising that it is challenging, if not impossible, to ascertain the exact prevalence of emotional or behavioral or disorders in our schools (Hallahan, Kauffman, & Pullen, 2011). According to the USDOE, emotional disturbance is the fifth largest disability category for school aged children with 418,068 students receiving special education services under the emotional disturbance category during the 2008-2009 school year. However, this is probably a gross underestimate of students in need of services due to the social stigma associated with the emotional disturbance label and differing identification procedures (Kauffman, Mock, & Simpson, 2007). Conservative estimates indicate youth and adolescents with mental health challenges are at least five times higher than current than the number of students identified with emotional disturbance (Costello, Foley, & Angold, 2006, Kauffman & Landrum, 2006). Further complicating the issue of identification is comorbidity of learning and attentional difficulties that either mask, or potentially lead to emotional disabilities, over time (Kauffman, Mock, & Simpson, 2007). Recently, Wiley and Siperstein (2011) found correlations between political climate and the number of students with EBD, with conservative states having far fewer students eligible for EBD services.

Despite difficulties in determining classification criteria and prevalence, there are four common characteristics of most definitions of emotional and behavioral disorders which include frequency, duration, and intensity of internalizing and/or externalizing behaviors across multiple settings. Rutherford, Quinn, and Mathur (2004) offer the following as examples of internalizing behaviors (a) anxiety disorders, (b) depression, (c) phobias, and (d) eating disorders. Cullinan and Sabornie (2004) indicate that students with internalizing behaviors may appear (a) withdrawn, (b) excessively active, (c) lethargic, or (d) numerous psychosomatic complaints. Examples of externalizing behaviors include fighting, destruction of property, sexual misconduct, and self-injurious behaviors. Scott, Nelson, and Liaupsin (2001) identity externalizing behaviors in classrooms include (a) making noises, (b) arguing with staff, (c) throwing objects, and (d) threatening peers. In order to gage the frequency, intensity, and duration of behaviors necessary for identification assessments should be completed. These include observations, record reviews, functional behavioral assessment, and behavioral rating scales (Kauffman, 2005).

Mathematics Instruction: Implications for Students with EBD

Mathematics instruction has shifted from a focus on arithmetic calculation to problem solving, logic, patterns, organizing evidence, communicating information clearly and concisely and proving solutions are merely some of the major elements of a secondary mathematics curriculum (National Council for Teachers of Mathematics, 2000; Sayeski & Paulsen, 2010; Strickland & Maccini, 2010). Yet, results of high-stakes testing initiatives indicate that both students with and without disabilities have not met academic standards at acceptable rates (Vannest, Temple-Harvey, & Mason, 2009).

Given students with EBD who exhibit a complex set of academic, behavioral, and social challenges (Montague, Enders, Cavendish, & Castro, 2011; Wiley, Siperstein, Forness, & Brigham, 2010) that merit specialized instructional supports (Brigham & Hott, 2010; Lane, Wehby, & Cooley, 2006), failure to pass state accountability measures has led to catastrophic consequences. In the area of mathematics, students with EBD exhibit large achievement deficits that, despite special education services, remain stable or worsen over time (Morgan, Frisco, Farkas, & Hibel, 2010). Nelson, Benner, Lane, and Smith (2004) found that math performance of students with behavioral disabilities was higher than students with learning disabilities in kindergarten; yet, by fifth and sixth grade, students with behavioral disabilities were performing significantly below students with learning disabilities. Further, Siperstein, Wiley, and Forness (2011) found that academic deficits were significantly more pronounced in mathematics in districts serving students from lower socio-economic backgrounds than those in high-income schools and Wiley, Siperstein, Forness, and Brigham (2010) found significant behavioral differences amongst youth with EBD. Despite legislative efforts, increased focus on access to the general curriculum, and development of common core standards, youngsters with EBD continue to fall victim to increasingly poor educational outcomes. Therefore, there is a substantial need to develop quality instructional practices that address the unique learning needs of students with EBD and their teachers.

Study Rationale

The research encompassing evidenced-based practices in the special education field is rapidly gaining momentum to support students experiencing academic difficulty. However, the current literature base has primarily focused on elementary aged students with little intervention research for secondary students with disabilities (Mastropieri et al., 2009). Given the aforementioned academic and behavioral needs of students with EBD, one intervention that has an emergent evidence base is the use of varying modes of response (Blood, 2010; George, 2010; Sutherland, Alder, & Gunter, 2003).

Advantages of response options have included: (a) motivates students (Munro & Stephenson, 2009), (b) assists with classroom management (George, 2010), (c) can be beneficial for both students and teachers (Wood, Mabry, Leah, Kretlow, Lo, & Galloway, 2009), and (d) is researched at the secondary level (Blood, 2010). While there is a literature base that extends well over 35 years to support the use of response options, there is a need to extend current research to secondary mathematics within current instructional frameworks taking into account state standards. To date, only three studies have involved secondary students with EBD and none of the studies were completed within secondary mathematics. Further, there is also a need for research to evaluate opportunity to respond interventions within the context of high stakes testing standards that drive instructional packing and curricular decisions.

Despite a clear need for academic supports for students with emotional behavioral disabilities (EBD), research endeavors have historically focused on determining how behavioral supports can be used to promote access to the general curriculum. The use of response tools has the potential to simultaneously address both behavioral and academic needs.

Research Questions

The purpose of the study is to determine the effects of response tools in mathematics on academic performance, on-task behavior, and response rates of secondary students with EBD. The following research questions are addressed:

1. Do response tools increase secondary school students with EBD math achievement? If so, are response cards or response systems more beneficial?

2. Do students respond more frequently, and accurately, when using response tools as compared to traditional instruction? If so, are response cards or response systems more beneficial?

3. Do students spend more time on-task when using response tools as compared to traditional instruction? If so, are response cards or response systems more beneficial?

4. What are student, instructional assistant, and teacher perceptions of the use of response tools?

2. LITERATURE REVIEW

The purpose of the literature review is to provide a systematic summary of research pertaining to interventions, active responding, and response tool use as they pertain to the current study. The chapter begins with a summary of mathematics interventions for students with EBD, followed by a rationale for increasing active responding as a component for achievement, then a review of response tools evaluated in K-12 education. Finally, a rationale for the current study is provided.

Mathematics Interventions for Students with EBD

Computer assisted searches for applicable literature were completed utilizing Academic Search Complete, PsycInfo, and ProQuest databases using various combinations the following descriptors: emotional, behavior, disorder, emotional disturb* with math*, mathematics, and arithmetic. Additionally, recent issues of Behavioral Disorders, Education and Treatment of Children, Exceptional Children, Journal of Emotional and Behavioral Disorders, Journal of Positive Behavioral Interventions, and Preventing School Failure were reviewed to ensure that recently published articles that had yet to be indexed were included. Finally, ancestral searches of literature reviews and meta-analyses were completed.

Studies were included in the review if they were published in a peer-reviewed journal. had dependent measures that evaluated math achievement, and the focus was on participants, enrolled in grades six to twelve, with EBD. Studies that included students with EBD which data could not be disaggregated were not included.

The sample consisted on 18 articles published in 10 journals. The journals included Behavioral Disorders, Beyond Behavior, Child and Family Behavior Therapy, Education and Treatment of Children, Exceptional Children, Journal of Special Education, School Psychology Review, Teaching Exceptional Children, Psychology in the Schools, and Remedial and Special Education. The studies evaluated the efficacy of self-management interventions (n = 8), instructional design (n = 3), and peer mediated strategies (n = 7). Additionally four meta-analyses published between 2000 and 2009 were reviewed. The sample included 159 students who received interventions in public schools (n = 9), alternative placements (n = 1), private schools (n = 4), laboratory schools (n =1), residential treatment centers (n = 2), and correctional facilities (n = 1).

Self-management interventions. Student directed strategies, such as self-management interventions, are designed to facilitate student involvement in the learning process (Agran, King-Sears, Wehmeyer, & Copeland, 2003). In a review of interventions for students with EBD, Mooney, Ryan, Uhing, Reid, and Epstein (2005) identified five self-management domains including (a) self-monitoring, (b) self-evaluation, (c) self-instruction, (d) goal setting, and (e) strategy instruction. This section summarizes studies that determined the effectiveness of self-management interventions.

Self-monitoring. Self-monitoring procedures require students to observe and record their behaviors during a specified activity or time period (Reid, 1996). Typically, there are two types of self-monitoring, self-monitoring of performance and self-monitoring of attention. Self-monitoring of performance involves students systematically recording their scores on assignments and self-monitoring of attention involves students evaluating behavioral progress (Reid, Trout, & Schartz, 2005).

Osborne, Kosiewicz, Crumley, and Lee (1987) implemented self-monitoring procedures in self-contained classrooms for students with mild disabilities, including students with emotional and intellectual disabilities. An ABAB reversal design was used to assess time on task and assignment accuracy. Two students with emotional disabilities enrolled in two different self-contained classrooms were taught to track attention to task, determining if work was completed, when audio tones were played during math class time. The first student increased his ability to sustain attention to 87%, a 66 and 23 percentage point increase over baseline one and two respectively. The authors indicated that the trend suggested by productivity data indicated that the student increased his assignment accuracy. The second participant also increased his time on-task from 24% during baseline conditions to 64% during treatment conditions. Insufficient academic data was collected to determine the effects of self-monitoring procedures on the student's math performance.

Carr and Punzo (1993) evaluated the effects of self-monitoring on the reading, mathematics, and spelling accuracy and productivity of three male students between the ages of 13 and 15, with EBD. The math portion of the 25 session study primarily focused on computation of basic facts. Results indicated that students increased both productivity, the number of problems completed, and accuracy, the number of correct problems. In math, the first participant maintained his completion of math assignments from 99.69% to 100% and increased his accuracy from 48.25% to 95%. The second and third participants also maintained productivity with 90.13% and 100% during baseline and 95.89% and 99.89% during intervention respectively. Participant 2 increased accuracy from 20.15% during baseline to 83.11% during treatment. Similarly, participant 3 increased his math accuracy from 69.80% to 97.22% during treatment.

Lazarus (1993) also studied the use of self-monitoring procedures on the mathematics performance of students with EBD. Four female and ten male students between the ages of 11 and 13 participated in the study. Participants received math instruction in differing self-contained classrooms. Each student worked towards individual math goals. A multiple baseline across three participants design was used. Five, direct intersubject replications were used to evaluate the data.

Students completed a curriculum based multiplication assessment to ensure precursor skills were in place prior to the intervention. Prior to intervention, students were individually trained to use a folder with an answer key and cue card including self-monitoring procedures. Following 10 to 15 minutes of daily instruction, students were administered a 20 question quiz. Students determined problem completion and accuracy goals ranging from 15 to 20 problems with 90% to 100% accuracy.

During baseline students rarely attempted more than 40% of problems presented and mean accuracy across the six classrooms was between 7% and 22%. Like Carr and Punzo (1993), after implementing self-management procedures, students increased both the number of problems and accuracy of completed problems. Students increased baseline scores from 2% to 22% to 72% to 93% across classrooms.

Strategy instruction. Strategy instruction begins with a teacher providing directions about how to solve a problem using a highly structured procedure. Students then independently follow the procedure to solve a problem or achieve a goal (Coyne, Kame'enui, & Simmons, 2001). Intervention studies that evaluated the efficacy of student directed strategies are presented in this section.

Skinner, Turco, Beatty, and Rasavage (1989) investigated the efficacy of a cover, copy, compare strategy (CCC) on the response rate and accuracy of solving multiplication facts. The cover, copy, compare strategy involved each student being provided with a set of problems, the student then completed each problem, and compared his answer to a key. Four students with EBD that were enrolled in a private school for students with behavioral challenges participated in the study. Three students were male and one student was female. One of the three students was a fourth grader; the other two were tenth graders. Results suggest that all students increased the rate, and accuracy, of responses. Further, students maintained multiplication skills over time. The high school students maintained their accuracy of 90% to 96% during baseline to 91% to 98% during treatment to 96% to 97% during maintenance. Both high school students increased their speed. The mean time of 237 seconds during baseline decreased to 184 seconds during treatment.

In a follow up study, Skinner, Bamberg, Smith, and Powell (1993) evaluated the use of the cognitive- cover copy compare (C-CCC) strategy on student performance on single digit division facts. Three students between the ages of 9.9 and 12.5 enrolled in a private school for students with behavioral disorders participated in the study. Results indicate that each of the students increased the number of problems accurately completed. Student one increased from 27 to 34 problems completed during baseline to 46 problems completed per minute during treatment. The second student increased performance from 23 to 29 problems completed per minute during baseline to 42 to 45 problems completed during treatment. The third participant increased his performance from 29 to 38 problems during baseline to 43 to 46 problems during treatment. Mean accuracy during baseline ranged from 92% – 100% and remained at 100% for all students during treatment.

Mnemonics. Cade and Gunter (2002) investigated the use of mnemonics strategy instruction on the acquisition of basic division facts. Mnemonic strategies pair visual imagery with auditory cues to promote learning (Scruggs & Mastropieri, 1990). Participants included three males with EBD who attended a special day school. Two participants were of African American descent and one was from Caucasian descent. Students ranged in age from 11 to 14 years. A multiple baseline across participants with multiple probes design was used.

Students were trained to use a finger tapping technique followed by songs such as "7, 14, 21, I'm having fun (Semple, 1992, pg.93)." Participants increased their scores from 4% to 8% during baseline to 83% to 96% after the first intervention phase. Findings indicate that mnemonics instruction increased division accuracy.

Self-instruction training. Self-instruction training is a cognitive behavioral approach supporting students. The strategy involves a student making self-statements to guide behavior (Graham, Harris, & Reid, 1992).

Swanson and Scarpati (1984) investigated the effects of self-instruction training on a male student's ability to complete two- and three-digit multiplication facts. The intervention was taught within a laboratory school setting . A single subject reversal design was used to evaluate the student's ability to gain strategies to solve math problems and then independently apply the strategies in a classroom setting. Results indicate that the student increased his ability to solve multiplication facts using self-instruction from 55% during baseline to 81.25% during baseline.

Multiple strategies. Davis and Hajicek (1985) studied the impact of two treatments, modeling and prompting and strategy instruction on multiplication of decimals using a multiple baseline design. Six students with conduct disorders and one student with schizophrenia participated in the study. The students attended a psychoeducational center for students with severe behavior disorders and the study took place in a self-contained classroom where students participated in the study treatments for 20 minutes daily. The mean participant age was 12 years old.

The modeling intervention involved the researcher completing a think aloud that demonstrated a series of self-talk steps including taking a deep breath and procedures for solving problems involving decimals. Students then independently solved three problems. The self-instructional training included two steps. The first step involved the researcher stating a rationale for why it is important to use self-instructions. The student then solved multiplication problems with decimals over a series of intervention sessions while talking to himself aloud, whispering self-instructions and finally using silent self-talk. Results indicate that students improved their accurate completion of problems but not attention. Compared to strategy training, students improved significantly. Student one improved his score by 189%, student two by 322%, student three by 134%, student four by 177%, student five by 36%, student six by 121%, and student seven by 100%.

Instructional techniques. Historically the special education field has advocated for direct instruction while mathematics educators have worked towards establishing inquiry-based methods (Cole & Washburn-Moses, 2010; NCTM, 2000). Mercer, Jordan, and Pullen (1996) advocated for the special education field to explore constructivist math approaches and implications for students with disabilities. Over a decade later, the National Mathematics Advisory Panel (NMAP, 2008) further advocated for an inquiry-based approach to mathematics instruction for students, including those with learning challenges. However, there is a need for continued research to exploring both direct instruction and inquiry-based models within the mathematics domain. The following section summarizes instructional strategies used to teach math concepts to students with EBD.

Enhanced Anchored Instruction (EAI). Bottge, Rueda, and Skivington (2006) evaluated the use of EAI on the math achievement of 17 adolescents who attended an alternative high school for students with behavioral difficulty. Behavioral challenges of participants included two or more of the following risk factors (a) truancy, (b) significant academic skill deficits, (c) adjudication, or (d) teenage parenthood.

The mixed methods study evaluated math achievement and instructional factors that may have attributed EAI efficacy. EAI incorporates multi-media based and hands-on activities to support math skill development of low-achieving students. Three teachers provided instruction for 28 days using lesson plans that supported EAI objectives. Each 75 minute session included a review of problems solved the previous day including student discussion of problems experienced when attempting to solve the problems. The instructor taught foundational math skills and then multimedia-based problems were presented. Students then engaged in applied projects using building materials. One problem asked for students to construct a skateboard ramp and the other problem asked students to build a hover craft out of PVC pipe.

Dependent measures included curriculum aligned problem solving tests that aligned with the standards recommended by NCTM (Bottge, Heinrichs, Mehta, & Hung, 2002), a fractions computation test, and the Iowa Tests of Basic Skills (University of Iowa, 2001) Computation, Problem Solving, and Data Interpretation subtests. Results indicate that students scored higher on the curriculum-aligned tests (*ES* = 0.75 and 0.78). However, there were no significant differences on the fraction computation test or on standardized measures. Descriptive data from classroom observations and follow up student interviews indicated that students felt that the EAI problems were relevant and important. Within two to three class sessions students were engaged and completing problems.

CRA Sequence. Riccomini, Witzel, and Robbins (2008) completed a pilot study evaluating the efficacy of the Concrete-Representational-Abstract (CRA) sequence of instruction. The authors compared the end-of-grade scores of nine sixth graders, from different schools within a large urban division, who completed a mathematics program that involved the CRA sequence. Results indicate improved performance on end-of-year state assessments and a significant difference between students' end of grade score between explicit and CRA instruction, $F(1, 14) = 6.16$, $p < .05$. Additionally, the median math level increased form basic (2) to proficient (3).

Direct Instruction (DI) and Computer-assisted Instruction (CAI). Billingsley, Scheuermann, and Webber (2009) evaluated the use of DI, CAI, and CAI with DI on the mathematics performance of secondary students with EBD. A single subject alternating treatment design was used to evaluate the math achievement of ten, ninth through eleventh graders, receiving instruction in a self-contained math classroom within a public school.

The Wechsler Achievement Test, Third Edition (WRAT-III) was administered to determine common skill deficits. Three curriculum based measures were then administered to determine a baseline. Students were exposed to randomized instructional approaches addressing 10 objectives including multiplication, division, and factional computation problems. The DI condition involved the teacher following procedures outlined by Scheuermann and Hall (2008) involving (a) the objective written on the board, (b) the teacher providing a connection between previous concepts and new material, (c) presentation of new material, (d) students completing problems on white boards with teacher assistance, and (e) independent practice. CAI was provided using OdysseyWare ® by Pathway Publishers ®. The teacher selected objectives and students worked independently with the software. During DI with CAI, the teacher explicitly taught objectives and students completed practice problems using software.

Results indicate that students' math performance improved in each condition with no clear delineation between methods. One of the students did not master concepts presented in any of the treatments. Five out of the ten students increased performance most dramatically during the DI approach and one student increased her performance most with CAI. Baseline scores ranged from 0% to 70%, DI scores ranged from 5% to 95%, CAI scores ranged from 10% to 95%, and DI with CAI scores ranging from 42% to 95%.

Peer-mediated strategies. Peer mediated strategies involve students serving as academic tutors and tutees (Spencer, 2006; Sutherland & Snyder, 2007) or working in cooperative learning groups (Hott & Walker, 2012). Typically, higher performing students are paired with lower performing students to review critical academic or behavioral concepts (Okilwa & Shelby, 2010; Sutherland & Snyder, 2007). Frequently used peer tutoring configurations include: (a) class-wide peer tutoring (CWPT), (b) peer assisted learning strategies (PALS), (c) same-age peer tutoring, (d) cross-age peer tutoring, and (e) reciprocal peer tutoring (Hott, Walker, Sahni, 2012). Class-wide peer tutoring interventions involve all students in a classroom.

Cross-age peer tutoring. Cross age peer tutoring configurations involve pairing an older student with a younger student. The older student serves as the tutor even though the younger student's skills may be at the same level or lower than the tutors (Hott, Walker, Sahni, 2012).

Gable and Kerr (1980) studied the impact of cross-age peer tutoring on the reading and mathematics performance of six adolescents with EBD from a residential setting who served as tutors to 23 middle school students that scored two to four years below grade level. Tutoring sessions were completed daily for 30 minutes for 8 weeks. While tutees made significant gains, mastering 719 out of 827 math calculation objectives, tutors made small gains. The authors indicate that minimal gains occurred due to the possibility of a ceiling effect as tutors mean test scores were 93.4%.

Maher (1982, 1984, 1986) completed a series of studies evaluating the use of cross-age peer tutoring program. The studies evaluated the effects of cross-age peer tutoring. High school students with EBD tutored elementary students with intellectual disabilities.

The first study (Maher, 1982) evaluated the impact of three interventions, cross-age peer tutoring (participant serves as tutor), peer tutoring (participant serves as tutee), and group counseling on the academic progress, absenteeism, and disciplinary referrals of 18 high school students who received special education services due to social maladjustment and emotionally disturbance. Behaviors included absenteeism, refusing to complete assignments, aggression directed towards other students, and poor academic progress in reading, math, and writing. Students demonstrated average intelligence and received services in the general education setting.

The baseline period lasted the two marking periods, 20 weeks, followed by a ten week intervention period. Maintenance data was collected during the final 10 week marking period. Students, nor their teachers, were aware of the intervention or study participation. Both were debriefed following the study.

Six students were trained to serve as peer tutors for elementary aged students with intellectual disabilities. Tutors were informed that tutoring would help students, their families, and teachers. Each tutor met with the elementary special education teacher to review spelling, calculation, and writing tasks that would assist elementary students for 15 to 20 minutes each week. At the conclusion of the meeting a written plan for tutoring sessions was drafted. The high school students tutored the elementary students two times per week for half an hour.

Six students received an orientation to "survival skills" necessary for high school. They were matched with a non-disabled peer tutor who conducted tutoring sessions in accordance with a schedule established by the school counselor.

The remaining six students participated in group counseling sessions on the importance of high school graduation and the necessary skills needed to graduate from high school. The group met two times per week for a half hour during the school day.

Grades in mathematics, social science, and language arts, number of disciplinary referrals, and percentage of days in school were calculated. While language arts and science grades improved, mathematics grades did not increase across conditions. The mean mathematics grades were 3.9 during baseline, 2.8 during intervention, and 2.3 during maintenance for the students participating in cross-age peer tutoring. Students who received tutoring earned mean mathematics scores of 3.8 during baseline, 3.8 during intervention, and 3.7 during the maintenance phase. Students in the counseling group earned mean mathematics grades of 3.4, 3.2, and 3.5 across the study phases.

Students who participated in cross-age peer tutoring had significantly less absences then students who received tutoring or participated in counseling groups. Further, students who served as tutors received significantly fewer disciplinary referrals then other groups.

The second study, Maher (1984) used a multiple baseline design to evaluate the use of cross-age tutoring. Participants included 16 high school students who were paired with elementary students with intellectual disabilities. The tutoring program consisted of four steps: (a) tutoring training, (b) planning for tutoring, (c) tutoring sessions, and (d) tutoring support conferences.

Dependent measures included academic assignment completion, quiz and test performance, and disciplinary referrals. Unlike the previous study, assignment completion was not disaggregated by subject area. Tutor increased assignment completion rates from 61.7% during baseline to 94.7% during peer tutoring and continued to maintain work completion rates with a mean of 93.1% during the follow up period. Percentage correct on quizzes was 56.4% during baseline and 88.3% during treatment. Disciplinary referrals decreased from 5.5 during baseline to 1.6 during treatment and 1.3 during follow up.

Same-age tutoring interventions. Same age peer tutoring configurations include students who are similar ages. Typically a higher performing student is paired with a lower performing student (Hott, Walker, Sahni, 2012). Maheady, Sacca, and Harper (1987) explored the use of same-age reciprocal tutoring on the math performance of 9th and 10th graders enrolled in general education math courses. The sample included students without disabilities and students with learning and behavioral disabilities studying math calculation, fractions, time, and money management. Ninth graders worked with the General Math text (Shaw, Wheatley, Kane, & Schaefer, 1980) while tenth graders studied a variety of applied math concepts.

Students were systematically assigned to groups according to math achievement levels. Students were divided into two teams. The first team included the highest performing student. The second team included the next highest performing student. The rotation continued moving from the highest performing student to the lowest performing student (Slavin, 1993). General and special education teachers collaboratively developed 30 item worksheets that students used weekly.

Students were placed in tutoring teams and worked together 30 minutes each day after the teacher taught new content for 40 minutes. A deck of cards with the numbers 1 through 30 were provided to each tutoring team. The tutee selected a card and then completed the corresponding problem. If the tutee answered the problem correctly, the tutor awarded points. If the tutee was unable to solve the problem or solved the problem incorrectly, the tutor assisted the tutee with calculating the correct response. Students took turns selecting cards from the deck serving as both the tutor and tutee. All students completed weekly quizzes and scores were awarded to teams. A weekly winner was announced.

During baseline scores ninth grade mean quiz scores were 62.20% (range = 50% - 82%) with no significant differences between general education and students with disabilities. After peer tutoring, mean test scores increased significantly. Mean increase of 20.53 points across classes was observed with students with disabilities outperforming non-disabled peers on several quizzes. Tenth grade scores also improved. Mean quiz scores increased from 59.65% in baseline to 81.65% after treatment. Additionally, both ninth and tenth graders earned higher math grades during the intervention phases.

Franca, Kerr, Reitz, and Lambert (1990) evaluated the use of peer tutoring on the math performance of eight male students, between the ages of 13-9 and 16-3 years old, enrolled in a private school for students with behavioral difficulties. Participants displayed diverse emotional or behavioral challenges including aggression, inattentiveness, oppositional behavior, and academic difficulty. A multiple baseline across participant dyads design was used to evaluate the effectiveness of a same-age tutoring intervention on math calculation skills.. After a pretest, students were assigned to dyads. Neither the tutor or tutee had demonstrated mastery of fractions concepts. Tutors were trained using a four step process, (a) problem presentation, (b) instructions, (c) error correction, and (d) social reinforcement. Tutors were retrained until they were able to complete steps independently for three trials.

Peer tutoring occurred daily for 15 minutes with mean intervention time across participants of 14.3 weeks. Dependent measures included math worksheets, attitude and social skills scales. Math worksheets contained faction problems drilled during the peer tutoring sessions. Students completed timed worksheets. Rate of problems correctly (correct rate) answered and missed (error rate) were calculated with an independent researcher completing reliability checks on approximately 25% of the worksheets. During baseline phases tutor mean correct rates were .59 per minute and mean incorrect rates were 1.20 per minute. Mean correct rate for tutors during the intervention phase increased to 1.67 and error rate decreased to .43. Conversely, tutee correct rate increased from .24 during baseline to 1.02 per minute. Error rates decreased from 1.54 to .74 per minute.

Students completed the Estes Attitude Toward Math Subscale (Estes, Estes, Richards, & Roettger, 1981) and the Pier-Harris Children's Self-Concept Scale (1969) to gage attitude towards math, self-concept, and social interactions. Both tutors and tutees attitudes towards math improved. Two tutors (50%) and all of the tutees improved attitudes towards math. Tutors were portrayed more positively after the intervention by peers. Results from student interviews indicated that students viewed peer tutoring as a positive intervention. Half of the dyads expressed interest in reversing roles as tutor and tutee.

Cooperative learning teams. Cooperative learning involves students working in small heterogeneous or homogeneous groups to complete a task (Hott & Walker, 2012). Students are evaluated individually or as a group.

Salend & Washin (1988) evaluated the use of team-assisted individualization (TAI) with youth committed to state care using a reversal, ABAB, design. TAI is a cooperative learning strategy which allows groups of students to work on individual assignments. Three classes of adolescent students with emotional or behavioral disorders who had committed a variety of criminal acts received core academic instruction in a special education class. Each class included six participants. They also received supplementary math instruction.

During the supplementary math class, each student worked with materials from the Basic Skills in Mathematics Series (Mathematics Basic Skills Development Project, 1981) designed to assist secondary aged students with math calculation skills development. Dependent measures included on-task behavior, cooperative behaviors, and academic performance. On-task behavior as evaluated on 15 second intervals using a whole interval recording system. Cooperative behaviors were noted using an event recording system. Academic productivity, the number of problems attempted, and academic accuracy, the number of problems completed correctly were documented by calculating the number of problems attempted and the number of problems accurately completed. The How I Feel Towards Others (Agard, Veldman, Kauffman, & Semmel, 1978), a sociometric rating scale, was administered at the end of Baseline 1 and Intervention 2 phases.

Results indicate that mean time on-task and the instances of cooperative behaviors increased. During the Baseline Phase 1, mean on-task behavior ranged from 45 to 68% of on-task intervals across the three classes. Mean time on-task during Baseline 2 ranged from 39 to 67.5% across the three classes. During the intervention phases, mean time on task increased to 93 to 97.1% of intervals. Cooperative behaviors were not observed during any of the class meetings during Intervention Phase 1 or Intervention Phase 2. During the intervention phases a mean of 3.3 to 6.9 instances of cooperation were observed. A clear and substantial relationship between TAI participation and academic progress could not be established. However, this could be attributed to the possible presence of a ceiling effect during baseline measures. The percentage of problems attempted during baseline phases ranged from 81.3 to 93.8 and 94.7 to 99 during the intervention phases. Items correct ranged from 67.8 to 90.6 during the baseline phases and 76.3 to 97.1 during the intervention phases.

Meta-analyses. Five recently published meta-analyses have been conducted to evaluate the efficacy of peer mediated strategies. Two focused exclusively on secondary students (e.g. Okilwa & Shelby, 2010; Stenhoff & Lignugaris-Kraft, 2007). Three focused exclusively on students with EBD (Ryan, Reid, & Epstein, 2004; Spencer, 2006; Spencer, Simpson, & Oatis, 2009). While peer tutoring is a widely researched and empirically validated intervention (Hall & Stegila, 2003), relatively few studies have focused on secondary students with EBD and even fewer within the mathematics domain. Stenhoff & Lignugaris-Kraft (2007) found 20 articles that were published between 1980-2005. Six additional studies were not included due to the inability to calculate percent of overlapping data or effect size given the content of the article. Of the 20 articles, 10 included students with EBD (Blake, Wang, Cartledge, & Gardner, 2000, Maheady, Harper, & Sacca, 1988[a], Maheady, Sacca, & Harper, 1987, Maheady, Dacca, & Harper, 1988[b], Mastropieri, Scruggs, Spencer, & Fontana, 2003, Presley & Hughes, 2000, Smith, Young, Nelson, & West, 1992, Spencer, Scruggs, & Mastropieri, 2003, Stowitschek, Hecimovic, Stowitschek, & Shores, 1982). Remarkably, the studies were completed over a decade ago. Of those studies, only one aforementioned study was completed in within the mathematics domain (Franca, Kerr, Reitz, & Lambert, 1990) and only one study disaggregated data for students with EBD (Franca et al., 1990).

Like Stenhoff & Lignugaris-Kraft (2007), Okilwa and Shelby (2010) evaluated the efficacy of peer tutoring interventions for secondary students. The research synthesis included 12 articles evaluating the academic performance of secondary students participating in peer tutoring interventions. Of the 12 studies, four studies included students with EBD (Mastropieri et al., 2006, Bowman-Perrott, Greenwood, & Tapia, 2007, Calhoon & Fuchs, 2003, Spencer, Scruggs, & Mastropieri, 2003). Two studies were completed in mathematics (McDonnell, Mathot-Buckner, Thorson, & Fister, 2001, Schloss, Kobza, & Alper, 1997), however; they did not include participants with EDB. Spencer (2006) completed a comprehensive review of the peer tutoring literature dating from 1972 to 2002 identifying 38 published studies. Of those 38 studies, five were completed in middle schools and 16 in high schools. Of those 21 studies, seven studies were completed within the mathematics domain. Two studies were conducted in elementary settings (Harper, Mallette, Maheady, Parks, & Moore, 1993, Levendoski & Cartledge, 2000) with five completed in secondary settings (Franca, Kerr, Reitz, & Lambert, 1990, Gable & Kerr, 1980, Kane & Alley, 1980, Maheady, Sacca, & Harper, 1987, Maher, 1982).

Conclusion. There is a lack of research at the secondary level, especially in the areas of problem solving and other more advanced mathematics domains (Templeton, Neel, & Blood, 2008). In a systematic review of academic interventions for students with EBD, Mooney, Epstein, Reid, and Nelson (2003) found only 55 studies evaluating the efficacy of academic interventions for students with EBD published between 1975 and 2002 with the number of studies published in recent years steadily declining.

More recently Hodge, Riccomini, Buford, and Herbst (2006) completed a systematic review of mathematics interventions for students with EBD published between 1985 and 2005. Thirteen studies were obtained with the majority focusing on basic skills including whole numbers, decimals, fractions, and basic computation skills. Interventions evaluated included student (n = 10), teacher (n = 1), peer-mediated (n = 1), and computer assisted learning (n = 1) strategies. However, of the 13 studies, only four were completed at the secondary level with all of the studies focusing on basic skills. Templeton, Neel, and Blood (2008) completed a comprehensive meta-analysis of math interventions for students with EBD. Fifteen studies were included in the study with conclusions supporting those previously established by Hodge and colleagues. A summary of interventions reviewed is provided in Appendix A.

A systematic review of the literature revealed few additional published studies evaluating mathematics interventions for students with EBD. Recent research has shifted towards efficacy of multimedia and problem based learning. However, there is a lack of recent research determining the value of interventions to improve grade level math skills or approaches to support access to the general curriculum. To date many studies have involved students in restrictive placements such as state care, residential settings, and private day schools. Additional research within special and general education classrooms within public schools is warranted. While single subject methodologies have merit, there is a need to also bring interventions to scale.

There is a clear need to evaluate the efficacy of interventions in mathematics in general education settings, replicate dated studies to reflect current demographics of students served, and increase the sample size. Moreover, studies should include students from with EBD from diverse backgrounds. See Appendix A for a summary of mathematics interventions.

Active Student Responding

Computer assisted searches for applicable literature were completed utilizing Academic Search Complete, PsycInfo, and ProQuest databases using various combinations the following descriptors: active, student, respon*, with behavior. Additionally, recent issues of Behavioral Disorders, Education and Treatment of Children, Exceptional Children, Journal of Emotional and Behavioral Disorders, Journal of Positive Behavioral Interventions, and Preventing School Failure were reviewed to ensure that recently published articles that had yet to be indexed were included. Additionally, ancestral searches of literature reviews and meta-analyses were completed. Additionally, a search of the library catalog for books and other relevant materials was conducted.

Historical background. After completing a series of studies, Brophy (1979) concluded that students who struggle or exhibit special needs require more nurturing, warmth, and encouragement than their typically achieving peers and that teachers should use direct and systematic instructional strategies within an environment that affords students numerous opportunities to answer questions. Further, Brophy advocated for a predictable pattern of questioning with each student having the equal opportunity to answer questions. These premises continue to hold merit today with current research efforts focused on simultaneously meeting the academic, behavioral, and social needs of students with learning and behavioral challenges.

"Academic learning" time was first presented in the Beginning Teacher Evaluation Study of the Far West Regional Laboratory (Berliner, & Fisher, 1985; Fischer et al., 1980) and defined as "the amount of time a student spends engaged in an academic task that s/he can perform with high success" (Fischer et al., 1980, p. 8). Findings indicated positive correlations between student and teacher interactions and student engagement were observed and positively linked with learning (Berliner & Fisher, 1985; Fischer et al., 1980).

Subsequently, researchers with the Juniper Gardens Children's project completed seminal research involving response opportunities and later coined the term "opportunity to respond" which involved the teacher presenting antecedent stimuli through instructional materials, prompts, questions, and signals to respond and subsequent student reactions to the material (Greenwood, Delquadri, & Hall, 1984). Specifically project directors, desired to explore the link between student engagement and achievement within urban, low performing districts. Student engagement measures typically include time on-task and student participation as measures of student engagement with the learning process (Greenwood, Horton, & Utley, 2002; Moore, 1983). They subsequently developed instruments (e.g. Code for Instructional Structure and Student Academic Response [CISSAR]) to evaluate the use of instructional time and opportunities for students to respond in elementary classrooms. The completed a seminal study of 12 students enrolled in 6 elementary classrooms, noting that only 75% of the instructional day was devoted to instruction and of that 75%, only 25% involved opportunities for students to respond. About 45% of the instructional day involved passive attention to the teacher during lectures. Students were afforded the opportunity to engage in reading aloud, answering questions, asking questions, and reciting approximately 4 minutes or less than one% of the instructional day.

The researchers later evaluated a composite of activities that included seven academic response domains: (a) writing, (b) academic game play, (c) reading aloud, (d) reading silently, (e) academic talk, (f) asking questions, and (g) answering questions. Response domains were positively correlated with achievement. Yet, simply having students attend to a task does not guarantee increases in achievement (Greenwood, Delquadri, Stanley, Terry, & Hall, 1985).

Conversely, Heward (1994) and colleagues (1996) explored active student responses as a predictor of academic performance shifting the focus of interval recording during instructional time blocks to response frequency within a unit of time. Further, indicating the amount of time engaged in learning activities may not be as important as the number of responses a student makes within that learning time.

Based on the research positively linking student responding with increased academic engagement and learning, a number of seminal studies in the areas of computer assisted instruction (e.g., Moore, Carnine, Stepnoski, & Woodward, 1987), peer-mediated strategy instruction (e.g., Cooke, Heron, & Heward, 1983), and self-monitoring techniques (e.g., Hallahan, Lloyd, Kosiewica, Kauffman, & Graves, 1979; Maag, DiGangi, & Rutherford, 1992). While techniques were in the early stages of research and development, Heward (1994) posed several low cost methods for increasing student opportunities to respond within classrooms including guided notes, choral responding, and student response cards. These methods continue to be researched within general and special education fields.

Response opportunities. Sutherland and Wehby (2001) completed a comprehensive review of the literature, between 1976 to 1997, evaluating the effects of response opportunities with students exhibiting emotional or behavioral difficulties. However, meta-analytic principles could not be applied due to the lack of data included in publications. The sample was relatively small (N = 19). Additional four out of the six completed studies were conducted by Skinner and colleagues.

Overall, it was found increased task engagement and decreased off-task and disruptive behavior when teachers afforded students greater opportunities to respond. Yet others (e.g. Crooks, 1988; Van Acker, 2002) suggest that level of engagement encompasses a multitude of other factors.

Finn (1993) investigated the correlation between student achievement and engagement as well as differences between students "at-risk" and typically achieving students' engagement and achievement. The first study evaluated socioeconomic status, school engagement, student identification with school, participation in school activities, and parent involvement from student, parent, teacher, and administrator's surveys collected from 800 schools as predictors of academic achievement. Findings suggested that academic achievement is positively influenced by student participation in school events and engagement in the classroom activities. In a follow up study, Finn investigated achievement predictors of urban minority, language minority, and low socioeconomic status. Results were similar to those found in the first study with differences between “successful at-risk” and “unsuccessful at-risk” students: (a) class and school participation, (b) class participation, (c) appropriate classroom behavior, (d) completion of homework, and (e) amount of television watched.

More recently, Sutherland, Alder, and Gunter (2003) evaluated the effects of varying rates of opportunities to respond on the classroom behavior of students with EBD. Participants included one girl and eight boys enrolled in an elementary school in the south east. Seven students were of Caucasian decent and one student was of African American decent. Findings from the single subject, reversal design study, indicate increases in opportunities to respond resulted heightened correct responding, more time on-task, and decreased disruptive behavior. However, there were notable limitations. These include that the study was completed within the confines of one classroom and the study did not include measures of academic achievement.

Stichter and colleagues (2009) studied the effects of teacher use of opportunities to respond couple with effective classroom management strategies within high- and low-risk schools. Observations in four public elementary schools located in the Midwest participated in the study. Descriptive assessments conducted within 35 classrooms were completed. The Setting Factors Assessment Tool (SFAT) was used as the primary assessment protocol. Findings indicated that students in title one schools received less opportunities to respond then their non-title one school counterparts. Findings are consistent with those previously evaluated by Sutherland and colleagues.

Response Tools

Computer assisted searches for applicable literature were completed utilizing Academic Search Complete, PsycInfo, and ProQuest databases using various combinations the following descriptors: response card*, clicker*, active respond*, response system, emotional dis*, behavior dis*, reading, math, science, and social studies. Recent issues, dated January 2004 until May 2011, of Behavioral Disorders, Education and Treatment of Children, Exceptional Children, Journal of Emotional and Behavioral Disorders, Journal of Positive Behavioral Interventions, and Preventing School Failure were reviewed. Additionally, a meta-analysis and a literature review of active responding research were acquired and ancestral searches of the documents were completed. Seminal and prominent researchers in the area of response cards and systems were contacted to ascertain current work in the area of response tools.

Studies were included in the literature review if the primary purpose was to evaluate the efficacy of response card or response system interventions involving students enrolled in grades Pre-Kindergarten through 12. The sample included interventions provided in general education and special education settings during the traditional school day. Studies employed quantitative, single subject, or mixed methodologies to evaluate the use of response cards or systems to support on-task behavior and academic performance. In the case of studies that used the same dataset (e.g., dissertations and subsequent peer reviewed journal articles), the most recent peer reviewed publication was utilized.

Seventeen studies were published between 1990 and 2011. Studies appeared in 11 journals which included: *Behavioral Disorders*, E*ducation and Training in Developmental Disabilities*, Education and Treatment of Children, Education, *Training in Autism and Developmental Disabilities*, *Journal of Applied Behavioral Analyses*, *Journal of Behavioral Education*, *Journal of Behavioral Interventions*, *Journal of Emotional and Behavioral Disorders*, *Journal of Positive Behavioral Interventions*, *Rural Special Education Quarterly*, and *Teacher Education and Special Education*. Additionally, 12 doctoral dissertations and Master's theses were located in ProQuest Dissertation and Theses Database.

Two types of response cards were utilized. Write on response cards constructed of shower board or plastic sheet protects with an inserted manila folder or cards. Response cards were cardstock or paper of varying sizes with preprinted answers. Response systems were developed by three companies including TurningPoint Technologies, Reply Systems, and iRespond.

Response cards at the primary level. Two studies evaluating the use of response cards at the primary level were completed. Dependent measures included time on-task, disruptive behavior, and student participation. Surprisingly, there were no academic measures.

Godfrey et al. (2003) conducted a study evaluating the use of three active responding techniques using an alternating treatment design. Five students with attentional difficulties enrolled in a preschool program participated in the study. Responding techniques included hand raising, choral responding, and response cards.

Findings suggest that active responding and time on-task increased most during the response card condition. Further, decreases in inappropriate behaviors were observed during the response card condition.

Authors acknowledged limitations that included data was collected only during one activity, calendar time. Academic progress was not measured. Only the number of responses was collected, not the accuracy of responses. Additionally, students had previously utilized choral responding and hand raising as means of responding during instruction. Therefore, a novelty factor may have occurred. While there were limitations, the study indicates that response cards may prove beneficial for managing behavior during circle time. Additionally, response cards could serve as a viable option for students who exhibit communication delays or are non-verbal.

Wood, Mabry, Kretlow, Ya-yu, and Galloway (2009) evaluated the participation and off-task behavior of four target students during circle time in a general education, rural Kindergarten classroom. Two of the four students had disabilities. One female student received services as a student with a developmental delay and the other male student has a speech and language impairment and specific learning disability. Student participation increased and disruptive behavior decreased for all four students.

Several limitations are noted. First, academic measures including correct responding were not evaluated. Also, students were seated in close proximity to one another which resulted in background noise from shuffling cards and the teacher reported that students indicated they had trouble hearing at times.

Response cards at the elementary level. Eight studies were completed with elementary students. Studies were completed within all core academic areas within general and special education settings. Two studies included only behavioral measures. The remaining six studies included academic measures.

Reading. Monro and Stephenson (2009) explored the use of response cards during vocabulary instruction. Five participants were selected due to low rates of classroom participation. Three students were English language learners who enrolled in the school 2 to 4 years prior to the study. Four out of five students earned higher test scores in the response card condition as compared to the traditional response condition.

While there is some evidence that the use of response cards might prove beneficial, a pretest was not administered so the level of prior knowledge could not be assessed. Additionally, despite increased in test scores, overall scores were still relatively low. While results are encouraging for the use of response cards as a strategy to support English language learners and low responders participants level of English acquisition was not reported and participants were from three different countries that may attribute to differences in participation expectations. None the less, there was some evidence that further exploration on the use of response cards with English language learners, and low responders, is warranted.

Clarke (2011) also evaluated the use of response cards during general education vocabulary instruction. Like Monro and Stephenson (2009), Clarke indicated that test scores results were variable during both response card and hand raising conditions.

Math. Christle and Schuster (2003) studied the effects of response cards on student participation, academic achievement, and on-task behavior during whole group mathematics instruction. A reversal, ABA, design was utilized to ascertain the effectiveness of response cards, plastic sheet protectors covering half of a recycled manila folder, dry erase marker, and small felt eraser, on the math achievement of 4th graders enrolled in a general education math course. Twenty four students, 9 boys and 15 girls, participated in the study. Eight of the 24 students were from Hispanic descent. From the 24 students in the class, five students were selected by the teacher as being representative of the class range of academic skills, participation, and on-task behavior. Three of the five students for whom data was collected were of Hispanic descent.

Academic progress was measured through weekly quiz scores. Students were administered a quiz consisting of 25 questions or problems derived from workbooks based upon material covered during the week. Scores were reported as a percentage correct. Weekly quiz scores increased for all five participants from the first baseline (range = 63% - 97%) to the response card condition (range = 93% - 100%). Conversely, each student's score remained stable or dropped during the second baseline phase (range = 58% - 100%).

Limitations include varying numbers of questions posed during each class session and relatively short baseline and intervention phases. Reliance of teacher perception to choose participants could be biased and not representative of typical classroom norms. While two of the five students received supplemental support from a Title 1 instructor, none of the students were identified as having disabilities. Further, pretests were not provided nor was the number of weekly tests reported. Finally, a second intervention phase was not included.

In 2006, Lambert et al. conducted a study comparing the use of response cards and traditional hand raising on the correct responses elicited during fourth grade mathematics instruction. Four students in classroom A and five students in classroom B were selected as target students as they were believed to represent classroom demographics. Correct responses were recorded during the hand raising condition when a student raised his hand, was called on by the teacher, and the student elicited a response. Correct responses during the response card condition were counted if a student recorded the teacher identified correct answer on his whiteboard. Students were not penalized for spelling errors. The classroom teacher served as the primary data collector. Twelve questions were posed within a 10 minute time frame for a rate of 1.2 questions per minute. Participants were five females and four males between the ages of 9-4 and 10-8. Eight of the nine students were of African American decent and one student is of Caucasian decent. The mean correct response rate during the hand raising condition was 0.12 responses per minute and .82 correct responses during the response card condition.

While the study provided evidence that response cards increase correct responding, several limitations should be noted. First, the teacher served as the primary data collector and instructor. This may have impacted instructional choices. Additionally, wrist watches were used to record time which may have impacted data collectors' ability to simultaneously attend to both time intervals and data collection. Further, response data was collected for only target students in the class, question levels varied across lessons, and functional behavior assessment was not completed prior to study implementation.

Science. Gardner, Heward, and Grossi (1994) extended the Narayan and colleagues (1990) study comparing traditional response methods of hand raising to write on response cards in an urban fifth grade science classroom. Dependent measures included a) teacher presentation rate, b) number of student responses, c) accuracy of student responses, d) next-day quiz scores, and e) biweekly review test scores. Social validity data was collected via a two question interview completed with each student. Findings indicated that all 22 students scored higher on the next day quizzes and biweekly tests in the response card condition. Moreover, 19 out of 22 students shared that they felt response cards helped them during instruction more than hand raising, and 20 out of 22 students said that response cards increased their academic performance.

Skibo, Mims, and Spooner (2011) used an alternating treatment multiple probe design to evaluate the use of response cards with three students between the ages of seven and ten with intellectual disabilities. Student intelligence scores ranged from 20 to 44. The primary dependent measure was the number of correct responses elicited which increased during the response card condition for all three students providing further evidence that students with significant disabilities' achievement can increase with the use of response cards. Limitations include a small number of participants and the instructor serving as the researcher. Future studies should evaluate teachers implementing the intervention with larger sample sizes.

Social studies. Narayan and colleagues (1990) evaluated the use of write on response cards on teacher question rate, student participation, and quiz scores in a general education fourth grade classroom. Eight boys and twelve girls participated in the study. Students averaged 13.0 correct responses during the response card condition as compared to 7.4 correct responses during the hand raising condition. Additionally, 13 out of 20 students earning higher quiz scores in the response card condition students averaged 13.0 correct responses during the response card condition as compared to 7.4 correct responses during the hand raising condition. Most students, 12 out of 20, indicated that response cards helped them to learn material and 14 out of 20 students shared that they earned better quiz scores during the response card condition.

Study limitations include the teacher serving as a primary data collector and the researcher serving as instructor. Quizzes were administered the same day as instruction and no pre or post tests were administered so it is difficult to determine if response cards were the sole source of increases in quiz scores.

Behavior. In addition to academic measures, Narayan et al. (1990) evaluated the rate questions posed by the instructor, student responses, and student perceptions of the use of response cards. While presentation rates were higher in the traditional hand raising condition, only one student had the opportunity to respond at a time. During the response card condition, the rate of student questioning was slightly lower but more students had the opportunity to answer each question. The number of student responses was calculated for six students whose behavior and academic performance was commiserate with the class. During the traditional hand raising condition, target students raised their hands an average of 11.6 times per session (range = 9.2 to 13.7) and 15.6 times during the response card condition (range = 13.5 to 17.6). Limitations include that the researcher served as the instructor thus having the potential to alter question rates that may not be indicative of traditional classroom norms.

Armendariz and Umbreit (1999) evaluated the effects of response cards on the behavior of a bilingual third grade class consisting of 10 boys and 11 girls for a total of 21 participants. Students were eight to nine years old and were from “lower socioeconomic backgrounds”. The study employed a single subject, ABA, reversal design. While the study took place during mathematics instruction, the only dependent measure was disruptive behavior. Disruptive behavior was defined as “getting up from seat, touching others, speaking out loud without raising hand, taking , moving head up and down or from side to side, talking to others, looking at the response cards of others, drawing on response cards, or flapping hands or any other object. During the baseline phase, which consisted of five sessions of traditional instruction that included traditional oral questions posed by the instructor and students raised their hands to respond. The intervention phase each student was provided with a piece of write on white board (12 in x 9.5 in) and dry erase marker for six sessions. The teacher posed questions following a script and students were instructed to write their answers on the response card and then hold the response card to their chest. A two minute time sampling procedure was utilized to evaluate disruptive behavior. Students then shared answers when directed by the teacher. Data was collected for three sessions during the second baseline, traditional instruction, second baseline phase.

Comparison of class means during the baseline and intervention phase indicated an 86% decrease in disruptive behavior (range = 59% - 100%). Class means between the response card condition and the second baseline condition indicated a significant increase in disruptive behavior for the majority of participants (n = 15). Three students' disruptive behavior remained constant and three students demonstrated a slight decrease in disruptive behavior between the last phases. Further 19 out of 21 participants reported that they preferred using response cards to traditional hand raising.

Armendariz and Umbreit (1999) evaluated the behavioral impact of response cards while previous studies (Gardner et al., 1994, Narayan et al., 1990) focused on academic outcomes. Further, the study was the first to have the teacher serve as the interventionist providing some evidence of practicality. However, the teacher did not utilize response cards beyond the study duration indicating that the practicality of the intervention may be problematic. While academic outcomes were not measured, the study applied response cards as an intervention in mathematics, extending the literature base from science (Gardner et al., 1994) and social studies (Narayan et al., 1990). However, the authors acknowledged significant limitations to include: (a) the limited duration of the study, (b) the instructor's behavior may have been altered as a result of being under the researcher's supervision, (c) the class size was smaller than many general education settings, (d) teacher perceptions of the intervention were not obtained, and (e) student behavior was neither aggressive or extreme. Additionally, only one treatment phase was completed. While disruptive behavior was less than in the second baseline phase than the first, observations two months after the final phase indicate that disruptive behavior had returned to the levels in the initial baseline phase. Finally, the authors suggested, additional attention to procedural reliability and observations in larger settings with students displaying more problematic externalizing behaviors.

Christle and Schuster (2003) also evaluated the behavioral effectiveness of response cards during elementary mathematics instruction. In addition to an academic measure, the number of student initiated response opportunities; number of student responses, and time on-task were recorded. A frequency count was utilized to record the number of times a student raised his hand after the teacher posed a question during the baseline phases or each time a student wrote an answer on the response card. During the hand raising condition, students raised their hand to answer questions from 0% to 100% of the opportunities and were called on to answer questions between 0 and 3 times. During the response card condition students answered 97% to 100% of the questions posed. Further, the average number of questions asked during the hand raising condition was 15 during the baseline phases compared to an average of 22 questions posed during the response card condition. Time on task was evaluated using a time sampling procedure which each of the five target student's behavior was calculated on five minute intervals over a 60 minute instructional block.

Christle and Schuster (2003) defined on-task behavior as (a) the student is seated in his/her seat and facing the teacher or some object directed to by the teacher, (b) the student having his/her hands on his/her own materials or raised when a question was asked by the teacher, and (c) the student was not talking unless he/she was called on by the teacher during the hand raising phases. During the response card phase, on-task behavior was described as (a) the student is seated in his/her seat and facing the teacher or some object directed to by the teacher, (b) the student is engaged with only his/her materials, or engaged in writing an answer on his response card and raises it when a question was asked by the teacher, and (c) the student was not talking unless the teacher asked him/her to orally respond. All students increased their time on-task.

The authors reported several limitations that included the study were quite brief, consisting of only 12 sessions and employed an ABA design which did not afford a second treatment option. Additionally, the number of questions posed varied among phases. Suggested future research include evaluating the use of response cards with students with exceptionalities, ensuring questions remain consistent across probes, and the collection of maintenance data.

Berrong and colleagues (2007) evaluated the use of preprinted response cards during calendar time. Eight students, three females and five males between the ages of 10 and 12, with moderate to severe disabilities participated in the single subject study which utilized an ABAB design. Student intelligence scores ranged from 41 to 59 and the study took place in a self-contained special education classroom. In the baseline, A, conditions students responded to questions by raising their hands. During the treatment, B, conditions students placed 3 in x 3 in preprinted cards on a response board. Each condition lasted a minimum of 5 sessions. Nine questions were asked pertaining to (a) weather, (b) temperature, (c) season, (d) month, (e) day of the week, (f) special class, (g) date, (h) special events or birthdays, and (i) the current year. Rules were reviewed daily and a classroom token economy was in place.

Like Armendariz and Umbreit (1999), dependent measures were exclusively behavioral. Percentage of active responding, time on-task, and inappropriate behavior were evaluated. Overall, active responding and time on-task increased and rate of inappropriate behavior decreased.

An active response was considered if a student raised his hand, tapped the table, or held the response card. Group mean percentages of active responding during the first baseline condition was 21.7 (range = 14.8 - 30) and 58.8 (range = 54 - 65) during the first treatment condition. The second baseline condition group mean was 28.7 (range = 25 - 33%). Similar to the first treatment condition, the percentage of active responding was 56.3 (range = 49 - 63) during the second treatment condition. No overlap occurred between conditions. Data was also analyzed at the student level. Percentage of active responding increased for seven of the eight participants during the first baseline to intervention phase. One student's percentage of active responding decreased from the second hand raising to the second response card condition. Two students did not actively respond during the second hand raising or response card conditions. One student responded more frequently during the hand raising conditions than the response card conditions.

Conversely, on-task behavior was defined as the student is (a) actively engaged in answering the instructor question, (b) looking at the instructor if she was talking, or (c) looking at a student who was answering a calendar question. Group means for on-task behavior during the baseline conditions were 35.7 (range = 28 - 45.7) and 36.9 (range = 22.5 - 54). Means during the respective response card conditions were 79.4 (range = 66.6

- 93) and 71.5 (range = 65.7 - 77.7). There was no overlap at the group level. At the participant level, each student's on-task behavior increased during the intervention phases. Further, participants demonstrated more on-task behavior during the response card condition then the second hand raising condition.

Finally, a frequency count was utilized to evaluate inappropriate behaviors which included (a) out of seat without permission, (b) talking or yelling without being called on by the teacher, and (c) hands on other participants. Mean inappropriate behaviors per minute across the group was calculated. Mean rate of inappropriate behavior was 0.77 (range = 0.5 - 1.2) and 0.89 (range = 0.76 - 1.14) during the first and second baseline conditions. During the treatment phases, the rate of inappropriate behaviors was 0.40 (range = 0.2 - 0.43) and 0.27 (range = 0.17- .04). There was a 14.3% overlap during the first hand raising and response conditions and no overlap between the second baseline and intervention phases.

Results suggest that the use of response cards for elementary students with moderate to severe disabilities is promising. The authors reported limitations that include the small number of participants, highly variable intelligence scores among students, the lack of academic performance data, and the varying difficulty of questions within one subject area. Additionally, maintenance data was not collected nor was student or teacher perceptions of the intervention reported.

In addition to academic measures for the entire class, Gardner et al. (1994) evaluated the participation rates of five target students who were selected as they represented the response behaviors of the class. Like Narayan et al. (1990), Gardner and colleagues studied the number of questions posed by the instructor during both traditional and write on response cards conditions. All five students increased responses during the response card condition, with a mean increase of 14%. As previously found, teachers posed more questions during the hand raising condition. However, during the response card condition learning trials increased (1 question presented x 30 minutes x 22 students) as opposed to hand raising (1.5 questions presented x 30 minutes x 1 student).

Gardner and colleagues (1994) noted that accuracy of student response was greatest in the area of recall questions. It was recommended that future studies explore the efficacy of the type of question appearing during instruction and student success with a similar question type on an assessment. Additionally, on-task behavioral measures were recommended. One limitation of the study was that the researcher implemented the intervention. Therefore, an exploration of the practitioner implementation of response cards is warranted.

As with previous studies, Munro and Stephenson (2009) collected behavioral data. Findings indicate that the rate of questions was 1.01 per minute during the hand raising condition and 1.06 questions per minute during the response card condition. While slight, the increase in the rate of question is unlike the findings of Narayan et al. (1990) who found slightly higher questioning rates in the hand raising condition. Low to no participation rates were observed for all participants during the hand raising condition and 46% to 100% participation rates were observed during the response card condition.

Response cards at the secondary level. The efficacy of response card use at the secondary level was evaluated in language arts, social studies, mathematics and academic review. Dependent variables included both academic and behavioral measures. The majority of studies evaluated the use of response cards with students exhibiting more severe disabilities.

Language arts. Davis and O'Neil (2004) explored the use of traditional response methods, hand raising, and response cards in a middle school writing instruction class. The study took place in a resource classroom. Participants included seventh and eighth grade students with learning disabilities, including students who received both special education and English as a Second Language (ESL) services. Six, out of a class of 11, students were initially selected for study participation due to problematic behaviors and low levels of academic responding. Two of the six students were subsequently removed from the class due to behavioral incidents. Therefore, four students participated in the study. Three females, two received ESL and special education services due to learning disabilities and one with traumatic brain injury, and one male with learning disabilities participated in the study that employed an ABAB design. Instruction included activities that writing business and personal letters, grammar, and usage. Academic measures included a percentage of correct academic responses and weekly 12 question fill in the blank quizzes.

Mean correct responses during instruction were 91percent in the response card condition and 74% in the hand raising condition. Additionally, weekly quiz scores were significantly higher in the response card conditions (*M* = 88%) than in the traditional hand raising conditions (*M* = 19%).

The study provides some evidence that English Language Learners (ELLs) and students with comorbid learning disabilities and language instruction needs may academically benefit from the use of response cards. However, several study limitations were noted. These limitations, similar to previous studies, include a relatively short study duration, small number of participants, and varying behavioral systems in the hand raising and response card conditions. None the less, the study was one of the first to take place in a resource setting. Interestingly, students reported preferring hand raising to response cards. Researchers indicated that this may in part be due to the reinforcers, beans in a cup, for a correct response in the hand raising condition.

Math. Horn and colleagues (2006) evaluated the use of preprinted response cards on the response accuracy of three students with moderate to severe disabilities during a telling time lesson. One female and two males between the ages of 12 to 15 years served as participants. The classroom was located in a rural school division. Data was collected during the ten minute telling time group. Ten questions were asked during each session. Mean percent of correct responses during the first hand raising condition was 60% and 56.6% during the second condition. The present of correct responses was 90% at the conclusion of the first and second response card conditions. Like previous studies, use of response cards were evaluated during only one activity. There were only three participants and the use of response cards was new to students so a novelty factor may have influenced study results.

Weatherford (2011) completed a six stage task analysis of three students with intellectual disabilities learning to tell time. The study evaluated correct and incorrect responses finding increased response accuracy, higher quiz scores and increased biweekly test scores between pre- and posttests with response cards. However, quiz score data was variable and inconclusive.

Science. Cavanaugh, Heward, and Donelson1996) investigated the use of response cards during lesson closure. The study included 23 ninth grade students enrolled in an earth science course. Eight of the 23 students had documented mental, behavioral, or learning disabilities or were “at-risk for not completing high school”. The study utilized an alternating treatment design to evaluate the use of passive review which involved the teacher orally reviewing key terms and active review sessions which required students to utilize write on response cards. Dependent variables included 30, 12-item next day tests and 11, 42-item weekly tests. Test items were derived from key points stressed during daily lessons and summarized during lesson closure. During the passive responding session the teacher summarized key points. During the active responding session, students identified key words or phrases that were iatrical parts of the daily lesson. Interobserver agreement was completed for 17 next day tests and four weekly tests with mean agreement at 99.3%. Procedural reliability was also completed for 29 sessions with 100% accuracy.

Results indicated that 13 of the 15 general education students and all 8 students with exceptionalities increased mean test scores during the active responding sessions. Weekly test results were also significantly higher in the active responding conditions.

Students did not indicate a preference for passive or active response options. However, participants reported learning the same or more and that they enjoyed the content the same or more than in other science classes. Moreover, the teacher reported that the students were more attentive during the response card conditions.

Study limitations included the lack of a pretest prior to the onset of the study. Therefore, familiarity with content could not be established nor could variations within the data be accounted for. Additionally, the authors did not operationalize the type of response card used, other than to note that "write on" response cards. Further, the specific characteristics of students at-risk or with disabilities were not clearly delineated making replication difficult. Finally, behavioral and social data was not collected.

Maheady, Michielli-Pendl, Mallette, and Harper (2002) used an alternating treatment design to evaluate the efficacy of hand raising, numbered heads together, and response cards on sixth graders science achievement. Participants were from diverse backgrounds including four students who were previously eligible for special education services and English language learners. Hand raising and response card conditions were similar to previous studies. During the numbered heads together treatment, students met in teams to determine an answer then responded as a group. Academic dependent measures included accurate responses during instruction, quiz scores, and test scores. Accuracy of responses, quiz scores, and test scores during class were higher in the response card and numbered heads together conditions. Student preferences indicated that they preferred using the numbered heads together and response card methods to raising their hands.

While results were generally positive, Maheady and colleagues acknowledged several study limitations. These include a relatively small sample size (n = 21), limited curriculum areas studied (chemistry), and relatively short study duration. Additionally, generalization and maintenance data was not collected.

Social studies. Al-Attrash (1999) evaluated the use of write on response cards, write on response cards and guided notes, and hand raising as response modes in a high school history class. Academic measures included quiz, tests, and essay scores, number and accuracy of student responses and student preferences. Results indicated increased quiz, test, and essay scores during the response card with guided notes treatment. Approximately half of the students indicated that they preferred the use of response cards with guided notes to traditional response methods such as hand raising.

Swanson (1999) completed a two-phase study on the use of response cards and then the use of response cards, self-monitoring, and goal setting in a general education social studies classroom. The first phase evaluated the use of response cards and hand raising. The second phase involved the study evaluated the use of response cards and self-monitoring and then response cards, self-monitoring, and goal setting. Results indicated that target students with and without learning disabilities scored higher on quizzes and tests in the response card conditions. Moreover, students preferred using response cards in isolation than to using response cards with goal setting and self-monitoring or to hand raising.

Over a decade later, George (2010) completed the first quantitative study evaluating the use of write on response cards in middle school social studies classrooms.

A crossover design was utilized with 29 middle school students ranging in ages between 11.7 and 15 years old from five classrooms. Academic measures included correct responses and chapter post test scores. Increases in correct responses during lectures as well as gains in test scores were observed. Additionally, students reported that they remembered more information and increased quiz and test scores when using response cards.

Academic review. Duchaine (2011) evaluated the use of response cards two general education courses focused on academic remediation. Six students with behavioral problems participated in the study, 3 students without disabilities served as comparison peers and three students with disabilities participated in the study. Results indicated that quiz scores increased by at least 10% of 3 out of 4 students enrolled in one class. The daily quiz scores were higher for all students enrolled in the second class during the response card condition. However, results for next day quizzes were inconsistent. Biweekly test results suggested that students generally increased retention of material overtime.

Behavior. Horn and colleagues evaluated behavioral outcomes. As in previous studies, increases in student active responding and on-task behavior were observed. Conversely, decreases in inappropriate behavior were observed. Limitations as previously discussed, provide a basis for continued study with more students across suburban and urban schools.

Maheady and colleagues (2002) also measured the number of responses emitted by students and teacher question patterns. Student participation was higher in the response card and numbered heads together conditions then in the hand raising condition. Students demonstrated a greater number of responses during the response card and numbered heads together conditions.

In addition to academic measures, George (2010) conducted behavioral analyses in the areas of on-task behavior and attempted responses. Increases in time on-task and attempted responses were observed. However, study duration was relatively short. Therefore, investigation into the merits of the use of response options over longer periods of time and teacher perceptions of the use of response cards are warranted.

Duchaine (2011) also evaluated time on-task and attempted responses. Like previous studies, student response attempts and time on-task increased during the response card condition. While results are promising, the author noted that some challenges with on-task data collection. At times, students were exhibiting off task behaviors; yet, they volunteered to answer a question. Also, only three students participated in the study, each with a differing disability classification. See Appendices B and C.

Response systems at the elementary level. Studies compared traditional response methods, such as hand raising, with student response systems in language arts, mathematics, and history. Dependent variables included both academic and behavioral measures. The sample included 197 students enrolled in general education third, fourth, and fifth grade classrooms.

Language arts. Abdoe (2010) evaluated the use of a student response system, “Clickers” by SMART technologies on third grade language arts critical standards.

While there was some variance within the dataset, students in the response system condition earned higher test scores that then the control group. While achievement pre- to posttest gains were mixed, students and teachers reported that they learned more when using response systems. Teachers reported that students learned more and they provided greater feedback during the response systems condition.

The researcher acknowledged several limitations which included significant differences between the control and treatment groups with the treatment group having a larger number of students performing “below basic” or “far below basic”. Also, several students did not complete entire tests with teachers reporting they allowed students to stop taking the test because it was too long and the students appeared to be tired.

Math. In addition to language arts measures, Abdoe (2010) also evaluated the use of response systems in third grade mathematics. While the control group outperformed students in the treatment group in mathematics, the teacher acknowledged to the researcher that she provided additional homework and feedback in the areas evaluated.

Social studies. Lively (2010) evaluated the use of an electronic response system on four, fourth and fifth grade history domains. Students enrolled in two fourth grade and two fifth grade classrooms served as participants. As with Abdoe (2010), achievement results were inconclusive. The classrooms that used the classroom performance system outperformed students in the comparison classrooms on history and economics measures and about the same the comparison group on civics measures. Students in the traditional instruction group demonstrated greater geography gains than the treatment group.

The most notable limitations include that all of the fourth graders served as a comparison group and all of the fifth grades served as the treatment group. Additionally, the researcher served as the fifth grade teacher. Given the significant limitations acknowledged by both researchers, additional research is needed with elementary students, particularly those performing significantly below grade level.

Behavior. In addition to academic measures, Abdoe (2010) also evaluated motivation and engagement. While academic measures were inconclusive, survey and interview results indicate that student motivation and engagement was significantly greater for the classes using response systems than comparison groups.

Response systems at the secondary level. Studies compared traditional response methods, such as hand raising, with student response systems in several content areas including mathematics, science and history. Three studies were completed within middle school mathematics, three studies within high school science, and two in high school social studies. Dependent variables included both academic and behavioral measures. The sample included 374 students. All studies occurred in the general education classroom with the exception of one study in a special education classroom for students with EBD.

Math. Grissom (2006) evaluated the use of a student response system, Clickers, with 6^{th} grade student achievement. Participants included 84, typically achieving 6^{th} grade students. No significant differences were observed between comparison and treatment groups. While there were no significant differences in achievement scores or teacher to student feedback, there were increases in student to student conversations in the response condition group. Limitations include relatively low sample size and threats typically associated with intact groupings used in quasi experimental research.

Rigdon (2010) evaluated the use of a student response system called Quizdom. While students reported that they learned more during the lessons, there were no significant achievement differences between pre- and posttest measures. Limitations include that the intervention was completed in a district where the researcher served as a district administrator; thus survey results of student and teacher perceptions maybe influenced by the researcher. Additionally, tests were not normed by a group of outside mathematics specialists.

Sartori (2008), like Abdoe (2010), also evaluated the use of a student response, system, Clickers, by Turning Point Technology. Participants included 108 average achieving students enrolled in middle school mathematics courses. Like previous research, there were no significant differences in pre- and posttest measures. However, teachers and students reported higher achievement in the group that used Clickers. There are several limitations which include that the sample was from a group of teachers who elected to use Clickers in their classrooms and data was provided by the district technology specialist. Also, the population only included average achieving students enrolled in a district where over 90% of students are passing state testing standards. Thus, there may be a potential for a ceiling effect.

Science. Three studies were completed at the high school level evaluating the use of student response systems in science courses. Conoley (2005) evaluated the use of an automated student response system in high school agriscience courses. Significant increases in student achievement were noted in the groups using response systems. Teachers and students reported perceptions of greater achievement and understanding in the response system group. Limitations included that teachers developed the questions for use in both conditions and therefore, may have been influenced. Also teachers reported spending greater amounts of time developing lessons when using response systems thus potentially increasing the quality of the lessons used in the study. Further, assessments were not evaluated by independent specialists.

As with previous research in science, Gilson (2010) also reported significant increases in student achievement when using response systems for a chemistry unit. Additionally, Gilson four students with disabilities were included the study. The most significant study limitation acknowledged a relatively small sample size (n = 27).

Recently, Mankowski (2011) compared the use of response systems, student response systems with peer mediated instruction and peer mediated instruction in high school science courses. While test scores increased slightly amongst the students using student response system in isolation, significant differences were not observed between peer mediated instruction and peer mediated instruction with response system use.

Social studies. Blood (2010) completed the first study exclusively focused on students with special needs. The effects of a student response system on the achievement of five high school students with emotional or behavior disabilities in a special education setting was explored using a single subject, reversal design. While there were no significant differences in daily quiz scores, slight increases in test scores were observed. Students also reported that they learned more during the sessions which they used

Clickers.   Two significant limitations of the study include a small sample size and relatively few questions posed during an instructional session. None the less, the study provides a sound basis for future research with students who have emotional or behavioral needs. Also, course material was used as a basis for the study which may or may not have aligned with state testing standards.

Behavior. While Grisson (2006) did not find any significant differences in achievement scores or teacher to student feedback, there were increases in student to student conversations in the response condition group. Consistent with previous research, Mankowski (2011) reported that student perceptions of the use of Clickers in the classroom was positive. Blood (2010) explored on-task behavior and student response rates, generally accepted predictors of student engagement, across conditions. Both time on-task and student response rates were higher in the response system conditions.

Conclusion. Studies on the use of response systems have primarily been completed within general education settings with few participants identified as having disabilities. Additionally, the majority of studies are dissertations that are recently published. Therefore, there is a need to evaluate the efficacy of the use of response tools with students with behavioral disabilities within the mathematics domain. See Appendix D.

3. METHODS

The purpose of the methods chapter is to describe the procedures used to carry out the study. The chapter begins with a summary and rationale for the research design followed by a description of study sites, participants, and materials. Next, study procedures and measures are defined. Finally, reliability and fidelity of treatment procedures as well as proposed analyses are outlined.

Design

The study was completed using a crossover design. A crossover design was selected for the following reasons: (a) a crossover design has been successfully utilized to evaluate academic and behavioral interventions within secondary EBD classrooms (e.g., George, 2010), (b) controls for differences between classrooms to include differences in student characteristics (Spencer, Mastropieri, & Scruggs, 2003), (c) can control for teacher effects due to varying styles of instruction (Brigham, Scruggs, & Mastropieri, 1992), and (d) each student serves as his own control as the student participates in each condition.

In order to evaluate the use of traditional response (hand raising), response cards (white boards), and response system (ActivResponders) with three intact groups of students, each classroom received a differing treatment within the same unit of instruction; thus, controlling for not only differences in instructor and classroom dynamics but potential differences among students and units. A graphic representation of the study design is included in Figure 1.

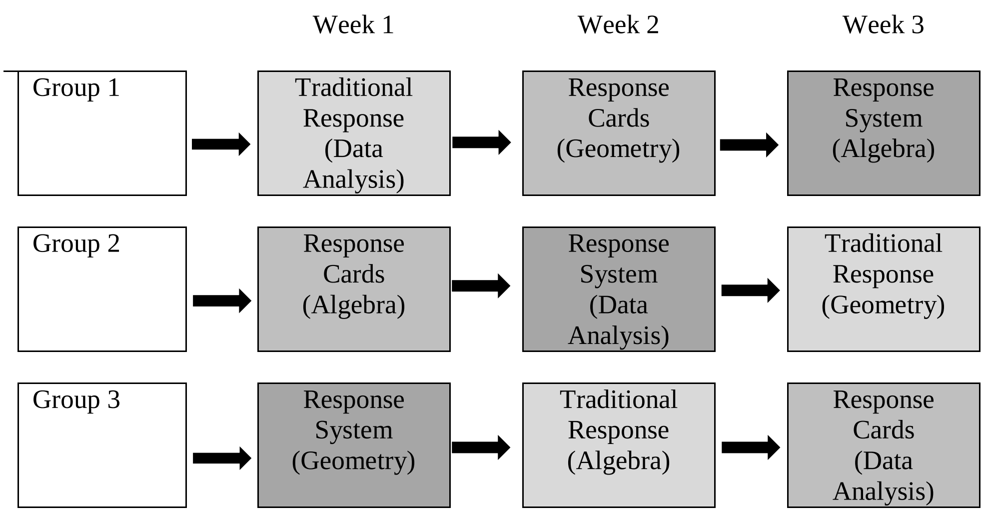


Figure 1. *Graphic Display of Study Design*

Sample and Participant Selection

The researcher identified districts meeting the following criteria: (a) located in an urban setting, (b) provided services to students with EBD within a comprehensive high school, (c) experienced difficulty meeting Adequate Yearly Progress (AYP) in the area of mathematics, and (d) followed the state approved instructional standards for mathematics. The researcher sent study proposals to districts meeting the aforementioned criteria and the research was approved by a district. The researcher subsequently submitted the Human Subjects Review Board (HSRB) application with a letter of district support to the university in February 2012.

Following approval from the HSRB and dissertation committee, the researcher explained the instructional staff consent form to teachers and instructional assistants responsible teaching the district's self-contained classes for students with EBD. Both teachers responsible for self-contained mathematics instruction consented to study participation. One teacher taught two sections of self-contained math for grades 9-11 for students with emotional and behavioral difficulties. A second teacher taught a self-contained section of math for grades 7-9 for students with emotional or behavioral difficulties. Two instructional assistants worked collaboratively among the three class sections also agreed to participate in the study. After consenting to participate in the study, the researcher provided copies of the recruitment letter and parental consent forms to the classroom teacher for distribution to all students enrolled in self-contained classes for students with EBD. After consent from the classroom teachers and participants' parents was obtained, student assent forms were completed by each student prior to collecting data.

Site and Participant Demographics

The research was conducted in a high school located on the north east coast. The school served approximately 927 students, 286 with disabilities. Forty-four students received services in self-contained classrooms for students with emotional and behavioral disabilities.

The high school met 61% of AYP targets in 2011. Reading proficiency scores decreased from 63.7% in 2010 to 52% in 2011. In mathematics, the percentage of students scoring proficient or advanced proficient on state accountability measures decreased from 55.4% in 2010 to 50.9% in 2011. Based on the performance of most subgroups, including students with disabilities, the district was placed on a corrective action plan by the state department of education. Of particular concern, were students receiving special education services and those from economically disadvantaged backgrounds.

The teacher responsible for providing instruction to two sections of self-contained emotional support mathematics in grades 9-11 was a Caucasian female with a Bachelor of Art degree in special education. The teacher possessed level one state licensure in the area of K-12 special education and met state highly-qualified standards in the area of mathematics. The teacher was 27 years old and was in her third year of teaching students with emotional and behavioral disabilities at the high school level.

The teacher responsible for providing mathematics instruction to the 8-9 graders was a Caucasian female with 26 years of teaching students with learning and emotional disabilities at the secondary level. She had Bachelor of Science degree in special education. She was highly qualified in the area of mathematics and possessed a level 2 teaching license with endorsements in K-12 special education.

The instructional assistants were also Caucasian females. One instructional assistant was 45 years old and had served in her current job for 6 years. The instructional assistant had an Associate Degree in Accounting and met district and state highly qualified standards. The second instructional assistant was 53 years old and had worked as an instructional assistant for the past 7 years. The instructional assistant had a high school diploma and met district and state highly-qualified standards through courses and professional development options. The week prior to the study, instructional assistants were informed that the district no longer had funds to support their positions during the next school year. Instructional staff demographics are summarized in Table 1.

Table 1

Instructional Staff Characteristics

Variable	Age	Education	Certification	Highly Qualified	Years Teaching
Teacher 1	27	BA	Level 1	Yes	3
Teacher 2	58	BA	Level 2	Yes	26
Paraprofessional 1	45	AA		Yes	6
Paraprofessional 2	53	HS		Yes	7

Forty-four students from three emotional support classrooms participated in the study, one class included students enrolled in grades 8 and 9 and two classes included students enrolled in grades 9 through 11. The mean participant age was 14.91 years old (range = 13 – 16). A total of 9 eighth graders, 14 ninth graders, 10 tenth graders, and 1 eleventh grader participated in the study. Participants included students who received special education services under the district labels of emotional disturbance (ED), other health impairment (OHI), and intellectual disability (ID) categories. Students receiving services under the OHI or MR classifications were considered to have emotional or behavioral difficulties associated with the disability or a secondary disability of emotional disturbance (ED) that warranted self-contained placement in a classroom designed for students with EBD. Student demographics by class are summarized in Table 2.

Table 2

Student Characteristics

Characteristic	Classroom 1 (n = 10)	Classroom 2 (n = 13)	Classroom 3 (n = 10)
Age			
13	0	0	1
14	2	1	7
15	6	5	2
16	2	7	0
Grade			
8	0	0	9
9	9	3	1
10	1	9	0
11	0	1	0
Primary Disability			
` ED	8	11	7
OHI	2	2	2
ID	0	0	1
Gender			
Male	8	10	6
Female	2	3	4
Ethnicity			
Caucasian	6	7	4
African American	1	3	
Latino	3	3	1

Behavioral profiles were completed in March 2012. Students, teachers, and parents completed the Behavioral and Emotional Rating Scale- 2 (BERS-2, Epstein, 2004) described in further detail below. A student and teacher behavioral rating scale was completed for each participant. The mean student strength index score from student profiles was 67.73 and teacher profiles was 66.67. Nineteen of the 33 participants returned the parent rating scales. The mean strength index was 60.63. Rating scales suggest that all students included in the study exhibit profiles characteristic of students with emotional or behavioral disabilities. Table 3 provides a summary of student, teacher, and parent profiles by class.

Table 3

Behavioral Ratings by Classroom

Variable	Classroom 1 *N*	*M*	*SD*	Classroom 2 *N*	*M*	*SD*	Classroom 3 *N*	*M*	*SD*
Student Strength Index	10	58.30	9.07	13	73.85	18.64	10	69.20	12.36
Interpersonal Strength	10	3.40	1.08	13	6.31	4.15	10	4.70	1.89
Family Involvement	10	3.60	1.58	13	6.69	2.69	10	6.00	1.16
Intrapersonal Strength	10	3.30	1.42	13	5.62	3.04	10	4.70	3.10
School Functioning	10	4.20	1.48	13	5.77	2.17	10	5.80	3.16
Affective Strength	10	5.10	2.38	13	6.54	3.71	10	6.40	1.70
Parent Strength Index	5	60.40	11.01	8	59.13	6.27	6	62.83	8.82
Interpersonal Strength	5	3.60	1.95	8	4.37	1.41	6	3.67	1.51
Family Involvement	5	4.00	1.88	8	3.75	1.29	6	4.83	1.17
Intrapersonal Strength	5	3.20	2.05	8	3.63	1.19	6	3.00	1.41
School Functioning	5	3.60	1.14	8	4.75	1.80	6	5.50	1.98
Affective Strength	5	6.60	2.80	8	3.75	1.39	6	6.00	3.03
Teacher Strength Index	10	62.90	7.57	13	67.69	4.13	10	69.10	14.02
Interpersonal Strength	10	4.70	1.42	13	5.69	1.11	10	4.90	2.23
Family Involvement	10	4.50	1.51	13	5.46	.78	10	6.30	2.71
Intrapersonal Strength	10	4.20	1.55	13	5.31	.63	10	4.30	1.95
School Functioning	10	4.00	1.57	13	5.15	1.34	10	5.80	3.23
Affective Strength	10	5.60	2.32	13	4.77	1.70	10	6.20	3.33

Note. Scaled scores of less than 6, or a strength index score of less than 80, is considered to be significantly low; scaled scores of less than 7, or strength index scores of less than 89, indicate a high probably that a student has an emotional or behavioral disorder

The mean intelligence score was in the lower end of the average range (*M* = 91.97, range = 72 – 118). Grade level reading achievement scores ranged from 1.5 to 13.0 (*M* = 5.42) and grade level mathematics achievement scores ranged from 2.1 to 13.2 (*M* = 6.5). Intelligence and achievement scores by class are included in Table 4.

Table 4

Student Intelligence and Achievement Means and Standard Deviations

Variable	Full Scale IQ			Math Achievement			Reading Achievement		
	N	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*
Classroom 1	10	93.20	9.90	10	7.29	1.50	10	5.50	2.88
Classroom 2	13	92.69	10.86	13	6.42	3.83	13	5.61	3.27
Classroom 3	10	89.80	14.00	10	5.82	3.32	10	5.10	1.30

Materials

This section provides an overview of the study materials. First, tools to collect demographic data are presented. Second, a summary of lesson plans including format and objectives across conditions is presented. Third, a description of tools used during each of the treatment conditions is provided.

Demographic data. Three measures were used to gather information related to participant demographics. The measures included the instructional staff demographic sheet, student demographic sheet, and BERS-2.

Instructional staff data sheets. The researcher created an instructional staff demographic data sheet. The sheet included the following information: (a) teacher first name, (b) ethnicity, (c) age, (d) degree(s) earned, (e) years teaching special education, and (f) years teaching secondary mathematics. The instructor data sheet form is included in Appendix E.

Student data sheets. The student demographic data sheet was adapted from Spencer, Mastropieri, and Scruggs (2003). The student demographic data form included information pertaining to the following: (a) student first name, (b) age in months, (c) grade level, (d) gender, (e) ethnicity, (f) disability areas, (g) initial eligibility date, (h) years in special education, (i) primary language, (j) intelligence test, date of administration, and score, (k) reading achievement test, date of administration, and score, (l) math achievement test, date of administration, and score, and (m) and state math testing participation and scores. The student demographic sheet is included in Appendix F.

Behavior rating scale. The BERS-2 is a norm referenced measure designed to evaluate the following domains: (a) interpersonal strength, (b) family involvement, (c) intrapersonal strength, (d) school functioning, and (e) affective strength (Epstein, 2004). The measure includes parent, teacher, and student rating scales that are triangulated to develop a student provide. Each rating scale takes approximately 10 minutes to complete.

The BERS-2 is designed to assist schools with determining the likelihood of emotional or behavior disorder and services for students. Epstein (2004) notes, as with other screening tools, results should be reviewed with caution and should not be the sole factor in determining eligibility. Subscale scores range from 4 to 20, with scores between 4 and 5 indicating a very high likelihood of emotional or behavioral disorder and subscale scores between 6 and 7 indicating a high likelihood of the presence of emotional or behavioral disorder. Strength index scores between 70 and 79 indicate a very high, 80-89 high, and 90-110 low probability of emotional or behavioral disorder (pp. 30). The California Evidenced-based Clearinghouse for Child Welfare (2012) assigned the BERS-2 an assessment rating of “A”, indicating that the assessment is deemed reliable and valid in two or more peer reviewed published studies.

Lesson plans. Three math strands, data analysis, geometry concepts, and algebra concepts, covering topics presented during the school year that are included on the state assessment test were selected by the division director of special education and researcher based on school and student data. A five lesson unit was developed by mathematics specialists, highly qualified special educators, and the researcher in consultation with the district special education director and classroom teachers. The mathematics specialists were highly qualified licensed mathematics teachers with Master of Education degrees. Each had a minimum of five years teaching experience at the secondary level within their respective content areas. Each lesson included a statement of strand and objective and a brief, approximately ten minute, review of the concepts presented to students during the first semester of school year 2011-2012. Each lesson covered a portion or entire state standard for the area of math study. Lessons included 15 questions that were presented in the state testing format on slides to be projected on a classroom Promethium Board.

Following the statement of standard and review, the lesson plan indicated that the teacher presented as many questions as possible for 30 minutes. After the fifth lesson, the lesson plan indicates administration of a 10 question multiple choice quiz. See Appendix G for a sample lesson plan.

Pre-intervention materials. The teachers shared that students used both response cards and ActivResponders in elementary school. They reported that white boards had been used in classrooms a few times during the beginning of the school year. Both teachers shared that students are familiar with both response modes. Additionally, both teachers indicated that the typically teach students in a whole group format and provide students with a pencil, paper, formula sheet, and calculator. Teachers share that they use the PaceMaker Pre-Algebra and Algebra textbooks and supplemental worksheets (Pearson, 2002a, Pearson, 2002b) provided by the district.

Traditional response condition materials. Teacher materials include a lesson plans and slides that project questions for the review portion of the lesson developed in accordance with the aforementioned procedures. Student materials include a formula sheet created by the state department of education, TI-85 calculator routinely used during instruction and permitted on the state standards assessment, number 2 yellow pencil, and an 8.5in x 11 piece of white scrap paper. Response card condition materials. Like the traditional response condition, teacher materials include the lesson plans and slides. Whiteboards were created using laminated shower board from a home repair store. The larger board was cut into 8.5 inch by 11 inch squares (Brigham, Hott, Emanuel, & Jenkins, 2010, Heward et al., 1996; George, 2010). Each student was also provided with a black, non-toxic, chisel marker and a 2 inch by 2 inch piece of felt for erasing. Student materials included a: (a) formula sheet, (b) TI-85 calculator, (c) 8.5 in. x 11 in. piece of shower board with duct tape around the edges (Hott & Walker, 2012), (d) black low-odor dry erase marker, and 2 in by 2 in piece of grey felt for erasing.

Response system condition materials. Like previous conditions, teacher materials include a lesson plan and slides. The response system includes interactive software that allows teachers to create presentations similar to Power Points. Each student is provided with an ActivResponder, commonly identified as a Clicker that transmits a signal that allows the teacher to collect and display student responses on a promethium board. The ActivResponder, similar to a SmartPhone, allows each student to respond to questions posed on a Promethean Board. Students can input full sentences, phrases, numbers, and symbols or respond to Likert scale, multiple-choice, and true or false type questions. While the data is presented as a class set on the Promethium Board electronic data is stored for each student as the student is assigned an ActivResponder that is associated with a student number. Student materials included a: (a) formula sheet, (b) TI-85 calculator, and (c) ActivResponder.

Procedures

The procedures section describes how the researcher carried out the study. First, a review of teacher reported pre-intervention procedures are presented. Second, a review of demographic data collection procedures is discussed. Third, a description of independent and dependent measures and data collector training is provided. Fourth, treatment fidelity is discussed. Finally, a review of study procedures is provided.

Pre-intervention. At the initial stages of the project, the researcher met with the district director of special education, principal, special education teachers, and instructional assistants. Publically posted district and school data were discussed. The teachers shared the routine class structure, materials, and classroom assessment procedures. The meetings allowed the researcher to develop an understanding of school, classroom, and student needs regarding preparation for state testing initiatives and appropriate content for review sessions.

Both teachers shared that they relied predominantly on whole class lecture followed by a questions from the text or worksheets. The 8th grade classroom utilized the Pacemaker Pre-Algebra text and supplementary materials as the primary resources for instruction. Likewise, the 9th-11th grade classroom utilized the Pacemaker Algebra text and supplementary materials as the primary classroom resources. Each text includes units that incorporate data analysis, geometry, and algebra concepts.

The researcher, teacher, and special education director collaboratively identified three strands of mathematics that were appropriate for students: (a) algebra concepts, (b) geometry concepts, and (c) data analysis. Within each strand, five review areas were identified. A pretest was collaboratively developed by mathematics teachers, a highly-qualified special education teacher, and the researcher. A mathematics specialist reviewed tests to ensure that they were aligned with standards.

Unit plan development. Next, units with scripted lesson plans and assessments were developed by secondary mathematics teachers each with a Master of Science degree in Mathematics. The math teachers worked in collaboration with a highly qualified special education teacher pursing a doctorate in instructional technology. Each math educator had 8-12 years of teaching experience at the secondary level within the research state. Two teachers had experience working with youth experiencing academic difficulty and had taught remedial mathematics courses and one teacher was dually certified in secondary special education and mathematics. After materials were developed, a math specialist and special education specialist reviewed all materials to ensure that they match standards, appear to be equivalent levels of difficulty across lessons and units, and evaluate question alignment with the state standards of learning. Prior to study implementation, the classroom teachers confirmed that material was covered during mathematics instruction and that lessons and assessments aligned with the district and state standards of learning.

The researcher assigned each unit a number and used an online random selection website to determine the order of units. The data analysis unit was presented first, followed by the algebraic concepts unit, and finally the geometry unit for classroom one and then counterbalanced so that each classroom received a differing unit each week. Each unit consisted of 5 review lessons on essential components of the standards within each of the selected domains. Lesson topics within each unit are displayed in Table 5.

Table 5

Unit Lesson Plans

Unit	Lesson Topics
Data Analysis	
Lesson 1	mean, median, mode, and outliers
Lesson 2	stem and leaf and box and whisker plots
Lesson 3	scatter plot correlations
Lesson 4	scatter plot equations
Lesson 5	probability and odds
Algebra	
Lesson 1	evaluating expressions
Lesson 2	solving one-step equations
Lesson 3	solving two-step equations
Lesson 4	solving inequalities
Lesson 5	solving systems of equations
Geometry	
Lesson 1	area and surface area
Lesson 2	perimeter and circumference
Lesson 3	calculating volume
Lesson 4	change in dimension
Lesson 5	the Pythagorean Theorem

Each lesson included a statement of the standard, then a ten minute review of the concept that was previously taught during the school year, immediately followed by 15 questions used for class review. The questions were projected on the Promethium Board. The math and special education teachers completed a mock lesson to ensure that the review portions of each lesson could be delivered within the ten minutes scheduled for lesson review. The lesson required that the teacher proceed through review questions for 30 minutes then administer a quiz following the fifth day of instruction following the data analysis unit. The same procedures were followed during each unit. After the first unit of instruction, a 10 question multiple choice quiz was administered to evaluate progress. After the second and third units, each student was administered a 20 question quiz. The first 10 questions evaluated concepts presented during the first week of instruction followed by ten questions that evaluated material presented during the previous week. The quizzes included two questions from each lesson. The questions were the same questions included on the pretest presented in a randomized order. A week, five instructional days, after the completion of the third unit, a ten question multiple choice quiz was administered to evaluate the retention of week three concepts. After the completion of the geometry unit, the teacher returned to pre-intervention instruction and taught a unit on fractions, decimals, and percentages.

Collection of demographic data. Prior to starting data collection, the classroom teachers completed the student demographic sheets for all student participants and returned them to the researcher. Teachers and instructional assistants completed the instructional staff self-reported demographic information on the instructional staff demographic sheet. The researcher trained a certified special education teacher with a Bachelor of Art degree in Special Education to compile and analyze BERS-2 data. The data collector completed an assessment course as part of her studies and was familiar with behavioral rating scale. The researcher provided training to the data collector until 100% accuracy of profile completion using mock BERS-2 protocols was achieved.

The teacher provided each student with an envelope and BERS-2 parent form at the end of the school day and requested that the student return the parent form in the envelope the following day. The teacher then provided the BERS-2 forms to the data collector. The teacher completed a BERS-2 teacher form for each student participant and the data collector worked with student participants to complete the BERS-2 student edition. She provided reading support and answered student questions about the BERS-2. The data collector completed the BERS-2 profile for each student in accordance with the BERS-2 administration manual. A second data collector reviewed the BERS-2 forms and profile sheets to determine inter-rater reliability.

Traditional response condition. Traditional response condition materials were provided to each student by the instructor. During the traditional response condition, the teacher stated the instructional standard, provided approximately a ten minute review of the lesson concept, and then instructed students to raise their hands to provide an answer to each review question in accordance with the scripted lesson plan. After each question the instructor waited approximately one minute or until the majority of the class appeared to finish solving the problem. The instructor called on a student. The student provided an answer. If the student answered correctly, the teacher provided a praise statement. An example of a praise statement was, "excellent work, [student name] correctly solved the problem." The teacher then moved to the next question. If the student answered incorrectly, the teacher called on another student. If the second student answered the question correctly, the teacher moved to the next question. If the student answered incorrectly, the teacher called on a third student to answer the question. If a student did not volunteer, or a second or third student did not volunteer to answer the question, the teacher provided the answer and a rationale. If the third student answered the question correctly, the teacher provided a praise statement such as "nice job, [student name], you correctly solved the problem". This process was outlined on the lesson plan and is followed until 15 questions are completed or 30 minutes whichever comes first.

Response card condition. During the response card condition, each student was provided with aforementioned response card condition materials. Like the traditional response condition, the teacher stated the instructional standard and provided approximately a ten minute review of the lesson concept. The following procedures are adapted from Lambert, Cartledge, Lo, and Heward, 2002). The instructor posed a question. Next the instructor asked students to write their answers on their whiteboards. After each question the instructor waited approximately one minute or until the majority of the class appeared to have finished solving the problem. The instructor asked students to hold up their whiteboards. If 75% or more of the class provided a correct answer, the teacher provided a group praise statement. An example of a praise statement was, "excellent work, [correct answer] is the right answer." The teacher then moved to the next question. If less than 75% of the class answered incorrectly, the teacher asked students to try again. If the 75% of the class answered the question correctly, the teacher provided a praise statement and moved to the next question. If 75% of the class answers incorrectly, the teacher revealed and explained the answer. This process was outlined on the lesson plan and was followed until 15 questions were completed or the 30 minute timeframe ended, whichever came first.

Response system condition. During the response card condition, each student was provided with aforementioned response card condition materials. Like the traditional response condition, the teacher stated the instructional standard and provided approximately a ten minute review of the lesson concept. The following procedures were adapted from Lambert, Cartledge, Lo, and Heward, 2002). The instructor posed a question. Next, the instructor asked students to write their answers on their whiteboards. After each question the instructor waited approximately one minute or until the majority of the class appeared to have finished solving the problem. The instructor asked students to hold up their whiteboards. If 75% or more of the class provided a correct answer, the teacher provided a group praise statement. An example of a praise statement was, "excellent work, [correct answer] is the right answer." The teacher then moved to the next question. If less than 75% of the class answered incorrectly, the teacher asked students to try again. If the 75% of the class answered the question correctly, the teacher provided a praise statement and moved to the next question. If 75% of the class answered incorrectly, the teacher revealed and explained the answer. This process was outlined on the lesson plan and was followed until 15 questions or 30 minutes were completed, whichever came first. See Appendix L for a sample lesson including detailed, scripted procedures.

Dependent Measures

The following measures were developed and used across conditions: (a) weekly quizzes, (b) delayed weekly quizzes, (c) student participation, (d) student response accuracy, (e) student time on-task, (f) student satisfaction survey, (g) instructional staff satisfaction survey. Quantitative measures were developed to evaluate the effects of response options on: (a) student achievement, (b) participation, (c) time on-task, (d) instructional personnel satisfaction, and (e) student satisfaction. All students were administered a pretest. Qualitative measures included one question on the student satisfaction survey. The staff surveys provided space for teachers and instructional assistants to provide written comments after each of the first nine questions and a question asking to share thoughts and perceptions about each of the response options. Procedures for data collection are presented after each dependent measure.

Pretest. A pretest was collaboratively developed by the researcher, a highly qualified special education teacher, secondary mathematics teachers, and a mathematics specialist. The pretest included 30 multiple choice questions. The pretest included two questions from concepts presented in each lesson for a total often questions per unit. The classroom teachers reviewed and confirmed that questions were appropriate for their students and that the questions aligned with district and state testing standard. Items were presented in the same format as the state accountability measure administered to students by the state's department of education.

The pretest was administered the week prior to the start of unit one. The researcher asked the teachers to distribute the pretests and materials to complete the test. The scoring and administration procedures were practiced prior to the teachers distributing the tests. The researcher observed pretest administration and completed field notes to document standard pretest administration.

The teachers provided each student with a sharpened, number 2 yellow pencil, TI-85 calculator, formula sheet, and pretest. The teacher asked students to complete the test to the best of their ability and provided the entire 45 minute instructional block for students to complete the test. Once tests were completed, the teacher graded tests. Each question was scored binominally, either correct or incorrect. If a student did not complete a problem, it was marked as incorrect. Then pretests were scored as a total percentage as well as a percentage correct within each section. A data collector with a BA in special education completed reliability checks on over 30% of pretest scores.

Unit quizzes. A ten question quiz, following state testing standards format, was collaboratively created by a high-qualified special education teacher, mathematics teachers, and the researcher. Quizzes were administered at the conclusion of each unit during a flextime block at the end of the school day. Quizzes contained 10 multiple choice questions from the instructional unit completed during the week. The questions were the same questions addressing standards from each unit included on the pretest. A data collector graded quizzes and a secondary data collector independently graded quizzes. See Appendix H for a sample unit quiz.

Delayed unit quizzes. Delayed unit quizzes contained the same questions from the pretest for the unit completed one week prior to the intervention. The delayed unit questions followed the unit quiz questions for a total of 20 questions administered in weeks 2 and 3 of the study. A data collector graded delayed unit quizzes in the same manner as weekly quizzes and the pretest. A secondary data collector completed reliability checks for all of the quizzes. See Appendix I for a sample delayed unit quiz.

Student participation rate. Two measures of participation were collected across each condition, percentage of attempts to respond to a question and percentage of correct responses. The researcher created a map of the classroom and system for recording student responses and accuracy of responses for each condition. The recording sheet was modeled after Hott et al. (2011). Two assistants from local colleges were trained to collect student participation data. One assistant was a junior studying elementary education at a local four year university. He completed courses in exceptional learners and classroom management during his sophomore year. He was familiar with event recording procedures. The second assistant attended a local community college and was enrolled in an instructional strategies course at the time of the study. She was scheduled to graduate with an Associate Degree in early childhood education at the conclusion of the semester.

Each research assistant was trained to collect data on a form that included a map of the classroom codes for each question. Data collectors were trained by the researcher using you tube of a classroom where a variety of disruptive behaviors could be observed. During the hand raising condition an attempt to answer a question was defined as a student raising his hand after a question was posed during the review portion of the lesson. Event recording was used to tally the number of questions attempted and the number of questions answered correctly. To calculate the rate of responses, the data collector divided by the total questions presented during the practice portion of the lesson with the total number of questions a student attempted to answer (Alberto & Troutman, 2009). The rate of correct responding was determined by dividing the number of correct responses by the total number of questions posed (Alberto & Troutman, 2009). Participation rate was calculated for each student.

During the response card condition, an attempt to answer a question was defined as a student writing a response to a question posed by the instructor on his board. Like the hand raising condition the total questions attempted was divided by the total questions posed to determine the percentage of attempted responses. Likewise, the number of questions answered correctly was divided by the total number posed to calculate the percentage of correct responses.

During the response system condition, student response attempts were calculated by the number of responses entered for a question divided by the total questions posed. To determine the percentage of correct responses, the number of correct answers provided by each student was divided by the total number of questions posed within each condition. Student responses were recorded by the Interactive software. At least 30% of the printed reports were verified by a data collector. See Appendix J.

Time on-task. The time on-task definition was adapted from Regan, Mastropieri, and Scruggs (2005). Time on-task was operationally defined as the student being: (a) in his designated area of room, (b) is manually engaged with appropriate materials, (c) is complying with teacher directives, (d) refrains from making derogatory comments about task/others; (e) asks relevant question(s) to adult, (f) maintains focus on appropriate task or to the lecture, and (g) may appear in thought by intermittently and quietly looking away from material or lecture material but is engaged only with self. To measure time on-task a momentary time sampling procedure was utilized. The researcher created a momentary time sampling chart similar to Hott and colleagues (2010). Observations of student behavior were collected on one minute intervals by a trained instructional assistant. A data collector observed 40% of time on-task measures.

Using a timer, the data collector observed each student beginning with the student sitting on the far right hand front seat of the classroom, followed by each student in the that row. The data collector then glanced at each student in the second right hand row observing from the front. Percentage of time on-task was calculated for each student. See Appendix K.

Instructional staff satisfaction survey. To assess the social validity of the interventions, the researcher created a 10 question survey modeled after Hott et al. (2010). Following each question a space for comments was provided. Each teacher completed the10 question survey after administration of the last delayed quiz.

Procedural Integrity and Reliability Measures

Procedural integrity measures were developed to evaluate the consistency of intervention implementation. Reliability measures were developed to ensure that measures were accurately scored.

Procedural integrity. Teachers and one instructional assistant were trained to deliver the scripted lessons. The researcher, in collaboration with the district technology specialist, provided one half-day training to deliver lessons in each of the conditions, (a) hand raising, (b) response card, and (c) response system. The researcher also provided training on quiz and test administration and scoring. The research team met for 15 minutes prior to each instructional day to review the lesson, ensure materials were in place, and answer any questions. The researcher was available during the school day and after school to answer questions or provide support as needed. Weekly research team meetings were held to support treatment fidelity.

Fidelity of treatment measures ensure that an intervention is implemented as described (Phye, Robinson, & Levin, 2005). Teachers and data collectors were trained by the researcher prior to study implementation using scripted training materials until 100% automaticity was established with researcher created scripted fidelity of treatment measures. Fidelity of treatment measures were collected during the traditional responding, response card, and response system conditions. Both teachers and the instructional assistants had previously received training through the district on the use of Promethium Boards and were familiar with their use. They also had previously attended training on the use of ActivResponders.

Scripted fidelity of treatment checklists were completed for 40% of lessons. Fidelity of treatment data was collected for the first lesson of the first unit and teachers were retrained depending on results. Fidelity of treatment checklists included the presence of all materials, statement of standard, review of concept, and review questions. Field notes were completed by the researcher and data collectors to document the administration of unit quizzes and delayed unit quizzes. See Appendix M.

Reliability measures. Reliability procedures ensure that measures are accurately scored (Dimitrov, 2009). As a general rule, 30% of measures is considered sufficient for establishing reliability (Phye, Robinson, & Levin, 2005). Data collectors were trained to collect on-task, participation, and achievement data adhering to set aforementioned procedures across conditions.

Achievement data. The classroom teacher and data collector with a BA in special education were trained to collect achievement data. The classroom teacher graded all assessments (pretest, unit quizzes, and delayed unit quizzes) and the trained data collector completed reliability checks for all quizzes and tests.

Time on-task. An instructional assistant and two data collectors were trained to serve as the primary data collectors for on-task behavior measures using researcher created training scripts until 90% interobserver agreement was established among data collectors. One instructional assistant with an AD in accounting served as the primary data collector for on-task behavior and two college students were available to complete reliability checks. If data indicated less than 90% interobserver agreement, the researcher retrained data collectors. Two data collectors were trained in case of absences due to unforeseen circumstances.

Participation. Two education majors at a local university were trained to collect participation data. A student with an Associate Degree in elementary education who was enrolled as a junior in a local university, served as the primary data collector. A second student was also trained and collected participation data for a minimum of 30% of class sessions. If less than 90 interobserver agreement was established, the researcher retrained data collectors.

Proposed Measures

To address research question 1, do response tools increase secondary students' math achievement? If so, are response cards or response systems more beneficial?, the researcher used multivariate analysis of variance (MANOVA). MANOVA evaluates population means across levels of a factor (Green & Salkind, 2011). Further MANOVA allows the researcher to evaluate linear combinations of the dependent variables (Dimitrov, 2009). The null hypothesis is that unit quiz and delayed unit quiz results are equal across conditions. The independent variables are traditional response, response card, and response system conditions. Dependent measures are the unit quizzes and delayed quizzes. MANOVA has three assumptions which include: (a) normal distribution of the dependent variables, (b) population variances and covariances are the same across factors, and (c) participants are randomly sampled. Due to the nature of the crossover design, each student acts as his own control. Due to the nature of the population participants are from intact groups.

If the MANOVA is significant at the .025 level then the researcher will complete additional follow up analyses using multiple separate analyses of variance (ANOVA). While this method is popular in the field there are researchers who disregard the follow up ANOVA procedures as they do not take into account the multivariate nature of the MANOVA (Dimitrov, 2009). ANOVA allows the researcher to analyze each linear combination of the dependent variable and to control for Type 1 error. The researcher proposes conducting MANOVA and follow up ANOVA procedures using the process outlined by Green and Salkind (2011).

To address research question 2, do students respond more frequently, and accurately, when using response tools as compared to traditional responding methods? If so, do students respond more frequently, and accurately, with response cards or response systems?, the researcher used of MANOVA procedures. A response rate and accuracy percentage is calculated for each student daily with a mean response rate for each unit. Pending significance at the .025 level, the researcher conducted follow-up ANOVA procedures for the same reasons as mentioned for research question 1. The independent variables are the response conditions (traditional, response cards, and response systems). The dependent variables are response rate, and response accuracy.

To address research question 3, do students spend more time on-task when using response tools as compared to traditional responding methods? If so, do students spend more time on-task when using response cards or response systems?, the researcher also proposes the use of an one-way ANOVA with three levels. As with previous analyses, the independent measures included the response conditions (traditional response, response cards, and response systems). The dependent measure was time on-task which will be reported as a mean time on task for each unit under each condition.

To address research question 4, What are student, instructional assistant, and teacher perceptions of response tools?, the researcher completed descriptive statistics similar to those used by Hott and colleges (2010) and coded written comments with qualitative thematic coding. Table 6 summarizes measures proposed.

Table 6

Dependent Variables, Measures, and Data Analysis Procedures

Research Questions	Dependent Measures	Data Analyses
RQ 1: Math Achievement	1. Pretest 2. Weekly Quiz 3. Delayed Quiz	1 way MANOVA (Wilks' Lambda, Box's) ANOVAs Post Hoc (Tukey)
RQ 2: Response Frequency Response Accuracy	1. Response Rate 2. Response Accuracy	1 way MANOVA (Wilks' Lambda, Box's) ANOVAs Post Hoc (Tukey)
RQ 3: Time On-task	1. Percentage of Time On-task	ANOVA Post Hoc (Tukey)
RQ 4: Student, Teacher, and Instructional Assistant Perceptions	1. Student Satisfaction Survey 2. Teacher Satisfaction Survey 3. Instructional Assistant Satisfaction Survey	Descriptive Statistics; Qualitative Thematic Coding

Note. RQ = Research question, MANOVA = Multivariate analysis of variance, ANOVA = Analysis of Variance

Summary

This chapter has provided detailed summaries of methods, materials, procedures, and dependent measures used to implement and analyze the findings of this quasi-experimental study. Mixed methods were used to evaluate the efficacy of response options in secondary classrooms for students with emotional or behavioral challenges. Results of the study will be presented in the next chapter.

4. RESULTS

This chapter presents the findings from a quasi-experimental study employing a cross-over design to evaluate the efficacy of low- and high-tech response options on the mathematics achievement, participation, and time on-task, of secondary students with EBD. A post intervention survey was administered to assess the social validity of the interventions. The results of statistical analyses for each of the following research questions are presented:

1. Do response tools increase secondary school students with EBD math achievement? If so, are response cards or response systems more beneficial?
2. Do students respond more frequently, and accurately, when using response tools as compared to traditional instruction? If so, are response cards or response systems more beneficial?
3. Do students spend more time on-task when using response tools as compared to traditional instruction? If so, are response cards or response systems more beneficial?
4. What are student, instructional assistant, and teacher perceptions of the use of response tools?

Fidelity of Treatment

Fidelity of treatment checklists were completed by a research assistant for 40% of the study lessons. Fidelity of treatment measures were completed on Mondays and then another randomly selected day during the week. Mean teacher lead review fidelity of treatment was 97% (range 92% - 100%). Mean fidelity of treatment for the questions portion of the intervention was 98% (range 94% - 100%). On two occasions the classroom three teacher omitted a praise statement. One four occasions, classroom three teacher added additional information to the lecture.

Research Question 1

Do response tools increase secondary school students with EBD math achievement? If so, are response cards or response systems more beneficial?

The first research question investigated the use of response tools on math achievement of secondary students with EBD. Three measures were used: (a) pretests, (b) weekly quiz, and (c) delayed weekly quizzes. The pretests and each quiz were scored by a research assistant. Another research assistant independently graded each of the assessments and interrater reliability was 100%. The pretest provided an indicator of student achievement prior to the study. Mean pretest performance was 28.99%. Means for the data analysis, algebra, and geometry sections were 30.91%, 32.73%, and 23.33% respectively. Descriptive information for pretest scores by class is presented in Table 7.

Table 7

Pretest Performance by Class

Classroom	Data Analysis *M*	*SD*	Algebra *M*	*SD*	Geometry *M*	*SD*	Pretest Score *M*	*SD*
Class 1 (*N* = 10)	29.00	18.53	35.00	21.43	20.00	14.14	28.00	14.59
Class 2 (*N* = 13)	32.31	13.01	28.46	17.72	32.31	17.87	31.03	12.05
Class 3 (*N* = 10)	31.00	16.63	36.00	15.78	15.00	10.80	27.33	10.04

Prior to evaluating response tool use on math achievement, a Box's Test for Equality of Covariance Matrices was conducted to ascertain whether the variances and covariance among the dependent variables were the same for all groups. Results of the Box's Test indicate that the test for homogeneity of dispersion matrices was not significant. Therefore, the assumption of equal variance-covariance was met.

Following the Box's Test, a one-way multivariate analysis of variance (MANOVA) was conducted to determine the effects of the three response tools (traditional responding, response cards, and response system) on mathematics performance. Dependent measures included unit quiz and delayed unit quiz scores. Significant differences were found among the three response options, $F(4, 13) = .62$, $p < .001$. Therefore, the null hypothesis, there are no differences in math achievement based on response type can be rejected. The multivariate $\eta^2 = .22$ suggests that 22% of multivariate variance of math achievement is associated with the type of response option used. See figure 2 for distributions of weekly quiz and delayed quiz scores.

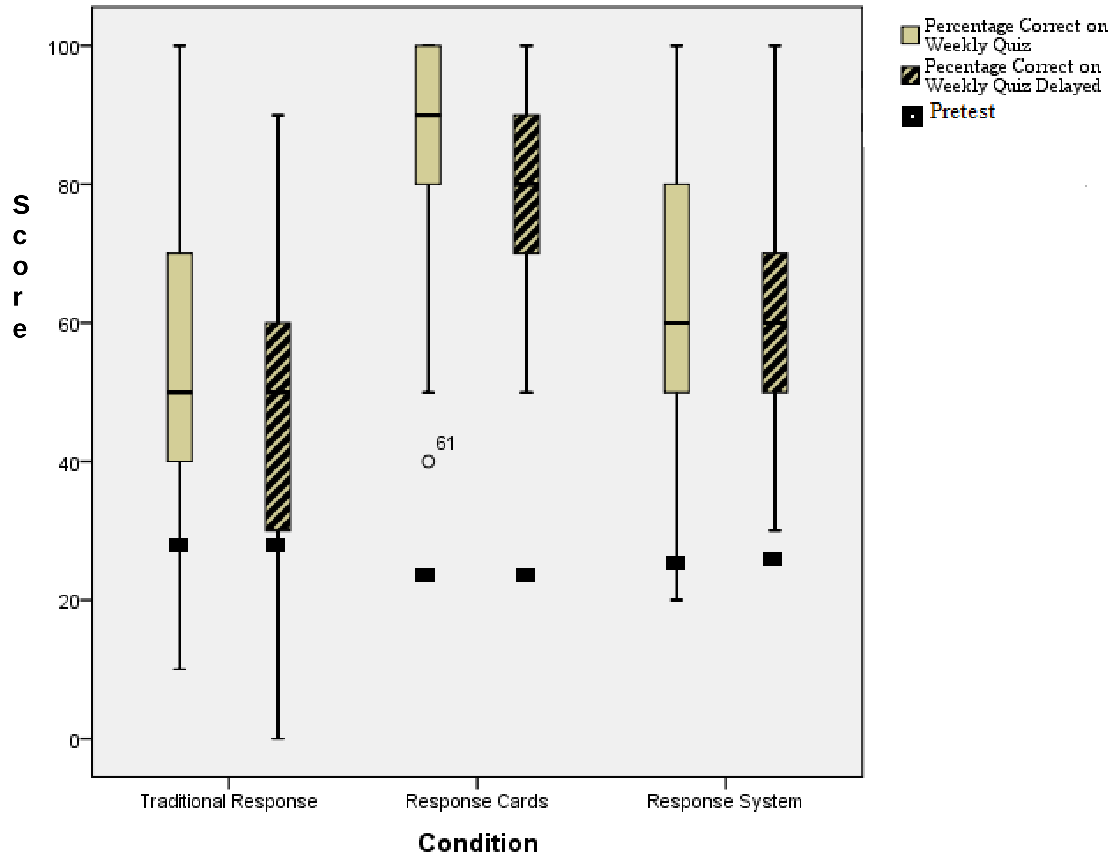


Figure 2. *Distributions of Weekly Quiz and Delayed Quiz Results*

Analyses of variances (ANOVA) on dependent variables were conducted following MANOVA procedures. Each ANOVA was tested at the .025 level. Results were significant for both weekly quizzes, $F(2, 96) = 22.01$, $p < .001$, $\eta^2 = .31$ and delayed quizzes, $F(2, 96) = 29.19$, $p < .001$, $\eta^2 = .38$. The variate $\eta^2 = .31$ suggests that 31% of the variance in weekly quiz scores is due to the type of response option used. Likewise, the $\eta^2 = .38$ suggests that 38% of the variance in delayed quiz scores is due to the type of response option used. Means and standard deviations are displayed in Table 8.

Table 8

Math Achievement Means and Standard Deviations

	Pretest		Weekly Quiz		Delayed Quiz	
Response Method	*M*	*SD*	*M*	*SD*	*M*	*SD*
Traditional	32.42	17.15	51.82	21.72	45.15	21.38
Response Cards	26.67	16.52	84.85	16.99	79.39	15.6
Response Systems	27.88	17.46	65.15	21.96	57.58	17.86

Post hoc analyses following the ANOVA procedures for both weekly quiz and delayed weekly quiz results were conducted using pairwise comparisons to explore which response option affected performance most strongly. The use of response cards resulted in statistically superior performance on both the weekly quiz and delayed quiz scores in comparison to the other two groups. The use of response cards resulted in performance increases on daily quizzes of at least 19.74 but not more than 46.33 ($p < .001$) in comparison to traditional responding and increases of at least 6.40 but not more than 32.99 ($p < .001$) in comparison to the use of response systems. Estimated marginal means are displayed for weekly quizzes in Figure 3 and delayed weekly quizzes in Figure 4.

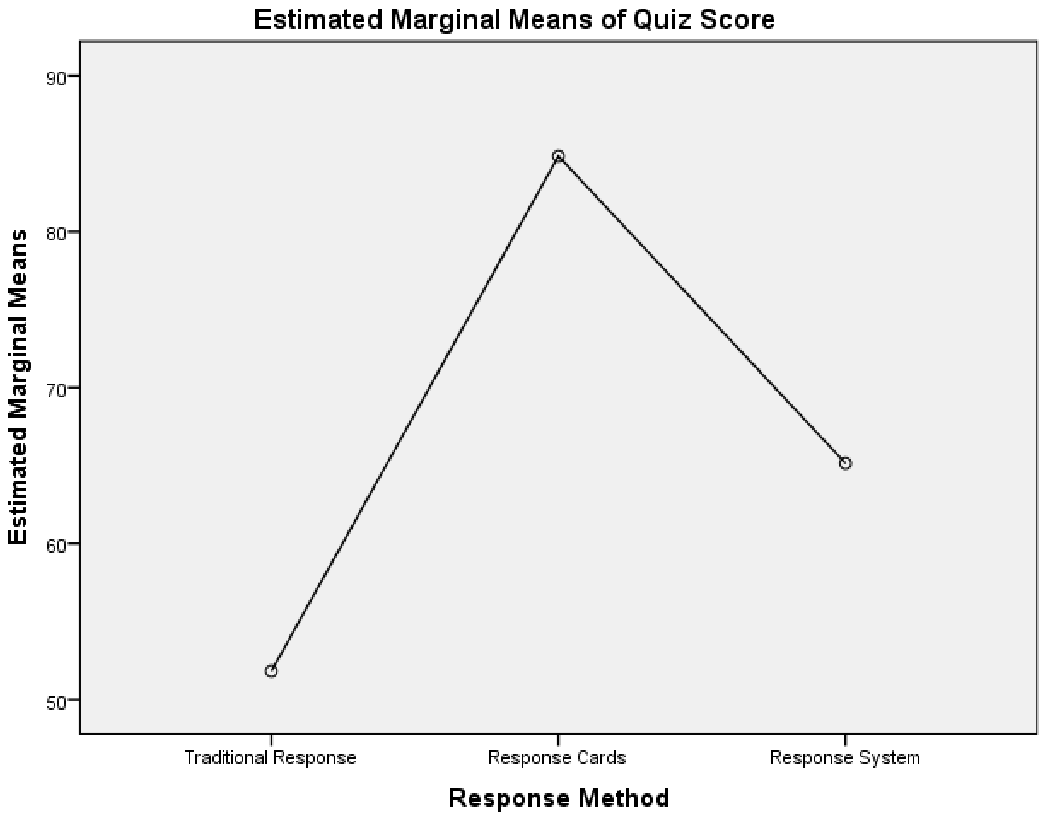


Figure 3. *Estimated Marginal Means of Quiz Scores*

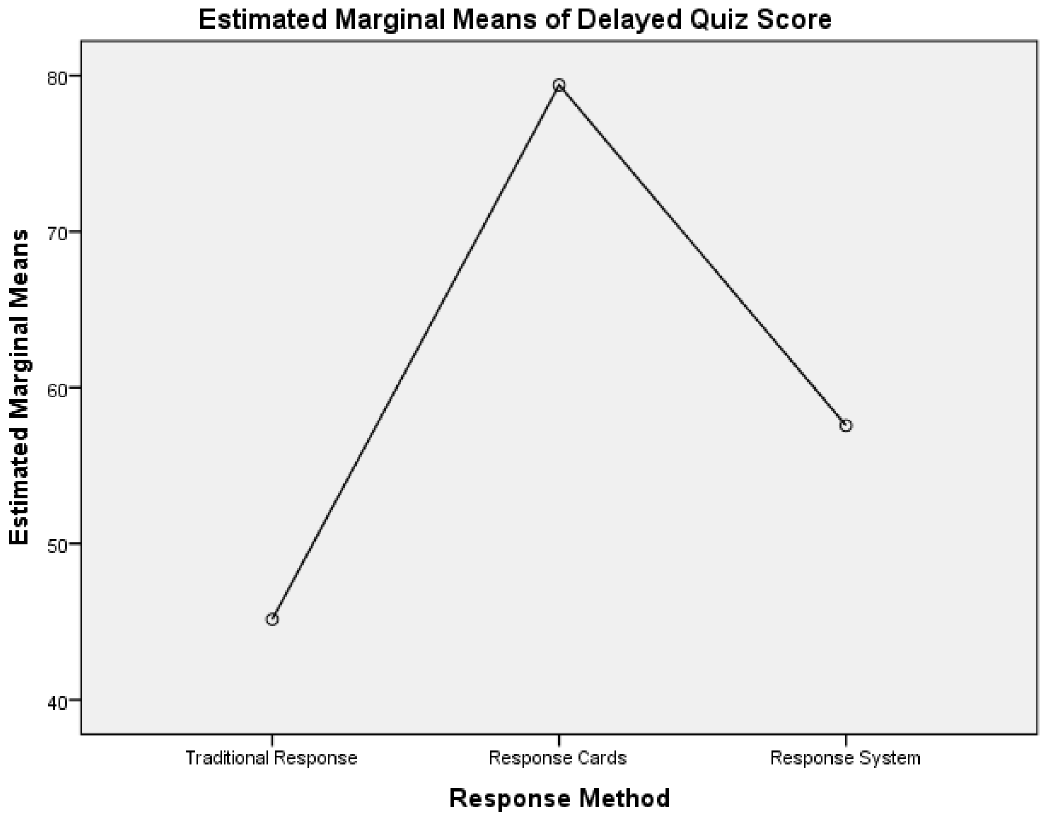


Figure 4. *Estimated Marginal Means of Delay Quiz Scores*

Additionally, the use of response systems resulted in higher performance on daily quizzes by at least 6.40 but not more than 32.99 ($p < .001$) when compared to the use of traditional responding. The use of response cards increased delayed quiz performance by at least 22.20 but no more than 46.29 ($p < .001$) in comparison to traditional responding and by at least 9.77 but not more than 33.86 ($p < .001$) in comparison to response systems. The use of response systems increased delayed weekly quiz scores by at least .38 but not more than 24.47 ($p = .020$) when compared to traditional responding. Group comparisons are summarized in Tables 9 and 10.

Table 9

Group Mean Differences for Weekly Quizzes

Group	Group Mean Difference Traditional Response	 Response Cards
Traditional Response	--	--
Response Cards	33.03*	--
Response Systems	13.33*	19.70*

Note. * = significant at the .025 level

Table 10

Group Mean Differences for Delayed Quizzes

Group	Group Mean Difference Traditional Response	 Response Cards
Traditional Response	--	--
Response Cards	34.24*	--
Response Systems	12.42*	21.82*

Note. * = significant at the .025 level

Research Question 2

Do students respond more frequently, and accurately, when using response tools as compared to traditional instruction?

Interrater reliability was calculated for 40% of sessions. Interrater reliability was completed each Monday and then on a randomly selected data for the rest of the week. Interrater reliability for response rate was 96% (range 92% - 100%) interrater reliability for response accuracy was 99% (range 97% - 100%).

In order to determine the effects of response options on student response rate and accuracy, a MANOVA procedure was conducted. Dependent measures included student response rate, the rate that students attempted to answered question, and student response accuracy, the rate that students correctly answered questions. In order for MANOVA procedures to be considered valid several assumptions must be met. These assumptions include: (a) subjects are randomly sampled, (b) observations are independent, (c) dependent variables follow a normal distribution, (d) all groups have the same variance on each dependent variable, and (e) the correlations between dependent variables are equal (Dimitrov, 2009, pp. 355). To evaluate the homogeneity of covariance matrices, the Box's Test was utilized. Results of the Box's Test were significant. Therefore, the homogeneity of covariance assumption is violated and the validity of MANOVA results is questionable. There are several reasons why this may have occurred. One being that the dependent variables are overly correlated thus there is not enough variance to support the procedure.

Following a significant Box M test, separate ANOVAs were conducted for each condition (Brown & Forsythe, 1974, Tabachnick & Fidell, 2007). While ANOVA is a fairly robust procedure, like MANOVA, there are data assumptions. These assumptions include: (a) independence, (b) normality, (c) linearity, and (d) homogeneity of variance.

Prior to conducting an ANOVA procedure to determine the effects of response options on student participation, the Levenes' Test of Equality of Error Variance was completed to test the third ANOVA assumption. Results of the Levenes' test indicate the assumption of equality of variance is not met, $F(2, 96) = 10.35$, $p < .001$.

To account for unequal variance, the Welch test was used. The Welch test is an alternative to ANOVA which accounts for asymptotic distribution (Welch, 1947). Results indicate that there are significant differences among response rates when students use response tools, $F(2, 62) = 219$, $p < .001$. See Table 9 for means and standard deviations.

Table 11

Means and Standard Deviations for Response Rate and Response Accuracy

	Response Rate		Response Accuracy	
Response Method	*M*	*SD*	*M*	*SD*
Traditional Response	18.09%	18.68%	6.45%	8.51%
Response Cards	93.64%	12.00%	84.33%	15.28%
Response System	91.64%	10.81%	73.94%	14.56%

Post hoc analyses were completed to ascertain differences in participation rates among the response tools. Due to the potential for unequal variance among groups, the Games-Howell test was completed (Kromrey & LaRocca, 1995, Seaman, Levin, & Serlin, 1991). Results indicate significant differences in student response rate between traditional response and response card conditions in favor of the latter. Tables 12 and 13 summarize group comparisons.

Table 12

Group Mean Differences for Response Rate

	Group Mean Difference	
Group	Traditional Response	Response Cards
Traditional Response	--	--
Response Cards	75.55*	--
Response Systems	73.55*	2.00

Note. * = significant at the .025 level

Table 13

Group Mean Differences for Response Accuracy

Group	Group Mean Difference Traditional Response	 Response Cards
Traditional Response	--	--
Response Cards	77.88*	--
Response Systems	67.49*	10.39*

Note. * = significant at the .025 level

Students in the response card condition responded more frequently by at least .66 but not more than .85 ($p < .001$). Students using the response system also responded more than students using traditional responding by at least .65 to .83 ($p < .001$). Differences between response cards and response systems were not statistically significant ($p = .758$). See Figure 5 for a graphical display of participation rate results.

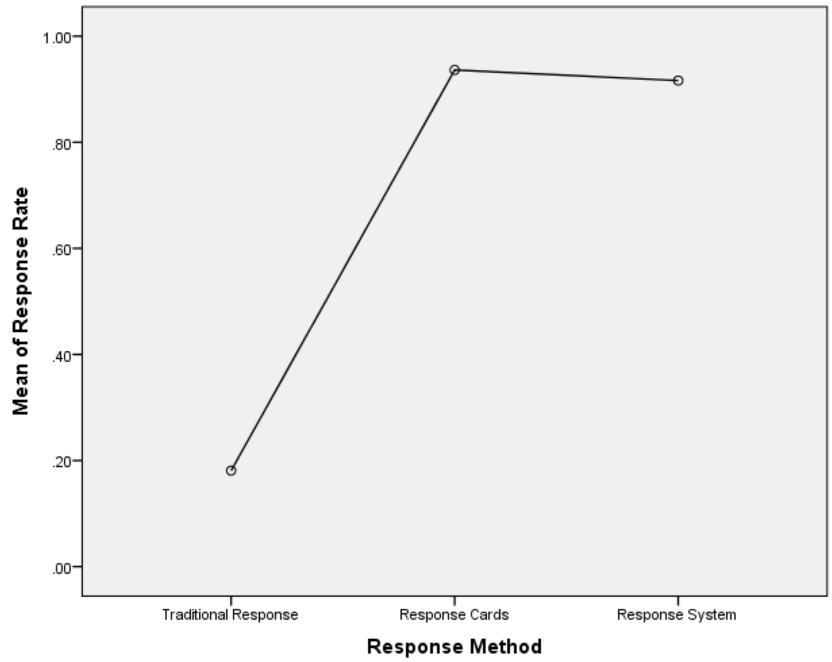


Figure 5. *Estimated Marginal Means of Response Rates*

Prior to conducting an ANOVA procedure to determine the effects of response options on student response accuracy, the Levenes' Test of Equality of Error Variance was completed to test the third ANOVA assumption. Results of the Levenes' test indicate the assumption of equality of variance is not met, $F(2, 96) = 4.778$, $p = .011$.

To account for unequal variance, the Welch test was used. The Welch test is a robust alternative to ANOVA which accounts for asymptotic distribution. Results indicate that there are significant differences among participation rates when students use response tools, $F(2, 59.07) = 470.65$, $p < .001$. See Table 9 for means and standard deviations.

Post hoc analyses were completed to ascertain differences in participation rates when using response tools. Due to the potential for unequal variance among groups, the Games-Howell test was completed. Results of the Games-Howell test indicate significant differences in student response accuracy between traditional response and response card conditions by at least .71 but not more than .85 ($p < .001$) in favor of the latter. Results also indicate that there are statistically significant differences in response accuracy between traditional responding and response systems by at least .60 but not more than .75 ($p < .001$). Further, response accuracy was statistically significant between response systems and response cards by at least .02 but not more than .19 ($p = .017$) in favor of the later. See Figure 6 for a graphical display of results.

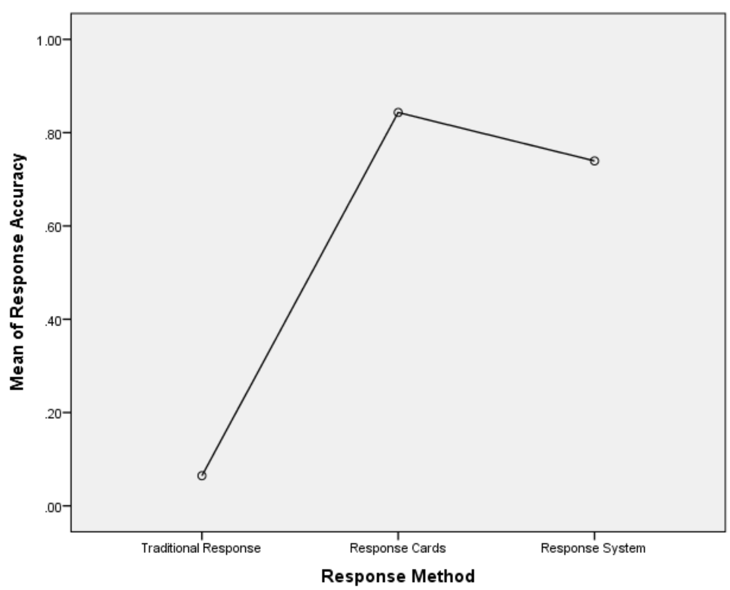


Figure 6. *Estimated Marginal Means for Response Accuracy*

Research Question 3

Do students spend more time on-task when using response tools as compared to traditional instruction? If so, are response cards or response systems more beneficial?

The third research question investigated student time on-task when using response tools. The dependent measure evaluated was percentage of time on-task. Interrater reliability was 84%. In order to evaluate question 3, an ANOVA was conducted. Prior to the ANOVA, the Levene's test of homogeneity of variance was completed. Results of the Levene's test were nonsignificant, $F(2,96) = 1.256$, $p = .290$. Thus, the homogeneity of variance assumption was met. Results of the ANOVA were statistically significant, $F(2, 96) = 23.31$, $p < .001$, $\eta 2 = .33$. The variate $\eta 2 = .33$ suggests that 33% of the variance in student time on-task is due to the type response option used. Mean time on-task during traditional responding was 48.18% (*SD* = 19.97). Mean time on-task during the response cards condition was 74.94% (*SD* = 17.69) and 73% (*SD* = 15.28) during the response systems condition. This represents an approximately 65% in time on-task when using response cards or response systems rather than traditional responding methods. See Table 14.

Table 14

Time On-task Means and Standard Deviations

Group	*M*	*SD*
Traditional Response	48.18	19.97
Response Cards	74.94	17.69
Response Systems	73.00	15.28

Post hoc analyses following the ANOVA procedures were conducted using pairwise comparisons to explore which response option effected time on-task most strongly. Results indicate that students spend more time on-task when using either response cards or response systems than traditional responding methods. See Table 15.

Table 15

Group Mean Differences for Time On-Task

	Group Mean Difference	
Group	Traditional Response	Response Cards
Traditional Response	--	--
Response Cards	26.76*	--
Response Systems	24.82*	1.94

Compared to traditional responding methods, students were on-task at least 16.35% but not more than 37.16% when using response cards ($p < .001$) and at least 14.41% but not more than 35.22% when using response systems ($p < .001$). Estimated marginal means are displayed in Figure 7.

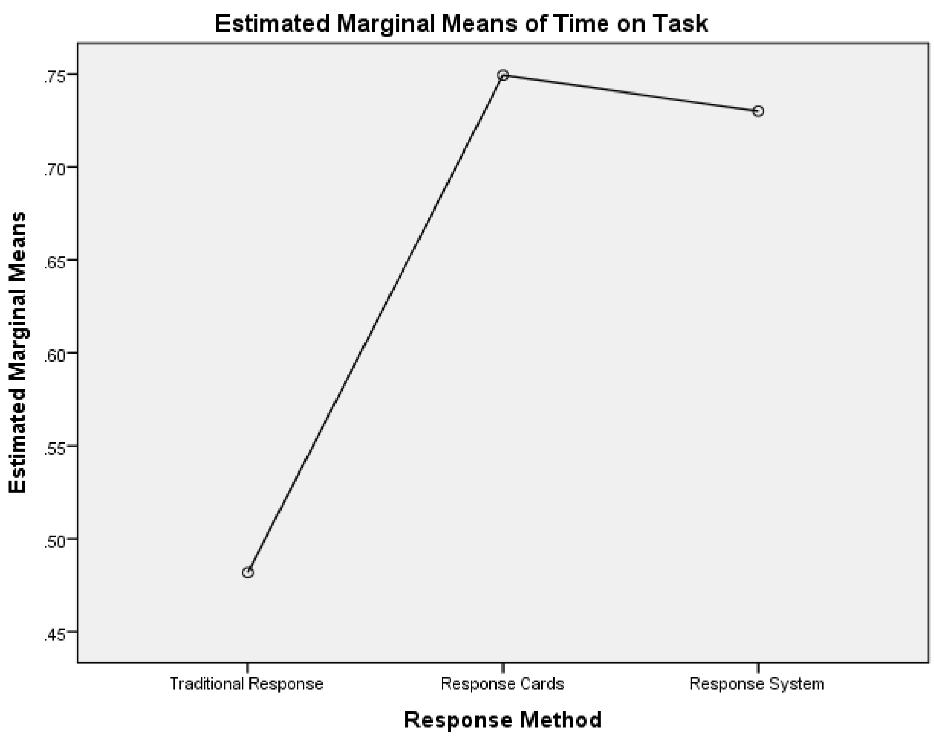


Figure 7. *Estimated Marginal Means for Time on Task*

Research Question 4

What are student, instructional assistant, and teacher perceptions of the use of response tools?

In order to determine the social validity of the use of varying response methods and glean insight into student perceptions, a ten question survey was administered following the completion of the study. The survey response rate was 88% due to one student declining to complete the survey and three students being pulled from class for another activity. Twenty-nine of the 33 participants completed the survey.

The first question asked students to indicate which response method helped them to best learn math. The majority of students reported that they learned math material best with the use of Clickers (response system). A few students reported no differences in math learning based on response tool use. See Table 16 for a summary of results.

Table 16

Response Method that Best Promoted Learning Math

Response Method	Number	Percent
Traditional Response	1	3.4
Response Cards	2	6.9
Response System	22	75.9
No Difference	4	13.8

The second question asked students to indicate which response method helped them to stay on-task. The majority of students reported that the use of Clickers (response system) helped them to stay on task the most. A few students reported no differences in time on-task based on response tool use. Student preferences for learning mathematics and time on-task were equivalent. See Table 17 for a summary of results.

Table 17

Response Method that Best Promoted Time On-task

Response Method	Number	Percent
Traditional Response	1	3.4
Response Cards	2	6.9
Response System	22	75.9
No Difference	4	13.8

The next question asked students to rank response tools. The majority of students indicated that they preferred using Clickers followed by white boards. Students reported they liked hand raising least. Results are summarized in Table 18.

Table 18

Student Response Method Preferences

	Least		Medial		Most	
	N	*Percent*	*N*	*Percent*	*N*	*Percent*
Method						
Traditional	23	79.3	2	6.9	4	13.8
Response Cards	3	10.3	24	82.8	2	6.9
Response System	3	10.3	3	10.3	23	79.3

Questions four and five asked students to report if they answered more questions when using response tools. The majority of students indicated that they "strongly agreed" or "agreed" that they responded to more questions when using white boards or Clickers than hand raising with approximately 80% of students noting more responses with response cards and almost 90% of students indicating more responses with response systems. Results are summarized in Table 19.

Table 19

Student Perceptions of Response Tools

	Strongly Disagree		Disagree		Undecided		Agree		Strongly Agree	
Response Methods	*N*	*Percent*	*N*	*Percent*	*N*	*Percent*	*N*	*Percent*	*N*	*Percent*
Response Cards vs. Traditional Responses	0	0	3	10.3	3	10.3	19	65.5	4	13.8
Response Systems vs. Traditional Responses	0	6.9	2	6.9	1	3.4	9	31.0	17	58.6

The next series of questions asked students about the continued use of response tools in their math classes and if they would like to use response tools in their other classes. Results indicate that the majority of students would like to continue using white boards and Clickers in their math classes. Students were also interested in using white boards in their other classes but not to the same extent as Clickers. See Table 20.

Table 20

Student Perceptions Continued Response Tool Use

Response Tool	Mathematics SD N	Percent	D N	Percent	U N	Percent	A N	Percent	SA N	Percent	Other Courses SD N	Percent	D N	Percent	U N	Percent	A N	Percent	SA N	Percent
Response Cards	1	3	4	14	3	10	17	59	4	14	2	7	9	31	11	38	5	17	2	7
Response System	0	0	1	3	3	10	7	24	18	62	0	0	1	3	3	10	10	35	15	52

Note: SD = strongly disagree, D = disagree, U = undecided, A = agree, SA = strongly agree

The final open-ended question asked students to share any information about the use of hand raising, white boards, and Clickers. Twenty-one of the 29 students shared written comments. Both the researcher and a secondary coder reviewed data coding responses by response option and whether the comment was negative, neutral, or positive. Only one statement was coded as negative. The student reported, “None of this helps… I hate it.” Student comments generally supported the continued use of Clickers and to some extent white boards. Students noted that Clickers helped them to stay on-task and complete their work. Many students shared that Clickers and white boards are fun. Appendix N includes a summary of student comments.

Both teachers and both instructional assistants completed surveys. One teacher reported that the white boards and Clickers were distracting and she would not continue to use them as she perceived hand raising as a more effective means of teaching. The other teacher reported that she felt white boards were the most effective response tool but that the students enjoyed the Clickers. The teacher indicated that she would continue to use both the Clickers and white boards in her math classes. Instructional assistant comments mirrored those stated by the teachers.

Conclusion

This chapter presented the results of a quasi-experimental study evaluating the effects of response tools on the mathematics achievement, performance, and time on-task of secondary students with EBD. Results suggest that the use of response tools increases academic achievement, participation, and time on-task. Student and teacher perceptions of response tools were generally positive. The next chapter will present limitations and a discussion of the results summarized in this chapter.

5. DISCUSSION

This chapter presents a discussion of the findings of a quasi-experimental study evaluating the efficacy of response tool use in secondary mathematics classrooms for students with EBD. Thirty-three students enrolled in self-contained mathematics courses in grades eight to eleven participated in the study. The students received brief scripted mathematics lessons reviewing key data analysis, algebra, and geometry concepts. Students then answered a variety of grade level multiple choice questions adhering to the state testing format using traditional responding, response cards, and response systems. Results indicated that the use of response cards and response systems increased math achievement, time on-task, and to some degree participation rate and accuracy, of secondary students with EBD in mathematics. Post intervention surveys indicated that students, and to some degree their instructional and assistants and teachers, support the use of response tools in their classes.

The use of response tools improved student mathematics achievement as evidenced by quiz and delayed quiz scores. Specifically, the use of response cards resulted in statistically significant achievement gains over and above response systems when compared to traditional responding methods. There is some evidence that use of response tools also increased student response rates and accuracy, especially when accounting for pretest scores. The use of response cards and response systems increased student response rates to almost the same degree with response cards and? increasing participation slightly more than response systems. The use of response tools also increased student time on-task. However, there were no significant differences in time on-task between response cards and response systems.

Finally, post intervention surveys indicated that students perceived the use of response systems as fun. Students overwhelmingly preferred the use of response systems to response cards. However, instructional staff preferred the use of traditional responding or response cards methods.

Additional discussion of study outcomes in the areas of math achievement, class participation, time on-task, and staff perceptions is presented next. Following the discussion of results, a summary of limitations and implications for future research are shared.

Mathematics Achievement

Three measures were used to evaluate student mathematics performance. Pretest scores were obtained to ascertain student pre-intervention performance as material had been previously presented. Weekly quizzes and delayed quizzes were used to measure student's ability to solve math problems. A discussion of student outcomes related to quizzes and delayed quizzes is presented below.

Results of the pretest indicate, despite curriculum pacing guides and teacher indication that concepts were thoroughly taught, that the majority of students were achieving significantly below expectations with the mean pretest score of approximately 30%.

Students, regardless of condition, increased their quiz performance from pre to posttest. Students received ten minutes of direct instruction reviewing a key concept within algebra, geometry, or data analysis units that are evaluated on state testing initiatives. Each 45 minute instructional block included a ten minute teacher directed review of the grade level concept followed by a series of questions that were in state testing format.

There is evidence that despite demonstrated mastery of a concept after a week, students' scores significantly dropped. Therefore, the need for continuous review and assessment to ensure that students maintain skills learned is a clear need. Curriculum based measures and ongoing assessment are a plausible means of collecting this data (Foegen & Morrison, 2010) and making informed instructional decisions (Nolet & McLaughlin, 2000).

While students indicated that response systems helped them to best learn math and some of the instructional staff indicated traditional response methods helped students to best learn math; however, results indicate a statistically significant difference in achievement for both quiz and delayed quiz scores in favor of response cards. These findings are generally supported by George (2010) who found a clear link between achievement in middle school social studies and the use of white boards and Blood (2011) who found a slight increase in high school social studies achievement when using response systems. However, this study is the first to evaluate the efficacy of response tool use with multi-step grade level tasks in the mathematics domain.

As the field continues to debate the type of math instruction and assessment that is best for students, students with EBD continue to achieve at a level far below their peers. This is evident in the graduation rates that have not improved over the last decade, continued use of punitive disciplinary practices such as suspension and expulsion, and teachers who are ill equipped to adequately provide mathematics instruction. Further complicating issues are increasing classes of students with diverse learning needs coupled with reductions in staffing and funding that impede progress. Therefore, there is a continued need for interventions that are research-based, affordable, and easily implemented. Response cards offer such as option.

For many students state accountably measures can be a road block to earning a standard diploma. Regardless of instructional method, there appears to be some evidence that supports the use of response tools and mathematics performance. Results of the study are encouraging, consistent with previous findings, and are easily implemented within twenty-first century classrooms. Use of white boards may prove more beneficial at the initial stages of learning as there may be a link to writing rather than typing calculations. However, some students reported that they were unsure or did not desire to use response cards in their other classes.

Student Participation and Behavior

This section will present a discussion of findings related to student response rate, response accuracy, and time on-task. Implications for the classroom and efficacy of response tool use are discussed.

Response rate and response accuracy. Mean response rate increased with the use of response tools as compared to traditional responding methods. Pretest scores played a critical role in ascertaining student progress. Special education classrooms include diverse learners with varying levels of intelligence and achievement. Results are similar to previous response tool research at the secondary level (e.g., Blood, 2010, Cavanaugh et al., 1996, George, 2010), and generally support the use of response tools to increase responding and potentially correct responding.

While the use of response tools at the secondary level, especially with tasks that require higher level thinking and problem solving is a new area of research, there is a rich body of research that indicates students with behavioral challenges need more guidance and support than typically achieving peers (e.g. Brophy & Good, 1986, Greenwood et al, 1984, Greenwood, 2002, Sutherland, Alder, and Gunter, 2003). While teachers perceive that they have little impact over student engagement (Lane & Beebe-Frankenberger, 2004), research shows that there is much that teachers can do to facilitate learning. These include teacher enthusiasm (Brigham, Scruggs, & Mastropieri, 1992), choice (Mizener & Williams, 2009), and praise (Kamps, Wendland, & Culpepper, 2006). The use of response tools to increase participation has the potential to afford additional opportunities for students to have choice, praise, and be nurtured as well.

Time on-task. There were statistically significant differences between the use of traditional responding and the use of response cards and response systems. Students were on-task slightly more when using response cards than response systems but the difference was minimal. The use of response tools is a viable option to help students stay on-task.

While a clear link between increased time-on task and response tool use in secondary grades (e.g., Blood, 2010) has not been established, this study provides some evidence that students spend more time on-task when presented with increased opportunities to respond with engaging tools. Students and half of the instructional staff reported that the use of response tools resulted in greater time on-task. However, one teacher reported that response cards helped students to stay on-task and learn greater amounts of materials, while students overwhelmingly indicated that response systems helped them to stay on-task for longer periods of time. When students are on-task the amount of time devoted to instruction, versus management, increases (Brigham et al., 1992; Walker & Hott, 2012) which may translate into increased learning and fewer disciplinary actions.

Student and Instructional Staff Perceptions

The next section will discuss post-intervention survey findings. First, student perceptions will be discussed, followed by teacher perceptions. Finally instructional assistant perceptions are presented. Implications for practice are shared.

Student perceptions. Student perceptions were generally positive. Several reported that the use of response systems is fun and that they would like to continue to use response systems in their math classes as well as other classes. A few students indicated that white boards helped them to solve problems and many indicated that they would like to continue to use them in their other classes. It is notable that several students indicated that they did not want to use response cards in their other classes and that they felt that response systems helped them to better learn mathematics. Students overwhelmingly reported that use of response systems helped them to best learn math;

yet, empirical data indicates that significant achievement gains were made with response cards to response systems.

Teacher and instructional assistant perceptions. One teacher and one instructional assistant reported that the use of response cards and response systems increased student learning, participation, and time on-task. They also reported that they would continue to use response tools in their classroom. Further, they indicated that the use of response cards allowed them to see the process students used to solve the problem. With response systems it was more difficult to identify which students needed help quickly and to provide follow up questions that were not preprogramed.

The other teacher and instructional assistant indicated that both response cards and response systems increased classroom disruptions and did not help students to learn mathematics material. Both preferred to use traditional responding methods but indicated that they may use response cards in the future. This is potential due to differing definitions and expectations of active engagement. The use of both response cards and response systems provides an opportunity for students to be responsible for their response and participation. While traditional responding methods such as hand raising rely on the teacher to determine which student or small group of students selected to answer a question. Behaviors such as drawing on the white boards and destroying expensive markers impeded progress. The teacher observations are similar to those reported by George (2011). Additionally, instructional assistant reports mirrored those provided by teachers.

Regardless of how effective, or ineffective, an intervention, the role of the classroom teacher, and in many cases instructional assistant, is insurmountable. If teachers are unwilling to use an intervention, regardless of effectiveness, then an impact for students is unable to be determined (Regan, in press). The opinions of the second teacher and instructional assistant are inconsistent with previous findings regarding the use of response cards (e.g. Christle & Schuster, 2003, Lambert et al., 2006, Maheady et al., 2002) or response systems (e.g., Blood, 2010, Conoley, 2005, Grissom, 2006). However, the notation regarding non-significant achievement differences when using response systems may have some merit (e.g., Lively, 2010) and warrant further investigation. While there was some negative survey feedback, it is notable that while the study was taking place that the school wrote a grant and all mathematics classrooms in the high school were equipped with a set of ActivResponders. It appears that schools are increasing investment in response systems. Therefore, it is judicious to evaluate their effectiveness.

Limitations

There are numerous study limitations. These limitations include study materials and intervention framework, data collection, and data analysis procedures.

First the intervention materials were developed by a highly skilled group of mathematics educators, special educators, and a technology specialist. The review activities may not be typical of those traditionally used in classrooms. Additionally, while the researcher attempted to ensure equivalency across units and assessments, there is an instruction factor that may have come into play. The teachers indicated that they had covered all of the standards, yet during research team meetings both teachers at some point had to ask the researcher or a data collector how to carry out the math concept. Field notes indicate that this occurred several times. Examples include finding volume of a cylinder, finding probability versus odds, and using substitution to solve equations. The pretest scores provide some evidence that either the material had not been previously mastered or students did not maintain skills over time.

In addition to problems associated with the intervention materials, the interrater reliability for on-task data was 84%. While interrater reliability is generally considered effective at 80% for on-task data, this is still relatively low. Moreover, on-task data was collected using a momentary time sampling procedure that may not have been sensitive enough to pick up the off task behaviors that occurred more frequently. Additionally, several students were clearly off-task but were participating and answering questions when using response tools. Examples include making comments about others, spitting, and roaming around the classroom despite being directed to return to seat.

Future Research

Future research in the area of mathematics includes how students perceive their learning versus empirical data and what happens when both are shared with students is a plausible area of study. Another area of future research involves evaluating the long term effects of response tool use on achievement. Students' achievement decreased over a one week period indicating either the need for additional review and practice or that the intervention may be largely insufficient over time. The use of curriculum-based measures may prove a plausible area of continued research to assist teachers and students with progress monitoring and instructional decision-making.

The use of response systems in high school classrooms is relatively new. It is plausible that lower achieving students benefit more than typically achieving students from the use of response tools. Additional research with the use of response systems seems appropriate. With the wide range of levels within typical special education classrooms, it may prove beneficial to evaluate the effectiveness of differentiated quiz options available with many of the new response system applications.

Additional exploration in the areas of teacher knowledge of evidenced-based practice in mathematics and the use of interventions appears warranted. Research in the area of student perceptions of how they learn and what tools help them to best access grade level mathematics tasks within a problem solving framework. The use of response cards may be a means of facilitating a discussion regarding how students choose to solve a problem as compared to direct instructional models where each student is solving the problem in the same manner.

Continued exploration of time on-task, both the operational definition during mathematics activities and with the use of response tools appears warranted. On several occasions students were actively engaged in the lesson but were clearly off-task according to the definition established for the study. The option of evaluating on-task, off-task, and multi-tasking is plausible (e.g., Agrawal, Bronaugh, & Mastropieri, 2011; Mastropieri et al., 2012). While students were on-task for significantly longer periods of time when using response tools, there may be a novelty effect. Therefore, continued research into the time on-task over longer periods of time should be evaluated.

Finally, the use of response tools coupled with other evidenced-based instructional practices such as DI, CRA, and CAI may be an area of future study. Additionally student-directed strategies such as self-monitoring or peer tutoring as an instructional component with response tools may be another area of focus.

Conclusion

This quasi-experimental study evaluated the efficacy of response tool use in secondary mathematics classrooms. Findings suggest that the use of response tools is an effective strategy to support students with EBD. Results suggest that increases in achievement and time on-task are associated with response tool use. Further, most students and their teachers support the use of response cards and response systems within their mathematics classes.

APPENDICES

APPENDIX A

Study	Design	Participants	Setting	Intervention	Math Skill	Dependent Measures	Outcomes
Billingsley et al. (2009)	Alternating Treatment	10 high school students with EBD	Self-contained classroom for students with EBD	DI, CAI, DI with CAI	Multiplication, division, and factional computation problems	Math achievement	Students math performance increased in each condition with no clear delineation between methods
Bottge et al. (2006)	Mixed Methods	17 students	Alternative school for students with behavioral difficulty	Enhanced Anchor Instruction (EAI)	Problem solving	Accuracy on curriculum aligned and standardized tests, student satisfaction and engagement	Increased performance on curriculum aligned tests, increased engagement during lessons, no differences in achievement on standardized measures
Carr & Punzo (1993)	Multiple Baseline	3 male students with EBD	Self-contained classroom in a public school	Self-monitoring	Basic facts	Accuracy Productivity	Increased assignment completion and accuracy

Study	Design	Participants	Setting	Intervention	Math Skill	Dependent Measures	Outcomes
Cade & Gunter (2002)	Multiple Baseline	3 males with EBD	Special day school	Mnemonic Instruction	Basic division facts	Accuracy	Increased accuracy for all students
Davis & Hajicek (1985)	Multiple Baseline	7 students with conduct disorders and 1 student with Schizophrenia	Psychoeducational Center for students with severe behaviors	Modeling and prompting, Strategy instruction	Multiplication of decimals	Accuracy Attention	Increased accuracy but not attention, greater accuracy with modeling than strategy instruction
Franca (1990)	Multiple Baseline	8 male students	Private school for students with behavioral difficulties	Same-age peer tutoring	Fractions	Accuracy Attitude towards Math Social skill scale	Increased worksheet accuracy, decreased error rates, improved attitudes towards math, positive student perceptions of the intervention
Gable & Kerr (1980)	Pre/post testing	6 students with EBD	Residential Center	Cross-age peer tutoring	Arithmetic	Accuracy	Minimal increases in academic performance for tutors

Study	Design	Participants	Setting	Intervention	Math Skill	Dependent Measures	Outcomes
Lazarus (1993)	Multiple Baseline	4 female students with EBD and 10 male students with EBD	Special Education Classrooms	Self-monitoring	Multiplication facts	Attempted Problems Accuracy	Increased number of problems completed, increased accuracy
Maheady et al. (1987)	Multiple Baseline	14 students with LD or ED	9^{th} and 10^{th} grade general education classroom	Same-age peer tutoring	Math calculation, fractions, time, money management, applied problems	Accuracy	Increased quiz scores and higher math grades
Maher (1982, 1984, 1986)	ABC, Multiple Baseline, Multiple Baseline	18 students with problematic behavior, 8 students with problematic behavior, 16 students with problematic behavior	Special Education Classrooms (elementary classrooms including students with intellectual disabilities)	Cross age peer tutoring	Math Social Science Language Arts	Grades Disciplinary referrals Attendance	Study 1 increased mathematics grades, decreased absenteeism, and fewer disciplinary referrals; Study 2 and Study 3 decreased absenteeism and fewer disciplinary referrals

Study	Design	Participants	Setting	Intervention	Math Skill	Dependent Measures	Outcomes
Osborne (1987)	ABAB	2 male students with EBD	Special Education Classrooms Public School	Self-monitoring	Not specified	Attention to task Accuracy	Increased time on-task for both students; Increased accuracy for one student
Riccomini et al. (2008)	Pre/post testing	9, 6th grade students with EBD	Public Schools	CRA instructional sequence	Math standards included on the end of year state assessments	Accuracy Math Level	Increased math performance and level
Salend & Washin (1988)	ABAB	18 students with severe conduct disorders committed to state care	Correctional Facility	Cooperative Learning Groups	Math calculation skills	On-task behavior, Cooperative behavior, Academic performance	Increased time on-task and cooperative behaviors, correlation between cooperative learning and math achievement was not evident

Study	Design	Participants	Setting	Intervention	Math Skill	Dependent Measures	Outcomes
Skinner et al. (1989)	Multiple Baseline	4 students (2 secondary students, 2 elementary)	Private day school for students with EBD	Cover, Copy, Compare	Multiplication facts	Response Rate Response Accuracy	Increased rate and accuracy of responses
Skinner et al. (1993)	Multiple Baseline	3 students with EBD	Private day school for students with EBD	Cover, Copy, Compare	Division facts	Number of problems completed Accuracy	Increased problems attempted and increased accuracy
Swanson & Scarpati (1984)	ABAB	1 educationally handicapped, non-psychotic male student	University special education laboratory school	Self-instruction training	Two- and three-digit multiplication facts	Accuracy	Increased accuracy that was generalized to other settings

APPENDIX B

Findings from Empirical Studies Evaluating Write-on Response Cards

Study	Design	Subject	Participants	Dependent Measures	Findings
Al-Attrash (1999)	Alternating treatment	Social Studies (general education)	29 students	Quiz, tests, and essay scores, response number and accuracy, student preferences	Increased quiz, test, and essay scores during the response card with guided notes session, approximately half of the students preferred responses cards with guided notes to hand raising
Armendariz & Umbreit (1999)	ABA	Mathematics (general education)	21 students	Disruptive behavior	Disruptive behavior was stable and less frequent in the response card condition
Cavanaugh, et al. (1996)	Alternating Treatment	Science (general education)	23 students (8 with ED, LD, or MR)	Next day tests, weekly tests	Increased quiz performance 13/15 general education students, 8/8 students with disabilities; Increased test scores for all students during the response card condition
Christle & Schuster (2003)	ABA	Mathematics (general education)	5 students who represented the class	Participation, on-task behavior, weekly quizzes	Increased participation, on-task behavior, and quiz scores during the response card condition

Study	Design	Subject	Participants	Dependent Measures	Findings
Davis & O'Neil (2004)	ABA	English (general education)	4 students with LD (2 ELL)	Response rate, response accuracy, disruptive behavior, quiz scores,	Increased rate and accuracy of responses during the response card condition, higher quiz scores in the response card condition, variable effects on quiz scores in both conditions
Duchaine (2011)	Alternating Treatment	Academic Review (general education)	6 students with behavioral problems (1 student with EBD, 1 with LD, 1 with Autism, 3 students without disabilities	Time on-task, attempted responses, next day quiz scores, biweekly quizzes	Increased time on task, attempted responses, and biweekly quizzes (3/4 students) during the response card condition, variable results for next day quizzes
Gardner, et al, (1994)	ABAB	Science (general education)	22 students	Teacher presentation rate, number of student response, accuracy of student responses, next quizzes, tests	Decreased presentation rate during the response card condition, response accuracy similar in both conditions, 21/22 students did better on next day quizzes and all students improved scores on biweekly tests during the response card condition

Study	Design	Subject	Participants	Dependent Measures	Findings
George (2010)	Group Experimental Cross Over Design	Social studies (special education-EBD)	29 students with EBD	Chapter posttest, academic responses, correct academic responses, on-task behavior, student preferences	15/22 scored higher on posttests in the response card condition, increased participation and response accuracy in the response card condition, most students liked response cards
Lambert, et al. (2006)	ABAB	Math (general education)	9 students with disruptive behavior	Number of responses, response accuracy, disruptive behavior, student preferences	Increased number and accuracy of responses during the response card condition, decreased disruptive behavior during the response card conditions, majority of students preferred response cards to hand raising
Maheady et al. (2002)	Alternating Treatment (HR, RC, Heads Together)	Science (general education)	21 6^{th} grade students	Number of responses, accuracy of responses, quizzes, tests, student preferences	Number and accuracy of responses, quiz, and test scores were higher in the response card and two heads together conditions, students preferred use of two heads together and response cards

Study	Design	Subject	Participants	Dependent Measures	Findings
Monro & Stephenson (2009)	ABAB	Vocabulary (general education classroom in British Columbia)	5 low responding students	Rate of teacher questions, rate of teacher feedback, percent of student initiated responses, test scores	Similar rate of questions in both conditions, more teacher feedback during the response card condition, higher quiz scores in the response card condition
Narayan, et al. (1990)	ABAB	Social Studies (general education)	20 students	Teacher presentation rate, number of student responses, accuracy of student responses, daily quiz scores	Increased rate of active responding, response accuracy, and daily quiz scores during the response card condition, 19/20 students preferred the use of response cards to hand raising, slightly lower presentation rate in the response card condition
Swanson (1998)	ABAB (phase 1) Multiple Baseline (phase 2)	Social studies (general education)	6 students (3 with LD, 3 without disabilities)	Quiz scores, test scores, student preferences	Students scored higher on quizzes and tests in the response card condition, students preferred using response cards in isolation

Study	Design	Subject	Participants	Dependent Measures	Findings
Weatherford (2011)	Task Analysis	Mathematics (special education)	3 students with ID	Response rate, correct response, incorrect response	Increased response rate and accuracy, higher quiz scores during the response card condition, inconclusive quiz scores, biweekly test scores increased

APPENDIX C

Findings from Empirical Studies Evaluating Pre-printed Response Cards

Study	Design	Subject	Participants	Response Tool	Dependent Measures	Findings
Berrong, et al. (2007)	ABAB	Mathematics (special education)	8 students with moderate to severe disabilities	3 x 3 in pre-printed response card	Active responding, on-task behavior, inappropriate behavior	Increased active responding, for 6-8 students, and on-task behavior during the response card conditions, variable inappropriate behaviors across conditions
Clarke (2010)	ABAB	Language Arts Vocabulary	5 students with mild mental disabilities	Pre-printed picture response cards	Active responding, accuracy of responses, on-task behavior, number of correct responses on a unit test	Increased responding, response accuracy, and on-task behavior during the response card condition; unclear results for end of unit tests
Godfrey, et al. (2003)	Alternating Treatment	Calendar time (general education)	5 preschool students with low response rates	Preprinted response cards	Active responding, on-task behavior, inappropriate behavior	Increased active responding and on-task behavior during the response card condition, decreased inappropriate behavior during the response card condition

Study	Design	Subject	Participants	Response Tool	Dependent Measures	Findings
Horn et al. (2006)	ABAB	Math (special education)	3 students with moderate to severe disabilities	Laminated flip board and preprinted response cards	Active responding, accuracy of responses, on-task behavior, inappropriate behavior	Increased active responding, correct responding, and on-task behavior during the response card conditions, decreased inappropriate behavior during the response card conditions
Inwood (1995)	ABAB	Colors (public preschool)	4 students with LD	Preprinted response cards	Participation, on-task behavior, response accuracy	Increased participation and on-task behavior during the response card condition, similar response accuracy in both conditions
Skibo et al. (2011)	Multiple Baseline	Mathematics (special education, separate public day school)	3 students with significant disabilities	Preprinted response cards	Number of correct responses	Increased correct responding during the response card condition
Wood et al. (2009)	ABAB	Mathematics (general education)	4 target students	Preprinted response cards	Participation, off-task behavior	Increased participation and decreased off-task behavior during the response card conditions

APPENDIX D

Findings from Empirical Studies Evaluating Electronic Student Response Systems

Study	Design	Subject	Participants	Response Tool	Dependent Measures	Findings
Abode (2010)	Mixed Methods	Language Arts Math (general education)	100 students	Student response system by SMART Technologies	Math and Language Arts Achievement, Motivation, Engagement	Achievement outcomes were mixed, Survey results and interviews indicated that student response systems increased motivation and engagement
Blood (2010)	ABABC	Social Studies (special education)	5 students with EBD	Student response system (Clickers) Turning Point Technologies	Response rate, time on-task, percentage correct on daily quizzes, percent correct on end of phase quizzes	Increased response rate and time on-task with response system, no definitive differences in quiz scores, slight increase in test scores but no significant differences in response system condition

Study	Design	Subject	Participants	Response Tool	Dependent Measures	Findings
Conoley (2005)	Mixed Methods	Science (general education)	61 students	Audience Response System	Student achievement, teacher and student perceptions	Significant increase in student achievement during the response system condition, teachers reported improved ability to analyze student results and allowed of more detailed feedback, students indicated response system was "fun", increased participation, and better understanding of material
Gilson (2010)	Quasi-Experimental	Science (general education)	27 students (4 received special education services)	iClickers	Student engagement, test scores	Student survey results indicated increases in student engagement during the iClicker lessons and increased achievement between pre- and posttests.
Grissom (2006)	Quasi-Experimental	Mathematics (general education)	84 students	Student response system (Clickers)	Student to teacher responses, student to student responses, achievement	No significant differences in student to teacher responses or achievement, increased student to student responses in the response system condition

Study	Design	Subject	Participants	Response Tool	Dependent Measures	Findings
Lively (2010)	Quasi-Experimental	Social Studies (general education)	97 students	Classroom Performance System	Student achievement	Results were inconclusive, decreased achievement in the geography domain, no significant change in civics, and improvements in the economic and history domains in the classroom performance system conditions
Mankowski (2011)	Quasi-Experimental	Science (general education)	30 students	Audience Response System with peer instruction	Student achievement, student engagement, student preferences	No significant achievement differences between peer instruction and peer instruction with audience response systems, minimal achievement improvements in active response system condition, students reported positive reactions to the use of clickers
Rigdon (2010)	Mixed Methods	Mathematics (general education)	59 students	Student response system manufactured by Quizdom	Student perceptions, pre and posttest scores	Interviews and survey data indicated that students "like" Quizdom and learned more during Quizdom lessons, no significant difference in post test scores than pretest scores during Quizdom
Sartori (2008)	Group Experimental	Mathematics (general education)	108 average achieving students	Student response system (Clickers)	Pre- and posttests, student and teacher satisfaction	No significant differences between pre and posttests, participants reported higher achievement with the student response systems

APPENDIX E

Instructional Staff Demographic Sheet

Study Identification Number: _______________________________ Age: ________

Ethnicity: __________________________Current Position: _________________________

Degree(s): ____

Highly Qualified: Yes No

Years in Special Education: ______________Years in Current Position: ______________

Years in Secondary Mathematics: _________ Years in District: ______________________

APPENDIX F

Student Demographic Sheet

Name: ______________________________________ Age in Months: ___________

Grade Level: _______ Gender: ___________ Ethnicity: ________________

Disability/Disabilities: ____

Initial Eligibility Date: ___________ Years in Special Education: _____________

ELL: Yes No

Intelligence Test: ________________ Date of Administration: __________
Score: ______

Reading Achievement Test: _______ Date of Administration: __________
Score: ______

Math Achievement Test: _________ Date of Administration: __________
Score: ______

PSSA Form: ___________________ Grade 5 Math Score: __________________

PSSA Form: ___________________ Grade 8 Math Score: __________________

Testing Scheduled for 2011 School Year:_______________________________________

APPENDIX G

Sample Lesson Plan

Lesson 1: Mean / Median / Mode and Outlier Lesson
Strand: Statistics and Data Analysis

Teacher Script: We will work with the following standards:
2.6.11.C Select or calculate the appropriate measure of central tendency, calculate and apply the interquartile range for one-variable data, and construct a line of best fit and calculate its equation for two-variable data.
2.6.11.A Design and conduct an experiment using random sampling
Teacher Script:

1. Mean is the average value of all data in a set. Add up the numbers then divide by the number of values in the set to find the mean.

Example: Find the mean of the following: { 65, 72, 83, 89 }

$$\textbf{Mean} = \frac{66 + 72 + 83 + 89}{4}$$

$$\textbf{Mean} = \frac{310}{4}$$

$$\textbf{Mean} = 77.4$$

Find the mean in the table below:

Test Score	# of people who earned this test score
70	3
80	2
90	1
100	5

(70+70+70+80+80+90+100+100+100+100+100)/11 = 87.27

2. The median is the value that has exactly half the data above it and half below it. To find the median, **order the numbers from smallest to largest**. The middle number is the median.

Example: Find the median of the following: { 65, 72, 81, 83, 89 }

Median = the middle number from smallest to largest

81

What happens when you try to find the median number in this data set?

Rates
17.2%
21.0%
22.6%
25.4%
28.5%
28.6%

Not so easy is it? There isn't a middle value - we have an even number of rates. In this case, we find the median by finding the mean of the two middle values

(22.6% and 25.4%): The median is 24.0%.

3. The mode is the number that appears most often in the set.

Example: Find the mode of the following: { 65, 65, 71, 72, 81, 83, 83, 83, 89 }

Mode = the number that appears most often

Mode = 83

Outliers:

If you have one, or more, outlying values (OUTLIERS) that do not follow the general trend of the numbers in a sample, the mean (average) can be affected dramatically. It can be drastically increased or decreased, and it might not be a value that represents the data.

Example of the Effect of Outliers – Suppose you collected data on the number of donuts 8 teenagers ate for breakfast. The data is listed below.

1, 2, 2, 2, 3, 3, 4, 6

You then find a 9th teenager who is a professional food challenger who ate 100 donuts for breakfast.

1, 2, 2, 2, 3, 3, 4, 6, 100

Surely, the mean will drastically change.

Mean without the 100 =	Mean with the 100 =

The mean is inflated when the outlier is included.

Use the procedures listed below for your assigned group.

Review
Traditional Responding (Hand Raising) Group

Teacher Script: **We are going to practice measures of central tendency. Please raise your hand to share your answer.**

Procedures

1. *Read each question aloud.*
2. *Call on a student whose hand is raised.*
3. *If, **and only if**, the student provides the correct answer, provide a specific praise statement.*
4. *If the student answers incorrectly, return to step 2.*
5. *If a student does not volunteer to answer or 3 students have answered the question incorrectly. Reveal and provide a rationale for the answer.*
6. *Reveal the next question and start with step 1. Continue with procedures for 30 minutes.*

Response Cards (White Boards and Markers) Group
Teacher Script: We are going to practice measures of central tendency. Use your white board to share your answers.
Procedures

1. Read each question aloud.
2. Provide wait time for students to complete the question.
3. Ask students to present their cards.
4. If 75% or more of the class makes a correct response, reveal the answer and provide specific praise for the correct answer.
5. If less than 75% correctly answers the question, ask students to try again. Reveal the correct response.
6. Reveal the next question and start with step 1. Continue with procedures for 30 minutes.
** Procedures adapted from Lambert et al. (2006)*

Response System (ActivResponders) Group
Teacher Script – We are going to practice using measures of central tendency. Use your ActivResponder to share your answers.
Procedures

1. Read each question aloud.
2. Provide wait time for students to complete the question.
3. Ask students to enter their answers.
4. If 75% or more of the class makes a correct response, reveal the answer and provide specific praise for the correct answer.
5. If less than 75% correctly answers the question, ask students to try again. Reveal the correct response.
6. Reveal the next question and start with step 1. Continue with procedures for 30 minutes.
** Procedures adapted from Lambert et al. (2006)*

Questions (Power Point 1)

APPENDIX H

Sample Unit Quiz

First Name:______________________________ Date:__________________________

Directions: Answer each question. Please show your work.

---

1. y = 4x
   y = 80 + 12x

   A) (-10, -40)
   B) (-12, -24)
   C) (-4, -8)
   D) (-6, -36)

---

2. 4p + 4 = 20

   A) 6
   B) 24
   C) 4
   D) 5

---

3. What is the value of the expression 2x + 7 when x= 6?

   A) 19
   B) 15
   C) 33
   D) 28

---

4. d/4 + 7 > 18

   A) $d \geq 44$
   B) d > 25
   C) d < 22
   D) d < 29

5. f – 5 = 36

A) 36
B) 31
C) 33
D) 41

---

6. y = 2x – 10
y = 3x - 5

A) (4, -15)
B) (-12, 3)
C) (-5, -20)
D) (9, 13)

---

7. v/ 7 - 9 = 1

A) 30
B) 40
C) 70
D) 50

---

8. 13 + k = 87

A) 100
B) 74
C) 98
D) 72

---

9. 3v – 10 < 14

A) $v \leq 8$
B) v > 9
C) v < 9
D) v < 8

---

10. What is the value of the expression p – 45 when p = 53?

A) 98

B) 8

C) 95

D) 7

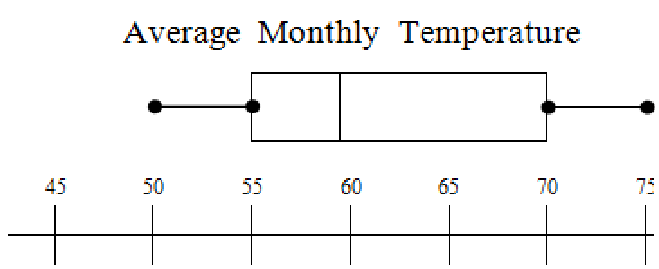
APPENDIX I

Sample Delayed Quiz

First Name: ______________________________ Date: ___________________________

Directions: Answer each question. Please show your work.

The box-and-whisker plot shows the average monthly temperatures for a city over a span of 5 years. Use the plot to answer question 1.

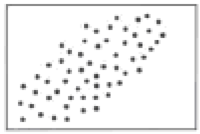


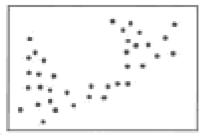
1. What is the value of the lower extreme?

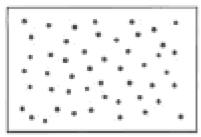
    A) 45
    B) 50
    C) 55
    D) 60

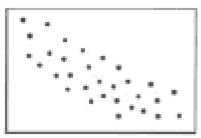
---

2. Which scatter plot shows no correlation?

A) 

B) 

C) 

D) 

The results of the last reading test are displayed in the stem and leaf plot below. Use the stem and leaf plot to answer question 3.

3. What is the median test score?

Stem	Leaf
3	0
4	
5	
6	9
7	2 3 3 4
8	5 6 8 9
9	1 2 6 7 7 7 7 7

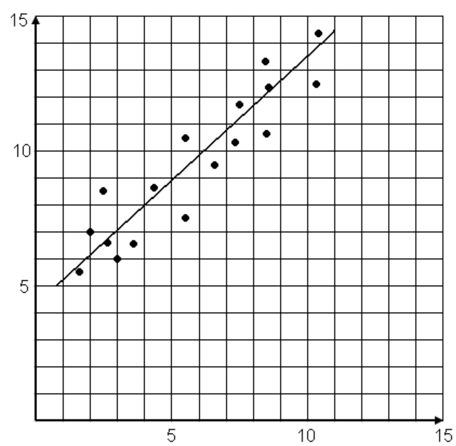
A) 83.50
B) 97.00
C) 30.00
D) 88.50

---

4. A bag contains 3 red gumballs, 2 blue gumballs, and 4 black gumballs. What are the odds that a gumball drawn from the bag will be red?

A) $\frac{3}{1}$
B) $\frac{1}{3}$
C) $\frac{1}{2}$
D) $\frac{2}{1}$

Use the scatter plot to answer questions 5.



5. Use the line of best fit to estimate the value of y when x is 6.

A) 8
B) 6
C) 7
D) 10

The results of the last math test are displayed in the stem and leaf plot below. Use the stem and leaf plot to answer question 6.

Stem	Leaf
3	**6**
4	
5	
6	**7 8 9**
7	**1 1 1 2 3 3 3 4**
8	**8 9**
9	**1 2**

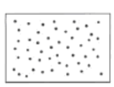
6. What is the mean test score?
   - A) 73.63
   - B) 73.50
   - C) 73.00
   - D) 71.00

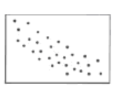
---

7. Which of the scatter plots suggests a negative correlation?

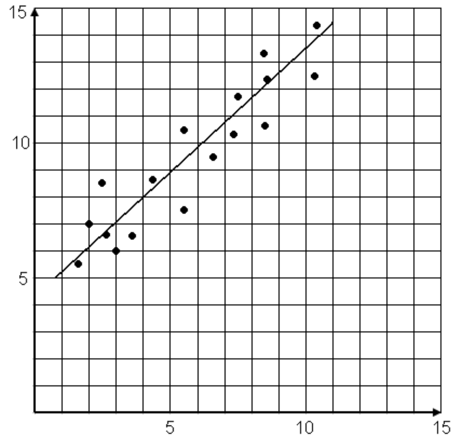
   A) 

   B) 

   C) 

   D) 

Use the scatter plot to answer questions 8.



8. Estimate the value of y when x equals 0.

A) 1
B) 4
C) 8
D) 10

---

9. If 125 boys and 150 girls were entered in a drawing for a $100 gift card, what are the odds that a girl would be chosen?

A) 6:5
B) 5:6
C) 5:11
D) 11:5

Monthly car payments for 7 of your friends are listed below. Use the data to answer question 10.

{$225, $240, $320, $320, $370, $350, $999}

10. If the outlier were removed, the mean car payment would

A) increase.
B) decrease.
C) stay the same.
D) The dataset does not include an outlier.

---

11. What is the value of the expression p – 45 when p = 53?

A) 98
B) 8
C) 95
D) 7

---

12. What is the value of the expression 2x + 7 when x= 6?

A) 19
B) 15
C) 33
D) 28

---

13. 4p + 4=20

A) 6
B) 24
C) 4
D) 5

---

14. f – 5 = 36
A) 36
B) 31
C) 33
D) 41

---

15. $d/4 + 7 \geq 18$

A) $d \geq 44$
B) $d > 25$
C) $d < 22$
D) $d < 29$

---

16. $y = 2x – 10$
$y = 3x - 5$

A) (4, -15)
B) (-12, 3)
C) (-5, -20)
D) (9, 13)

---

17. $v/ 7 - 9 = 1$

A) 30
B) 40
C) 70
D) 50

---

18. $13 + k = 87$

A) 100
B) 74
C) 98
D) 72

---

19. $3v – 10 < 14$

A) $v \leq 8$
B) $v > 9$
C) $v < 9$
D) $v < 8$

---

20. $y = 4x$
$y = 80 + 12x$

A) (-10, -40)
B) (-12, -24)
C) (-4, -8)
D) (-6, -36)

APPENDIX J

Data Collector: Participation Training Materials

<u>Training Script</u>

The purpose of our project is to evaluate the use of response tools on the mathematics performance of secondary students with emotional or behavioral disabilities. A portion of the research includes collecting data on students' participation during instruction. Participation data will be collected during the review portion of the math class block using a frequency recording procedure. We will collect data during 1^{st} block, 4^{th} block, and 5^{th} block math classes. You will serve as a primary data collector or collect reliability data two times per week. It is important that we are consistent and everyone pays close attention to data collection requirements.

We will have three types of response options (hand raising, white boards, ActivResponders). If a student raises his hand, writes a response (not drawing or scribble), or enters an answer on his ActivResponse system then it is considered participating. There are three letters used to record responses. For the hand raising condition, mark P and the question number if a student raises his hand but is not called on by the teacher. For the hand raising, white board, and ActivResponder conditions mark A and the question number if a student attempts to answer a question (answers but incorrectly). Mark a C and the question number if a student answers a question correctly across the three conditions. Only one letter should be marked per student per question. If a student does not attempt to answer a question, a letter would not be recorded.

Discussion: What if a student draws on his white board? What if a student shouts out an answer?

Let's try it.

Show you-tube video. Ask to collect and compare data using the form. Discuss results of you tube. Discuss that observer drift can occur and emphasize the need to remain focused and watch the stopwatch. Redo until reach 100% inter-rater reliability.
http://www.youtube.com/watch?v=tAz7TD02ytU&feature=related

Observer: ____________________________ Date: _________ Time: _________________________________
Class: ______________________________ Grade: ________ Topic: _________________________________

P#: Student raised hand (hand raising condition only)
A#: Student answered a question
C#: Student answered a question correctly

Notes:

APPENDIX K

Data Collector: On-Task Training Materials

Training Script

The purpose of our project is to evaluate the use of response tools on the mathematics performance of secondary students with emotional or behavioral disabilities. A portion of the research includes collecting data on students' time on-task during instruction. On-Task data will be collected for the entire math class block using a time sampling procedure. We will collect data during 1st block, 4th block, and 5th block math classes. You will serve as a primary data collector or collect reliability data two times per week. It is important that we are consistent and everyone pays close attention to data collection requirements.

First, we will discuss on-task versus off-task behaviors. For purposes of our research, a student who is on-task (a) is in designated area of room, (b) is manually engaged with appropriate materials, (c) is complying with teacher directives, (d) refrains from making derogatory comments about task/others, (e) asks relevant question(s) to adult, (f) maintains focus on appropriate task or to the lecture, and (g) may appear in thought by intermittently and quietly looking away from material or lecture material but is engaged only with self.

Discussion: What are some behaviors that may be considered off task? (calling out rather than raising hand, scribbling on white board, playing with cell phone, in bag, walking around the classroom, name calling etc.)

Discussion: What would on-task behaviors look like? (student is seated, engaged only with materials (white board, marker, ActivResponder depending on lesson)

To evaluate time on on-task, we will record student on-task/off-task behavior on 60 second intervals. Each student will be assigned a number. You will sit in the front of the classroom. At the onset of the lesson you will start your stop watch. Every 60 seconds, you will scan the room and place and + or – on your chart. An x indicates the student is on-task and a – indicates the student is off-task. Every minute, you will scan the room starting with student 1 and ending with the student sitting in the last seat on the right row. You will scan each horizontal row starting with the left row and moving to the row farthest on the right (demonstrate).

Let's try it.

Show you-tube video. Ask to collect and compare data using the form. Discuss results of you tube. Discuss that observer drift can occur and emphasize the need to remain focused and watch the stopwatch. Redo until reach 100% inter-rater reliability.

http://www.youtube.com/watch?v=tAz7TD02ytU&feature=related

Observer: ____________________________ Date: _________ Time: ____

Class: ________________________________ Grade: _______ Topic: ____

Interval	Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1																
2																
3																
4																
5																
6																
7																
8																
9																
10																
11																
12																
13																
14																
15																
16																
17																
18																
19																
20																

Interval	Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
21																
22																
23																
24																
25																
26																
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36																
37																
38																
39																
40																

Notes: ____

____

____

APPENDIX L

Intervention Training: Teachers, Instructional Assistant, University Student

Materials:

- White Boards, Markers, Felt
- ActivResponders
- Calculator
- Formula Sheet
- Lesson Plans (Number Patterns, Volume)
- Copy of Review Questions
- Treatment Fidelity Measures

The researcher will provide training to teachers who provide instruction including response tools (hand raising, white boards, and ActivResponders). It is estimated that the training will take approximately four hours. An instructional assistant who is routinely in both classrooms will trained in case of an unforeseen circumstance that precludes a teacher from attending school or providing instruction at some point during the research. A student from a local community college/university will be trained to collect fidelity of treatment data. Teachers will be trained until they are able to deliver a lesson following scripted procedures with 100% accuracy. The data collector will practice documenting treatment fidelity.

The researcher will review the lesson plan format and materials for each condition. The researcher will model the lesson below with hand raising, white board, and ActivResponder response options. The researcher will note that the response tool used for the lessons will be different each week and that the response tool directions will be highlighted on each lesson plan provided. The researcher will then model a lesson. Teachers will observe directions and how to use each of the response options.

Strand: Algebraic Concepts
Researcher will state "today we will be covering" and read the standard.
Standard: 2.8.8.C Find the missing elements and recognize, describe and extend patterns to include linear, exponential and simple quadratic equations.
The researcher will review the teacher script that is projected on the promethium board.
Teacher Script:

1. *A sequence is a set of numbers that follows a pattern or a rule. You can often find additional, or missing numbers of a sequence by figuring out the pattern or rule*.

   Example: What two numbers come next of the sequence?
   2, 6, 10, 14, …

Step 1: Identify the rule of the sequence (add 4)
Step 2: Find the next two numbers (14 + 4 = 18, and 18 +4= 22)
Answer: the next 2 numbers of the sequence are 18 and 22.

2. *Some questions will ask you to find the numbers that come next in the pattern, while other questions will ask you to find the number that is missing in the sequence. Remember you have to figure out the rule first!*
   Example: What is the missing number in the sequence?
   3, 6, _______, 24, 48

Step1: Identify the rule or pattern the sequence is following (multiply by 2)
Step 2: Use the rule to find the missing term (6 x 2 = 12 and 12 x 2 = 24)
Answer: The missing number in the sequence is 12

The researcher will review and model procedures for each of the conditions.

Review

Traditional Responding (Hand Raising) Group

Teacher Script: We are going to evaluate number patterns. Please raise your hand to share your answer.

Procedures

1. Read each question aloud.
2. Call on a student whose hand is raised.
*3. If, **and only if**, the student provides the correct answer, provide a specific praise statement.*
4. If the student answers incorrectly, return to step 2.
5. If a student does not volunteer to answer or 3 students have answered the question incorrectly. Reveal and provide a rationale for the answer.
6. Reveal the next question and start with step 1. Continue with procedures for 30 minutes.

Response Cards (White Boards and Markers) Group

Teacher Script: We are going to evaluate number patterns. Use your white board to share your answers.

Procedures

1. Read each question aloud.
2. Provide wait time for students to complete the question.
3. Ask students to present their cards.
4. If 75% or more of the class makes a correct response, reveal the answer and provide specific praise for the correct answer.
5. If less than 75% correctly answers the question, ask students to try again. Reveal the correct response.
6. Reveal the next question and start with step 1. Continue with procedures for 30 minutes.
** Procedures adapted from Lambert et al. (2006)*

Response System (ActivResponders) Group

Teacher Script – We are going to evaluate number patterns. Use your ActivResponder to share your answers.

Procedures

1. Read each question aloud.
2. Provide wait time for students to complete the question.
3. Ask students to enter their answers.

4. If 75% or more of the class makes a correct response, reveal the answer and provide specific praise for the correct answer.
5. If less than 75% correctly answers the question, ask students to try again. Reveal the correct response.
6. Reveal the next question and start with step 1. Continue with procedures for 30 minutes.
** Procedures adapted from Lambert et al. (2006)*

Practice Questions (projected on promethium board)

1.What number comes next in this sequence?

4, 8, 16, …

A 24
B 32
C 40
D 48

2.What two numbers come next in the sequence?

98, 90, 82, 74, …

A 65, 42
B 68, 54
C 66, 58
D 60, 52

3. What is the missing number in this sequence?

3, 5, 9, ______, 33, 65

A 17
B 18
C 20
D 16

4. What number comes next in this pattern?

56, 46, 36, 26, …

A 21
B 106
C 6
D 16

5. What two numbers come next in this pattern?

2, 1.75, 1.50, 1.25, …

A 1, 0.75
B 1.05, 0.50
C 0, 0.50
D 0.75, 0.25

6. What is the missing number in this sequence?

95, 70, _______, 20

A 35
B 40
C 45
D 30

7. What number comes next in this pattern?

4, 2, 0, -2, …

A -5
B -6
C -3
D -4

8. What is the missing number in this sequence?

3, 14, 25, ____, 47, 58

A 34
B 32
C 36
D 38

9. What two numbers come next in this sequence?
5, 5.5, 6, 6.5, 7, …
A 7.5, 8
B 8, 8.5
C 8, 9
D 7.25, 8.25
10. What number comes next in this pattern?
4, 6, 10, 16, 24, …
A 30
B 34
C 36
D 38
11. What two numbers come next in this pattern?
-1, -3, -5, -7, …
A -9, -11
B -10, -12
C -9, -13
D -11, -13
12. What is the missing number in this pattern?
1, 4, _____, 64, 256
A 22
B 24
C 14
D 16
13. What number comes next in this sequence?
2, 4, 6, 12, 14, …
A 24, 28
B 28, 30
C 30, 34
D 26, 32
14. What is the missing number in this sequence?
7, 14, 21, ______, 35, 42
A 28
B 24
C 26
D 30
15. What number comes next in this sequence?
64, 56, 48, 40, …
A 24
B 36
C 32
D 30

Teachers will be provided with a Geometry lesson. Teachers will practice the lesson for each condition until they are able to deliver the lesson with 100% accuracy. The data collector will complete fidelity of treatment forms as will the researcher until 100% reliability is established.

Geometry Unit

Strand: Measurement and Estimation (Geometry)
Teacher Script: Today we will be working with the following standard:

Standard: 2.3.11.C – Use properties of geometric figures and measurement formulas to solve for a missing quantity.

Teacher Script:

Definitions:
- **Volume** is the measurement "inside" a 3-dimensional shape. (Units for area is units^3.)
- **Height** of a 3-dimensional shape is the distance between the two EQUAL bases. Also, the height and the bases meet at 90°.

Whenever dealing with formulas always follow the three steps:
1. Write out the formula you are using
2. Plug in the numbers/values that you know
3. Solve for the missing variable

Formulas to use for this section:

$V_{RectPrism}$= (Area of Base) • (height)
$V_{RecPrism}$ = l • w • h

$V_{Cylinder}$ = (Area of Base) • (height)
$V_{Cylinder} = \pi \cdot r^2 \cdot h$

$V_{TriPrism}$ = (Area of Base) • (height)
$V_{TriPrism}$ = (½ • b • h) • (height)

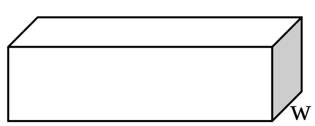
$V_{Cone} = \frac{1}{3}$ (Area of Base) • (height)
$V_{Cone} = \frac{1}{3} \pi \cdot r^2 \cdot h$

$V_{Pyramid} = \frac{1}{3}$ (Area of Base) • (height)
$V_{Pyramid} = \frac{1}{3}$ l • w • h

Examples:

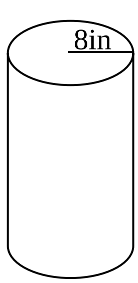
E1: The Volume of the shape below is 120in^3. What is the value of the missing dimension?

(height)



$V_{RectPrism}$= (Area of Base) •
$V_{RecPrism}$ = l • w • h
120 = 6 • w • 4
120 = 24w
5 = w

E2: The approximate volume of the shape below is 3014.4in^3. What is the value of the missing dimension?



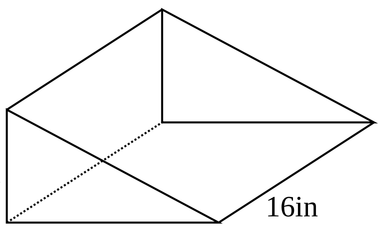
$V_{Cylinder}$ = (Area of Base) • (height)
$V_{Cylinder} = \pi \cdot r^2 \cdot h$
$3014.4 = \pi \cdot 8^2 \cdot h$

$$\frac{3014.4}{64\pi} = \frac{\pi \cdot 64 \cdot h}{\pi \;\; 64} \quad \leftarrow \text{Divide both sides by } 64\pi$$

h

15 = h

E3: The Volume of the shape below is 120in^3. What is the value of the missing dimension?



32

$V_{TriPrism}$ = (Area of Base) • (height)

$V_{TriPrism}$ = (½ • b • h) • (height)

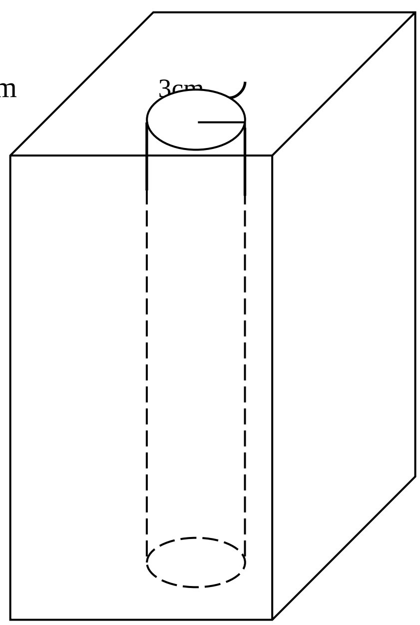
120 = (½ • b • 4) • (16)

120 = (2b) • (16)

$$\frac{120}{32} = \frac{32b}{32} \quad \leftarrow \text{Divide both sides by}$$

3.75in = b

E4: Find the volume of the shape below. Note: the shape is a rectangular prism with a hollow cylinder in the middle.



• h

• 20

$V_{RecPrism}$ = l • w • h

= 10 • 12 • 20

= 2400cm^3

$V_{Cylinder} = \pi \cdot r^2$

$= \pi \cdot 3^2$

$= \pi \cdot 9 \cdot 20$

$= 180\pi$

$V_{RecPrism}$	2400.0cm^3
- $V_{Cylinder}$	565.2cm^3
$V_{NewTotal}$	1834.8cm^3

Notes on how to solve this.

- Find the Volume of the "box"
- Find the Volume of the Cylinder
- Subtract off the cylinder because that part does not exist if it is hollowed out.

Review

Review

Traditional Responding (Hand Raising) Group

Teacher Script: **We are going to determine area and surface area. Please raise your hand to share your answer.**

Procedures

1. Read each question aloud.
2. Call on a student whose hand is raised.
*3. If, **and only if**, the student provides the correct answer, provide a specific praise statement.*
4. If the student answers incorrectly, return to step 2.
5. If a student does not volunteer to answer or 3 students have answered the question incorrectly. Reveal and provide a rationale for the answer.
6. Reveal the next question and start with step 1. Continue with procedures for 30 minutes.

Response Cards (White Boards and Markers) Group

Teacher Script: We are going to determine area and surface area. Use your white board to share your answers.

Procedures

1. Read each question aloud.
2. Provide wait time for students to complete the question.
3. Ask students to present their cards.
4. If 75% or more of the class makes a correct response, reveal the answer and provide specific praise for the correct answer.
5. If less than 75% correctly answers the question, ask students to try again. Reveal the correct response.
6. Reveal the next question and start with step 1. Continue with procedures for 30 minutes.

** Procedures adapted from Lambert et al. (2006)*

Response System (ActivResponders) Group

Teacher Script – We are going to determine area and surface area. Use your ActivResponder to share your answers.

Procedures

1. Read each question aloud.
2. Provide wait time for students to complete the question.
3. Ask students to enter their answers.
4. If 75% or more of the class makes a correct response, reveal the answer and provide specific praise for the correct answer.
5. If less than 75% correctly answers the question, ask students to try again.

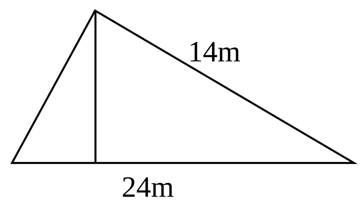
Reveal the correct response.

6. *Reveal the next question and start with step 1. Continue with procedures for 30 minutes.*

** Procedures adapted from Lambert et al. (2006)*

The teacher will go through the presentation using each of the response tools.

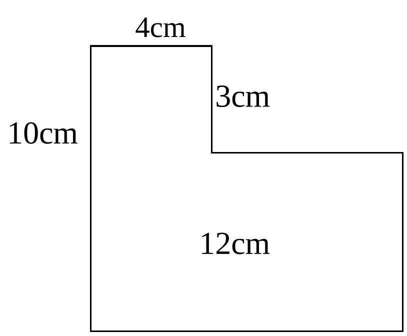
1. The area of the triangle below is $72m^2$. Determine what the height of the shape.



A. 4 m
B. 2 m
C. 10 m
D. 6 m

---

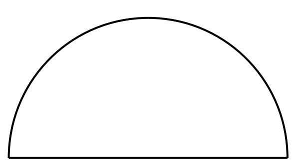
2. Find the area of the shape below.



A. 124 cm^2
B. 132 cm^2
C. 120 cm^2
D. 96 cm^2

---

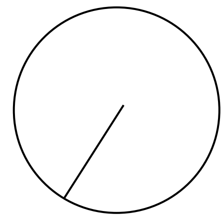
3. What is the area of the shape below is the radius is 8cm.



A. 12.56 cm^2
B. 200.96 cm^2
C. 50.24cm^2
D. 100.48 cm^2

---

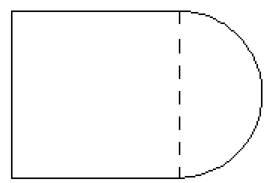
4. Find the approximate length of the radius if the area is 25π.



A. 5m
B. 10 m
C. 7.9 m
D. 2.5 m

---

5. If the area of the shape below is 48m2. What is the height of the shape? this shape? (The curved part of the diagram is a semicircle.)



A. 50.13 meters
B. 36.84 meters
C. 42.84 meters
D. 92.52 meters

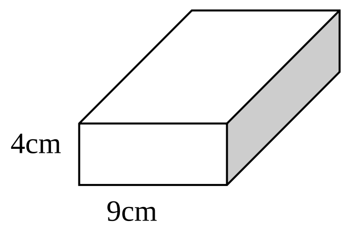
---

6. If 2 opposite sides of a rectangle measure 6ft. and the area of the shape is $120ft^2$. What is the other dimension worth?

A. 40 ft
B. 5 ft
C. 20 ft
D. 10 ft

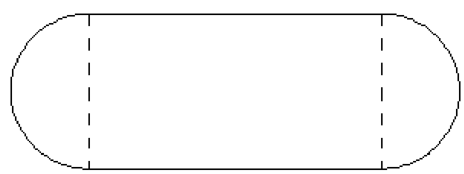
---

7. The surface area equals 384cm^2. Find the width of the prism.



A. 12 cm
B. 13 cm
C. 10.6 cm
D. 29.5 cm

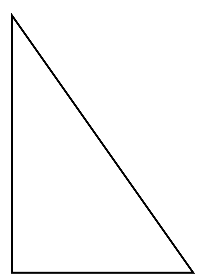
8. Determine the area of the following shape given the following dimensions of the <u>rectangle</u>: *8 cm by 12 cm*



A. 96 cm^2
B. 146.24 cm^2
C. 121.12 cm^2
D. 296.96 cm^2

---

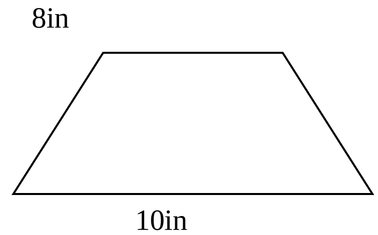
9. The area of the triangle below is 112 mm. The height of the shape is 16m. What is the measure of the base?



A. 17 mm
B. 7 mm
C. 14 mm
D. 56 mm

---

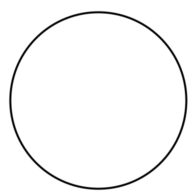
10. The Area of a trapezoid equals $36in^2$. The picture below gives both bases. What is the measure of the height?



A. 8 in
B. 16 in
C. 18 in
D. 2 in

---

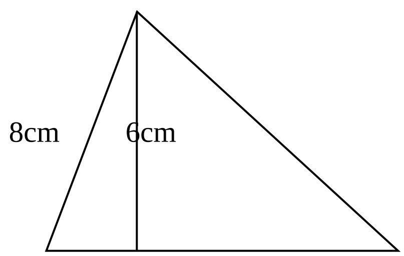
11. If the approximate area of the shape below is 200.96, what is the radius?



A. 16 in
B. 64 in
C. 8 in
D. 4 in

---

12. If the area of the shape below is $84cm^2$. Find the base of the triangle.



A. 28 cm
B. 10.5 cm
C. 1.75 cm
D. 14 cm

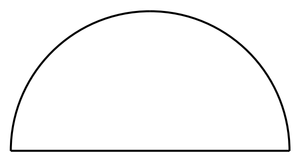
---

13. If the area of a square equals $256m^2$, what is the length of one side?

A. 128 m^2
B. 16 m^2
C. 64 m^2
D. $8m^2$

---

14. The area of the semicircle is 100.48 in^2. The radius of the semicircle is how much?



A. 4 in
B. 8 in
C. 12 in
D. 16 in

---

15. A circle has an area of 100π in. What is the diameter of the circle?

A. 31.8 in
B. 50 in
C. 25 in
D. 100 in

APPENDIX M

Treatment Fidelity Checklist
Traditional Response Condition (Hand Raising)

Class: ______________________	**Date: _____________**	**Lesson: _____**
Data Collector: ______________	**Class Start: ________**	**Class End: ________**

Circle Yes or No

Teacher States Standard: Yes No

Teacher Completes the Lesson Script: Yes No

If discrepancies are observed, document them in the space provided below.
____
____
____
____
____

Teacher states "We are going to determine area and surface area. Please raise your hand to share your answer". Yes No

Place a + beside each step that the teacher completes for the review portion of the lesson.

Question 1
____ Teacher reads the question aloud
____ Teacher calls on a student whose hand is raised.
____ If, **and only if**, the student provides the correct answer, the teacher provides a specific praise statement.
____ If the student answers incorrectly, the teacher calls on another student whose hand is raised.
____ If a student does not volunteer to answer or 3 students have answered the question incorrectly. The teacher reveals and provides a rationale for the answer.

____ The teacher reveals the next question and start with step 1.

Question 2
____ Teacher reads the question aloud
____ Teacher calls on a student whose hand is raised.
____ If, **and only if**, the student provides the correct answer, the teacher provides a specific praise statement.
____ If the student answers incorrectly, the teacher calls on another student whose hand is raised.
____ If a student does not volunteer to answer or 3 students have answered the question incorrectly. The teacher reveals and provides a rationale for the answer.
____ The teacher reveals the next question and start with step 1.

Question 3
____ Teacher reads the question aloud
____ Teacher calls on a student whose hand is raised.
____ If, **and only if**, the student provides the correct answer, the teacher provides a specific praise statement.
____ If the student answers incorrectly, the teacher calls on another student whose hand is raised.
____ If a student does not volunteer to answer or 3 students have answered the question incorrectly. The teacher reveals and provides a rationale for the answer.
____ The teacher reveals the next question and start with step 1.

Question 4
____ Teacher reads the question aloud
____ Teacher calls on a student whose hand is raised.
____ If, **and only if**, the student provides the correct answer, the teacher provides a specific praise statement.
____ If the student answers incorrectly, the teacher calls on another student whose hand is raised.
____ If a student does not volunteer to answer or 3 students have answered the question incorrectly. The teacher reveals and provides a rationale for the answer.
____ The teacher reveals the next question and start with step 1.

Question 5
____ Teacher reads the question aloud
____ Teacher calls on a student whose hand is raised.
____ If, **and only if**, the student provides the correct answer, the teacher provides a specific praise statement.
____ If the student answers incorrectly, the teacher calls on another student whose hand is raised.
____ If a student does not volunteer to answer or 3 students have answered the question incorrectly. The teacher reveals and provides a rationale for the answer.

____ The teacher reveals the next question and start with step 1.

Question 6
____ Teacher reads the question aloud
____ Teacher calls on a student whose hand is raised.
____ If, **and only if**, the student provides the correct answer, the teacher provides a specific praise statement.
____ If the student answers incorrectly, the teacher calls on another student whose hand is raised.
____ If a student does not volunteer to answer or 3 students have answered the question incorrectly. The teacher reveals and provides a rationale for the answer.
____ The teacher reveals the next question and start with step 1.

Question 7
____ Teacher reads the question aloud
____ Teacher calls on a student whose hand is raised.
____ If, **and only if**, the student provides the correct answer, the teacher provides a specific praise statement.
____ If the student answers incorrectly, the teacher calls on another student whose hand is raised.
____ If a student does not volunteer to answer or 3 students have answered the question incorrectly. The teacher reveals and provides a rationale for the answer.
____ The teacher reveals the next question and start with step 1.

Question 8
____ Teacher reads the question aloud
____ Teacher calls on a student whose hand is raised.
____ If, **and only if**, the student provides the correct answer, the teacher provides a specific praise statement.
____ If the student answers incorrectly, the teacher calls on another student whose hand is raised.
____ If a student does not volunteer to answer or 3 students have answered the question incorrectly. The teacher reveals and provides a rationale for the answer.
____ The teacher reveals the next question and start with step 1.

Question 9
____ Teacher reads the question aloud
____ Teacher calls on a student whose hand is raised.
____ If, **and only if**, the student provides the correct answer, the teacher provides a specific praise statement.
____ If the student answers incorrectly, the teacher calls on another student whose hand is raised.
____ If a student does not volunteer to answer or 3 students have answered the question incorrectly. The teacher reveals and provides a rationale for the answer.

____ The teacher reveals the next question and start with step 1.

Question 10
____ Teacher reads the question aloud
____ Teacher calls on a student whose hand is raised.
____ If, **and only if**, the student provides the correct answer, the teacher provides a specific praise statement.
____ If the student answers incorrectly, the teacher calls on another student whose hand is raised.
____ If a student does not volunteer to answer or 3 students have answered the question incorrectly. The teacher reveals and provides a rationale for the answer.
____ The teacher reveals the next question and start with step 1.

Question 11
____ Teacher reads the question aloud
____ Teacher calls on a student whose hand is raised.
____ If, **and only if**, the student provides the correct answer, the teacher provides a specific praise statement.
____ If the student answers incorrectly, the teacher calls on another student whose hand is raised.
____ If a student does not volunteer to answer or 3 students have answered the question incorrectly. The teacher reveals and provides a rationale for the answer.
____ The teacher reveals the next question and start with step 1.

Question 12
____ Teacher reads the question aloud
____ Teacher calls on a student whose hand is raised.
____ If, **and only if**, the student provides the correct answer, the teacher provides a specific praise statement.
____ If the student answers incorrectly, the teacher calls on another student whose hand is raised.
____ If a student does not volunteer to answer or 3 students have answered the question incorrectly. The teacher reveals and provides a rationale for the answer.
____ The teacher reveals the next question and start with step 1.

Question 13
____ Teacher reads the question aloud
____ Teacher calls on a student whose hand is raised.
____ If, **and only if**, the student provides the correct answer, the teacher provides a specific praise statement.
____ If the student answers incorrectly, the teacher calls on another student whose hand is raised.
____ If a student does not volunteer to answer or 3 students have answered the question incorrectly. The teacher reveals and provides a rationale for the answer.

____ The teacher reveals the next question and start with step 1.

Question 14
____ Teacher reads the question aloud
____ Teacher calls on a student whose hand is raised.
____ If, **and only if**, the student provides the correct answer, the teacher provides a specific praise statement.
____ If the student answers incorrectly, the teacher calls on another student whose hand is raised.
____ If a student does not volunteer to answer or 3 students have answered the question incorrectly. The teacher reveals and provides a rationale for the answer.
____ The teacher reveals the next question and start with step 1.

Question 15
____ Teacher reads the question aloud
____ Teacher calls on a student whose hand is raised.
____ If, **and only if**, the student provides the correct answer, the teacher provides a specific praise statement.
____ If the student answers incorrectly, the teacher calls on another student whose hand is raised.
____ If a student does not volunteer to answer or 3 students have answered the question incorrectly. The teacher reveals and provides a rationale for the answer.
____ The teacher reveals the next question and start with step 1.

Record any questions or notes related to factors that impacted the lesson.

Notes:

APPENDIX N

Summary of Student Survey Comments

Survey #	Hand Raising	White Boards	Clickers	Other
2			I love math clickers only.	
4	I think clickers are better than white boards which are better than hand raising. Clickers make me concentrate better.	I think clickers are better than white boards which are better than hand raising. Clickers make me concentrate better	I think clickers are better than white boards which are better than hand raising. Clickers make me concentrate better.	
5			I think clickers are great because they seem to keep me on task and focused.	
6				None of it helps. I hate it.
7			I would like to use clickers because it is easier to use and faster to put the answer in.	
8			We should keep using clickers in the classroom because they are fun.	
9				It is good to use these things so we can learn more and pay attention.
10		I think we should		

		use the white boards because they are fun and easy to erase.		
11		I like that I can see what other people write on their white boards so if I get stuck I can get some help. I am not cheating. I want an idea about how other students are figuring out the problem.		
12	We should continue using the hand raising, white boards, or clickers because it keeps us on task. It helps us to stay focused.	They are fun to use in math. I like the clickers better than the white boards. We should continue using the hand raising, white boards, or clickers because it keeps us on task. It helps us to stay focused.	They are fun to use in math. I like the clickers better than the white boards. We should continue using the hand raising, white boards, or clickers because it keeps us on task. It helps us to stay focused.	We should continue using the hand raising, white boards, or clickers because it keeps us on task. It helps us to stay focused.
13	I do not like hand raising because I just like white boards and clickers too much. If I was a teacher I would at least let us use the clickers in [teacher's name] class.	I do not like hand raising because I just like white boards and clickers too much. If I was a teacher I would at least let us use the clickers in [teacher's name] class.	I do not like hand raising because I just like white boards and clickers too much. If I was a teacher I would at least let us use the clickers in [teacher's name] class.	
14			CLICKERS! They were fun to use.	
16		White boards,		

		definitely white boards.		
17				
18				I don't care what we use because we are still learning the same thing.
19			This is just another gimmick to make us do our work. I like clickers but none of it will force me to learn. I control what I learn.	This is just another gimmick to make us do our work. I like clickers but none of it will force me to learn. I control what I learn.
20			I love Clickers. Seriously, I do. [teacher name] is awesome because she choose clickers.	
21		We used to get free time in math. We used to have fun. Then professor and her friends came and took away our free time. Clickers and white boards did not make me learn. I decided how much I was going to learn.	We used to get free time in math. We used to have fun. Then professor and her friends came and took away our free time. Clickers and white boards did not make me learn. I decided how much I was going to learn.	We used to get free time in math. We used to have fun. Then professor and her friends came and took away our free time. Clickers and white boards did not make me learn. I decided how much I was going to learn to

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CURRICULUM VITAE

Brittany L. Hott began her career in education as a middle school special education teacher. She earned a Master of Education in Special Education with a concentration in emotional and behavioral disabilities from Virginia Commonwealth University, Richmond Virginia. Brittany has worked in the juvenile justice system as a special education coordinator and most recently served as an instructional specialist for middle schools in an urban school division. She completed an Educational Specialist degree in School Administration and Supervision from the University of Virginia, Charlottesville, Virginia.

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