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Using Blended Learning to Improve the Mathematics Achievement of Students with High Incidence Disabilities in an Alternative Education School

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ACCEPTANCE

This dissertation, USING BLENDED LEARNING TO IMPROVE THE MATHEMATICS ACHIEVEMENT OF STUDENTS WITH HIGH INCIDENCE DISABILITIES IN AN ALTERNATIVE EDUCATION SCHOOL, by ZACHARY G. JOHNSON, was prepared under the direction of the candidate's Dissertation Advisory Committee. It is accepted by the committee members in partial fulfillment of the requirements for the degree, Doctor of Philosophy, in the College of Education & Human Development, Georgia State University.

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Zachary G. Johnson

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USING BLENDED LEARNING TO IMPROVE THE MATHEMATICS ACHIEVEMENT OF STUDENTS WITH HIGH INCIDENCE DISABILITIES IN AN ALTERNATIVE EDUCATION SCHOOL

by

Zachary G. Johnson

Under the Direction of David E. Houchins

Abstract

Students with high incidence disabilities in the public school system often perform multiple grade levels below their typically-developing peers in mathematics achievement. These students exhibit lower levels of on-task behavior that limits their access to effective instruction, thus requiring instructional interventions that personalize learning, differentiate materials, and ultimately promote academic engagement. In recent years, the use of technology-mediated and computer-assisted instruction has shown to have positive results with students with disabilities. Blended learning, an intervention that combines face-to-face instruction with computer-based instruction, has been shown to improve the on-task behavior and achievement of students with disabilities. In Chapter One, a systematic review of the literature was conducted in an effort to locate blended learning math studies for secondary-level students with disabilities and to assess the scientific rigor of those studies. Twelve intervention studies were synthesized and categorized in three major areas: (a) online- and computer-based curricula for independent practice/instruction, (b) media-based interventions with video prompting, and (c) strategy instruction. Blended learning intervention studies that found positive results in math achievement and on-task behavior of students with disabilities utilized a station-rotation format. Additionally, studies that met the high standards of special education research (CEC, 2014) saw stronger gains for student math achievement. In Chapter Two, blended learning was implemented with three middle school students with emotional behavior disorders in a therapeutic setting. Using a multiple baseline across participants single case design, this study examined the relationship between blended learning mathematics instruction and student on-task behavior, teacher engagement, and mathematics achievement. Both student and teacher engagement increased with the use of station-rotation blended learning. Math achievement, measured through the AIMSweb curriculum-based math probes, improved for two of three student participants. Social validity questionnaires revealed that students and teacher enjoyed the blended learning intervention; however, continued use depended on properly functioning technology. Future research in the area of blended learning math instruction should strive to accurately measure on- and off-task behavior under the computer-based condition. Additionally, researchers should develop measurements of math achievement that accurately assess the content that is taught during instruction.

INDEX WORDS: Blended Learning, High-Incidence Disabilities, Alternative Education School, Mathematics Achievement, Emotional and Behavioral Disorders, On-Task Behavior

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DEDICATION

I would like to dedicate this dissertation to my wonderful parents, Sheila Zachariah and Sam Johnson. Your unconditional love and unwavering support guided me along this journey. Additionally, I would like to dedicate this dissertation to my nieces Ela and Anya, and my soon-to-be-born son. Always know that if your heart is in the right place, you can accomplish anything

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1 A LITERATURE REVIEW OF BLENDED LEARNING MATHEMATICS STUDIES FOR SECONDARY-LEVEL STUDENTS WITH HIGH INCIDENCE DISABILITIES

Increasingly, attention has been placed on the academic achievement for all students, including students with high incidence disabilities (e.g., emotional behavior disorder, learning disability, mild intellectual disability). The achievement gap between students with disabilities (SWD) and typically developing students is of particular concern considering that low academic achievement can limit success in school, postsecondary education attainment, employment, and independent living (Test et al., 2009). Although recent reports have suggested slight gains in achievement for SWD in mathematics and reading (National Assessment of Educational Progress [NAEP], 2013), the achievement gap remains significantly large between SWD and their peers. Researchers have noted that SWD often present challenging social and academic behaviors that can dramatically reduce their access to effective instruction in the classroom (Aron & Zweig, 2003; Lehr, Moreau, Lange, & Lanners, 2012; McCall, 2003). The Individuals with Disabilities Education Act (IDEA, 2004) and the Every Child Achieves Act (2015) have drawn more attention to the academic achievement of SWD and called for the use of evidence-based practices (EBP) to positively impact social and academic performance in the K-12 settings.

One instructional practice that has the potential to increase student on-task behavior and academic achievement is the use of computer-based instruction (CBI; Billingsley, Scheuermann, & Webber, 2009; Vasquez & Straub, 2012) or technology-based independent practice (Bottge et al., 2014; Haydon et al., 2012; Kagohara et al., 2013). Early examinations of CBI in special education classrooms found that it offered a streamlined approach to providing personalized instruction for students based on individual needs, strengths, and weaknesses (Fitzgerald, Koury, & Mitchem, 2008). Some of the benefits of using CBI with SWD included: (a) adjusting the level and pace of instruction; (b) immediate and corrective feedback; (c) establishing clear and attainable goals; and (d) ease of outcome and formative data (Fitzgerald, Koury, & Mitchem; Means, Toyoma, Murphy, & Bakia, 2013). Due to the increased focus and extensive research on the use of CBI in the past few decades, researchers have compiled literature reviews examining its use specifically with SWD (Kagohara et al.; Vasquez & Straub).

Two literature reviews have examined the use of CBI with SWD (Kagohara et al., 2013; Vasquez & Straub, 2012). Vasquez and Straub conducted an extensive review of the online and distance-education intervention literature for SWD. They found six empirical studies conducted between 2005 and 2010. Of the six included studies, three were conducted in the K-6 grade setting (Englert et al., 2005; Englert et al., 2007; Yong & Ping, 2008) while the remaining three were conducted at the high school level (Bozdin et al., 2007; Izzo et al., 2010; Savi et al., 2008). Participant sample sizes ranged from 12 to 287 and included students with learning disabilities (LD), emotional behavior disorder (EBD), hearing impairments, and those students considered to be at-risk for disability and academic failure. One study (16.7%; Yong & Ping) looked specifically at synchronous online instruction (no delay in the transfer of information similar to watching a live lecture) while the remaining five studies (83.8%; Bozdin et al.; Englert et al., 2005; Englert et al., 2007; Izzo et al.; Savi et al.) examined asynchronous online instruction (considerable delay between lecture recording and content delivery). Interestingly, all six studies focused on outcome measures related to reading, writing, and science; no studies looked at mathematics achievement. Although only three studies (Englert et al., 2007; Savi et al; Yong & Ping) found statistically significant findings in favor of experimental (online instruction) groups compared to traditional textbook-based learning groups, all studies reported increased rates of on-task behavior. In a review of 15 studies examining the use of mobile technology instruction for students with developmental disabilities, Kagohara et al. (2013) reported only one study that focused on academic learning outcomes (Kagohara, Sigafoos, Achmadi, O'Reilly, & Lancioni, 2012) while the remaining 14 focused on communication skills, leisure, and employment. In the single-case academic study (Kagohara, Sigafoos, Achmadi, O'Reilly, & Lancioni), researchers were interested in teaching two elementary-level students with Asperger's syndrome and attention deficit hyperactive disorder (ADHD) to improve their writing by using an iPad to run spell-check software. During the intervention, participants were exposed to instructional videos on the iPad; results of the study revealed that students maintained 100% usage of spell-check procedures once video-modeling was removed. Researchers from these 15 studies reported positive findings pertaining to social behaviors such as improved communication skills; however, limited conclusions were drawn regarding the impact on academic achievement. Although mobile technology was used to deliver both communication skills and academic instruction, the use of instructional technology has advanced and is being used in ways that combine face-to-face instruction with CBI. Research in the use of technology-rich environments combined with independent practice, the blended learning (BL) model of instruction, has revealed the potential for

BL to be an effective method of addressing both academic and behavioral concerns for all students (Halverson et al., 2017).

Blended Learning

BL, loosely defined as the combination of face-to-face and CBI (Staker & Horn, 2012), has emerged as the predominant and preferred model of technology-mediated and computer-assisted instruction (CAI) in the K-12 education setting nationwide (Halverson et al., 2017; Watson, 2008). Unfortunately, due to the rapid rate of technological advances and instructional technology integration, it can be difficult to identify adoption rates of BL in K-12 classrooms. According to Horn and colleagues (2011), K-12 students enrolled in online courses topped 4 million as of 2010. Surveying national school districts, Picciano and Seaman (2009) found that 75% of districts reported the use of online or BL. In 2014, Watson and colleagues found that 28 states indicated they were using fully online K-5 curricula. Additionally, seven states reported the use of supplemental online instruction for grades K-5. Unfortunately, when looking for similar adoption rates of BL models of instruction for SWD, limited research exists regarding the use and efficacy of BL models of instruction for this population. Although specific findings regarding current rates of adoption in the special education classroom are limited, the National Center for Education Statistics (NCES), in 2013, reported that at least half of the national average of SWDs (7.2%) were enrolled in BL or virtual school programs between 2011 and 2012 (Gulosino & Miron, 2017). Although initial reviews and meta-analyses of BL focused primarily on college-level students (Bernard, Borokhovski, Schmid, Tamim, & Abrami, 2014; Kirkwood & Price, 2014), current systematic literature reviews (Brinson, 2015), and meta-analyses (Murphy at al., 2014) focusing on K-12 students fail to disaggregate data for SWD. Additionally, the varied definitions of BL complicate the systematic search of literature.

BL has been presented in various forms over the years based on specific settings, grade levels, and content areas of instruction. The widely accepted definition of BL is the combination of teacher-led face-to-face instruction, conducted within a brick-and-mortar facility, and online- or CBI (Staker & Horn, 2012). Over the years BL, or hybrid instruction, has taken on different forms; two of the most common formats of BL are the station-rotation and flipped-classroom models. The flipped-classroom model, pioneered primarily in postsecondary and undergraduate college courses (Means, Toyoma, Murphy, & Bakia, 2013; Rooney, 2003), allows the student to navigate instructional content on their own, away from a brick-and-mortar facilities through online- or CBI, combined with independent or group classwork with teacher/instructor oversight (Staker & Horn). The station-rotation model, usually conducted within one particular classroom, involves the use of small-group centers (or stations) within the classroom that include teacher-led content instruction, individual remediation, and independent or group practice with one or more stations utilizing online- or computer-based resources or assignments (Staker & Horn). Notwithstanding specific forms or methods of implementation, BL has shown encouraging results with social (Barbour & Reeves, 2009; Haydon et al., 2012; McDougal, Morrison, & Awana, 2012) and academic outcomes (Bottge, Ma, Gassaway, Toland, Butler, & Cho, 2014) for students in the K-12 setting.

The use of BL has been shown to positively impact instruction in the following ways: differentiating instruction (Dziuban et al., 2006); personalized learning (high-quality adaptive online platforms allow for consistent and personalized instruction that enable students to work at their own pace using their preferred modalities; Barbour & Reeves, 2009; Halverson et al., 2017;) academic achievement (Bottge, Ma, Gassaway, Toland, Butler, & Cho, 2014; Means, Toyama, Murphy, Bakia, & Jones, 2009); and, on-task behavior or academic engagement (Barbour & Reeves; Haydon et al., 2012; McDougal, Morrison, & Awana, 2012). Researchers have examined the corpus of empirical research in this area in an effort to establish BL as an EBP for students in the K-12 system; however, little evidence exists as to the effects of BL on academic and behavioral outcomes for SWD.

Although previous research in BL has focused on students with and without disabilities, few literature reviews disaggregated findings for SWD. Lo and Hew (2017) conducted a comprehensive review of the literature in an attempt to locate empirical research regarding the use of flipped-classroom BL instruction for K-12 students conducted between 1994 and 2016. Their extensive search yielded a total of 15 studies, of which 11 studies were comparison studies that compared the BL condition to a traditional method of instruction. Two of the comparison studies compared flipped-classroom conditions to modified or different versions of flipped-classrooms (Lai & Hwang, 2016; Wang, 2016); nine studies (Bhagat et al., 2016; Chao et al., 2015; Chen, 2016; Clark, 2015; DeSantis et al., 2015; Huang & Hong, 2016; Kirvan et al., 2015; Schultz et al., 2014; Tsai et al., 2015) compared student academic achievement and engagement in flipped-classrooms to traditional teacher-led conditions. Of the nine comparison studies, five studies (55%) reported statistically significant findings in favor of the flipped-classroom group while the remaining four studies (45%) found no significant differences in academic achievement between the flipped-classroom group and the business-as-usual

(BAU) group. Additionally, although formal procedures were not used to measure on-task behavior of participants, three studies (Bhagat et al.; Chao et al.; Wang) reported an increase in student motivation and two studies specifically reported an increase in academic engagement (Clark; Snyder et al., 2014). However, researchers cautioned generalized interpretations of these findings given that many interventions were implemented with short durations (e.g., four weeks) and positive outcomes may have been due to the novelty of using new technology in the classroom (Clark).

Means and colleagues, in two separate meta-analyses (Means, Toyama, Murphy, & Bakia 2013; Means, Toyama, Murphy, Bakia, & Jones, 2009), examined the effects of comparison studies looking at online-instruction, partial online blended instruction, and face-to-face instruction. In 2009, Means et al. conducted a review of 46 studies, yielding 51 effect sizes, which had been conducted since 2004 and included participants ranging from 8th grade to undergraduate-level college courses. Analysis of the 51 effect sizes revealed that 28 effects dealt purely with online interventions while 23 provided effects for BL conditions compared to BAU conditions. Ultimately, they found that classes with online learning, whether fully online or blended, produced stronger academic outcomes than those classes taught entirely through face-to-face instruction (main effect size for all 51 contrasts +0.24, $p < .001$). In a follow up meta-analysis, Means et al. (2013) examined 50 effect sizes found across 45 studies comparing fully online, partial online BL, and face-to-face instruction. Study participants ranged from age 13 to 44 and included students in the K-12 system up through graduate school. Although authors reported a moderate effect of BL compared to BAU ($Q = 3.25$, $p < .001$), when looking at the seven studies specifically conducted with students in the K-12 grades, effect sizes were less than moderate and considered weak ($Q = 1.66$, $p < .001$).

Although Lo and Hew (2017) and both Means et al. studies (2009; 2013) found positive results regarding the use of BL over traditional means of instruction, limited findings can be drawn regarding the effects on SWD. There is a clear dearth of research, specifically literature reviews and meta-analyses, concerning the impacts of BL on the mathematics achievement and behavioral outcomes for SWD in BL conditions in the K-12 school system. Thus, the purpose of this review was to locate and examine those BL mathematics interventions that were used specifically with SWD in the K-12 school system.

Rationale for Literature Review

The use of BL through online- and CBI can be used to provide teachers with a means for differentiating instruction, personalizing learning for SWDs, and can improve academic achievement (Means et al., 2009) and engagement (Barbour & Reeves, 2009). There has been a considerable increase in the use of online- and computer-based curricula to provide mathematics instruction to students in the United States (Halverson, Spring, Huyett, Henrie, & Graham, 2017). Picciano and Seaman (2009), looking at school districts nationwide, determined that at least 75% of districts reported students receiving online- or blended instruction (Horn, Staker, Hernandez, Hassel, & Ableidinger, 2011). Considering that SWD often display negative behaviors that interfere with academic achievement and engagement (Aron & Zweig, 2003; Lehr, Moreau, Lange, & Lanners, 2012; McCall, 2003), special education teachers should use evidence-based interventions that promote on-task behavior and academic achievement. The use of BL models of instruction have been found to positively impact students' academic achievement (Bottge, Ma, Gassaway, Toland, Butler, & Cho, 2014) and academic engagement (Haydon et al., 2012; McDougal, Morrison, & Awana, 2012). Unfortunately, many of the recent systematic literature reviews and meta-analyses failed to identify specific BL interventions that were used for mathematics instruction with SWDs. The purpose of this literature review was to identify and examine specific BL interventions that were used to deliver mathematics instruction to secondary-level SWD. The primary research questions were "What experimental, quasi-experimental, and single-case design BL mathematics interventions have been conducted with secondary-level SWD?" and "What was the quality of BL mathematics intervention studies conducted with SWD?"

Method

A systematic review of experimental, quasi-experimental, and single-case design interventions of BL mathematics studies for SWD was conducted. In order for a study to be considered for this review, it had to meet the following criteria: (a) the study was published in English; (b) the participants were enrolled in public schools in grades 6-12; (c) the intervention specifically mentioned BL or a mixture of CBI and face-to-face instruction; (d) the participants included students with high incidence disabilities (e.g., EBD, LD, other health impaired [OHI], mild intellectual disability [MID]); (e) results were disaggregated for SWD; (f) at least one outcome measure related to mathematics achievement; (g) the research was an experimental, quasi-experimental, or single case design study; (h) the study was in a peer-reviewed journal; and (i) the study was conducted within the United States. The initial search was carried out using the following electronic databases: ERIC, Academic Search Complete, Child Development &

Adolescent Studies, CINAHL Plus with Full Text, Computer Source, Education Source, Information Science & Technology Abstracts (ISTA), MEDLINE, MEDLINE with Full Text, Primary Search, PsycARTICLES, Psychology and Behavioral Sciences Collection, PsycINFO, and Vocational and Career Collection. The initial search was limited to those that were published between the years of 1980 and 2018 in order to identify all research regarding the use of BL and the use of CBI with SWD. Results were limited to peer-reviewed academic journals. Search terms and combinations included: *blended learning* OR "*hybrid learning*" OR "*station rotation*" OR "*flipped classroom*" OR "*enhanced anchored instruction*" OR "*online learning*" OR "*online instruction*" OR "*e-learning*" OR "*computer-assisted instruction*" OR "*computer-based instruction*" AND *student* with disabilit** OR "*special education*" OR "*learning disabilit**" OR "*emotional behavior disorder*" OR "*special education*" AND *k-12* OR "*public school**" OR "*middle school**" OR "*high school**" OR "*secondary*" OR "*elementary school**." In addition to the electronic search conducted using online databases, a hand search was conducted with seven journals that commonly report studies related to technology use in the classroom and SWD (*Journal of Special Education Technology*; *Behavioral Disorders*; *Journal of Educational Technology & Society*; *Computers & Education*; *Online Learning*; *International Journal of in Mathematics, Science, and Technology; The Journal of Special Education; Exceptional Children; Journal of Emotional and Behavioral Disorders; Remedial and Special Education*). After the hand search of available publications, a comprehensive search of pre-publication articles was conducted with those journals that offer online-first access including: *Exceptional Children, Journal of Emotional and Behavioral Disorders, Remedial and Special Education, Journal of*

Special Education Technology, and *Behavioral Disorders* accessed through the online.sagepub.com website.

Finally, a search of Online-First, in-press, and e-journal articles was conducted in October of 2018. Specific top-tier journals were searched because they regularly publish high quality academic intervention research pertaining to SWD (i.e., *Exceptional Children, Journal of Emotional and Behavioral Disorders*, *Remedial and Special Education, Journal of Special Education Technology, Behavioral Disorders*). One additional study met the inclusion criteria for study analysis. Initial electronic database search yielded 944 results. Three hundred thirty-one (n = 331) articles were removed from the list due to repeat entries. The resulting sample included 612 articles.

One additional researcher, familiar with special education research, was trained how to select appropriate intervention studies by the primary researcher. In addition to reviewing the requirements for inclusion and exclusion, both researchers examined the first 10 articles together to ensure that studies were being analyzed in the same way. Inter-observer agreement (IOA) was calculated by dividing the number of agreements by the total number of cases then multiplying that number by 100.

In the first round of inclusion/exclusion, both researchers independently reviewed the title and abstracts of studies to determine if they were intervention studies and whether or not the focus of the study was mathematics instruction. Articles were excluded for the following reasons: research-to-practice or policy papers (n = 188), non-mathematics content (n = 97), English/Language Arts (n = 93), literature reviews and meta-analyses (n = 53), international (n = 19), correlational (n = 30), or qualitative studies (n = 19) resulting in 50 BL mathematics studies for further analysis. Calculated

IOA for the first round of coding was 93%; 100% agreement was reached after further discussion.

During the second round of coding, both researchers independently read abstracts and titles to determine if the studies focused on the correct grade-level, disability eligibility, or any other inclusion/exclusion parameters that were missed in the previous round of coding. Fifteen studies were removed because they focused on elementary-level students, four studies addressed disabilities that were not included in this review, and four studies were correlational studies. In the second round of coding, agreement between the two researchers was 94%; 100% agreement was reached after discussing differences.

During the last round of coding, 14 studies were read thoroughly to determine if all inclusion criteria were met and if the intervention could be considered BL (some combination of computer- or media-based instruction and face-to-face instruction). Two studies were not considered to be BL and one was removed because it did not contain outcome measures related to mathematics achievement. During the final stage of coding, IOA was 100%.

Once the 12 articles were identified for inclusion in this review, they were further analyzed and coded for methodological rigor. In order to establish the extent of methodological rigor, the standards of evidence-based practice in special education, described by the Council for Exceptional Children (CEC; 2014) were used. The primary researcher reviewed the rubric for quality indicators provided by the CEC with the additional researcher; requirements of each indicator were discussed in order to clarify any ambiguity. The primary researcher created an Excel checklist that contained the various parameters of each indicator. Both researchers individually assessed each article against the components of each CEC indicator with an overall agreement of 97.6%; they discussed all discrepancies until they reached 100% agreement.

Results

The results of this systematic review of literature are presented in two stages: (a) synthesis and comparison of specific intervention parameters and outcomes; and (b) analysis and assessment of methodological rigor based on the CEC (2014) quality indicators (see Tables 1.1 and 1.2).

Twelve studies were located that met the inclusion criteria. Of the 12 studies, five studies (41.6%) were single-case design studies and seven studies (58.3%) were group comparison studies. In an effort to effectively synthesize BL and technology enriched instructional practices, studies were organized based on how technology was used during instruction: (a) BL using online- and computer-based curricula instruction/practice, (b) media-based interventions with video prompting, and (c) technology-mediated strategy instruction (see Table 1.1).

Online- and Computer-Based Curricula for Instruction/Practice. Three studies specifically looked at the use of technology and CAI for instruction and practice: one study compared BAU against CAI combined with face-to-face instruction (Billingsley, Scheuermann, & Webber, 2009), another study compared the use of an online assessment and intelligent tutoring program against a BAU condition (Koedinger, McLaughlin, & Heffernan, 2010), while the third study compared the use of traditional worksheets against iPad-delivered worksheets (Haydon et al., 2012). Billinglsey and colleagues (2009) were interested in comparing the effectiveness of three instructional conditions: (a) teacher-led face-to-face instruction, (b) CAI using the OdysseyWare computer-based curriculum, and (c) a combination of both face-to-face instruction and CAI. Using an alternating treatment single-case design study, the mathematics achievement of 10 SWD was assessed using teacher-created curriculum-based assessments (CBAs). After exposing students to each condition over the course of 9 weeks, visual analysis of outcome data for each participant related to percent of correct answers on teacher-created mathematics probes showed a clear preference for the combined condition. Similarly, Koedinger and colleagues (2010) compared the impacts of using the ASSISTments web-based intelligent mathematics tutoring system to traditional mathematics instruction with textbook-based instruction over the course of one school year. Mathematics achievement of 255 sixth and seventh grade SWD was assessed using the Massachusetts Comprehensive Assessment System (MCAS, 2007). In addition to the overall mathematics achievement measured by the standardized assessment, the researchers were also interested in measuring the amount of program usage by both students and teachers. Regarding the pretest-posttest standardized assessment scores, main effects were noted for condition (treatment vs. control) and student group (regular vs. special education); treatment differences for special education students were statistically significant, $F(1, 1235) = 11.44$, $p < .001$. Haydon et al. compared the use of iPad-delivered worksheets to the traditional method (paper-and-pencil) worksheet with three SWD in an AES; student correct responses on mathematics worksheets increased from between 2.55 to 3.93 from the traditional worksheet to iPad worksheet condition. Additionally, Haydon and colleagues observed and reported data pertaining to student active engagement and on-task behavior using a formalized method of classroom observation; results of the study showed higher levels of student engagement during technology-enriched instructional conditions (see Table 1.1 for details).

Media-based Interventions with Video Prompting. Seven studies (Bottge et al., 2004; Bottge et al., 2006; Bottge et al., 2007; Bottge et al., 2010; Bottge et al., 2014; Bottge et al., 2015; Saunders, Spooner, & Davis, 2018) specifically looked at the effects of media-based interventions with video prompting on the mathematics achievement of middle and high school SWD. One such intervention, enhanced anchored instruction (EAI), is an instructional strategy that utilizes computer-based interactive lessons, CD-ROM videos, and applied hands-on projects in an effort to improve student problem-solving and computation skills (Bottge, Rueda, & Skivington, 2006). Four of the EAI studies compared the use of EAI to business-as-usual (BAU; Bottge et al., 2004; Bottge et al., 2007; Bottge et al., 2014; Bottge et al., 2015). One study (Bottge et al., 2004) found mixed results when comparing EAI groups to BAU; results from the word problem test yielded a significant main effect in favor of the BAU group ($F(1 , 83) = 9.30$, $p = .003$, $\eta^2 = 0.10$) while results from the video problem test showed a statistically significant main effect in favor of the EAI group ($F(1 , 67) = 17.32$, $p = .000$, $\eta^2 = 0.21$). Using a group comparison (Bottge et al., 2007), researchers found statistically significant effect sizes in favor of EAI groups in both the Fractions of the Cost test ($t = 5.08$, $p < .001$, Cohen's $d = 1.08$) as well as the problem-solving test (ES = .56, $p < .01$). Utilizing a single-case design, Saunders and colleagues (2018) looked specifically at three students with MID and examined the effects of video-prompting and finger-counting on the basic operation real-world problems. Participants were exposed to video-simulated real-world problems that were prerecorded and contained the following components: (a) contextual statements, (b) description of initial set, (c) demonstration of the action, (d) description of the change amount, and (e) reading and writing of the question. In addition to finding the correct answer, student responses were broken down to progressive tasks in order to achieve the required response; correct responses and steps of the task analysis increases across all sessions and percent of non-overlapping data (PND) was 100%. Regardless of the specific type of video-prompting or real-world application, students with high incidence disabilities demonstrated increased mathematics achievement through this use of BL across a majority of the studies.

Strategy Instruction. Two single case design studies (Bouck et al., 2017; Sheriff & Boon, 2014) specifically looked at the instruction of a particular strategy, through the use of BL, to impact student mathematics achievement. Bouck and colleagues (2017) were interested in the effects of teaching middle school students with LD, OHI, and MID to use virtual manipulatives. This strategy is closely tied to the concrete-representational-abstract (CRA) framework. Students were instructed to use the *Fraction Tiles* app to virtually manipulate equivalent fractions, drawing the equivalent fractions with paper-and-pencil, and then completing mathematics questions related to those fractions. Sheriff and Boon (2014), on the other hand, taught students to use computer-based graphic organizers using the *Kidspiration* 3 software to solve one-step word problems. Three middle school students with MID participated in the study and were trained on how to complete computer-based graphic organizers and to use them to answer word problems. In both studies, mathematics achievement was assessed using the independent practice work completed by the students. Bouck and colleagues used the results from the *Fraction Tile* app while Sheriff and Boon used teacher-generated 9-question worksheets. Both studies yielded positive results regarding the mathematics achievement of students with high incidence disabilities. Bouck and colleagues found that all three students using the VRA framework increased percentage of correct responses with an average mean of 84.7% and a Tau-U of 98%. Similarly, Sheriff and Boon found that students using the computer-based graphic organizer intervention increased the number of correct responses with an overall mean of 47.9% and a PND of 100%. All six students under both strategy instruction conditions improved their mathematics achievement scores related to one-step word problems and equivalent fractions.

CEC Quality Indicators

Indicator 1: Context and Setting. All 12 studies (100%) located in this review met the requirements for context and setting. Eight studies (66.6%) were conducted in public middle schools (Bottge et al., 2004; Bottge et al., 2010; Bottge et al., 2014; Bottge et al., 2015; Bouck et al., 2017; Koedinger, McLaughlin, & Heffernan, 2010; Saunders, Spooner & Davis, 2018; Sheriff & Boon, 2014) while one study (8.3%) was conducted exclusively with SWD in 6th grade (Bottge et al., 2004). One study (8.3%; Bottge et al., 2007) was conducted across various schools including middle and high schools in grades 6-12; the remaining three studies (25%; Billingsley, Scheuermann, & Webber, 2009; Bottge et al., 2006; Haydon et al., 2012) were conducted in high school grades ranging from 9th through 12th grade. Of the four high school studies, one study (8.3%) was conducted in a public alternative school (Haydon et al.) and one study

Table 1.1 *Features of Blended Learning Mathematics Studies for Students with Disabilities*

Study	Context and Setting	Participants/ Intervention Agent	Independent Variable(s) and Dosage; Implementation Fidelity	Research Design	Outcome Measures/ Dependent Variable(s)	Results
Billingsley, Scheuermann, & Webber (2009)	1 Public high school self-contained classroom	*N* = 10; ED, LD, OHI, TBI; gr 9-11; 14-17 yrs Classroom teachers; Teacher training not described.	(1) Direct teach (2) Computer-assisted instruction (CAI) using *OdysseyWare* (3) Combined direct teach and CAI 3 sessions for each condition over 9 weeks Fidelity not reported	Alternating-treatments single-subject	Mathematics learning: assessed using teacher-created curriculum-based assessments (CBAs), baseline probes covered nine objectives to be covered during intervention; intervention probes were 20 questions covering 10 objectives; probe was also used as post-intervention measure.	Mean scores for each participant across direct teach, CAI, and combined condition respectively: Clay (70, 10, 80), Crane (90, 95, 95), Lupita (60, 53, 93), Thaddeus (70, 40, 53), Manny (5, 27, 42), Bryan (73, 50, 73), Chad (58, 58, 80), Junior (47, 58, 53), Tyrene (95, 58, 78), and Hank (38, 67, 78). Effect sizes: CAI 0.696, direct teach 0.767, and combined 0.83.

Bottge, Heinrichs, Mehta, Rueda, Hung, & Danneker (2004)	1 public middle school; Upper Midwest 4 math classes Teacher 1 class 28% disabilities Teacher 2 class 9% disabilities	*N* = 93, *n* = 17 SWD; LD, SL, OHI; gr 6 2 mathematics teachers; 9-26 yrs experience; teacher training not described.	*Enhanced Anchored Instruction* (EAI) and *Text-based instruction* (TBI) No description of dosage/exposure Observation notes and video recorded sessions, researcher observed 100% sessions with IOA conducted 10% of the time	1: group, quasi-experimental 2: longitudinal, multi-level, natural variation design (intervention group only)	*Fraction computation test* (FCT), 18-item, addressed add and subtract simple fractions, mixed numbers with and without renaming, Cronbach's alpha .98, interrater reliability 99%. *Word problem test* (WPT), written at fourth grade level, tested ability to solve single- and multi-step word problems, content mirrored instruction in EAI and TBI conditions, Cronbach's alpha .97, interrater reliability 99%. *Video problem test* (VPT), solving video-presented construction problem, tested ability to: compute money, indicate lengths, convert lengths, combine lengths, and calculate costs, Cranbach's alpha .80, interrater reliability 94%. *Hovercraft problem test* (HPT), performance-based assessment, students had to show how to build rollover cage out of PVC pipe by: calculating money, add/subtract fractions, and determine costs of materials, Cronbach's alpha .94, interrater reliability 91%.	FCT: significant interaction between class and type of instruction, $F(1, 77) = 4.14$, $p = .04$, $\eta^2 = .05$. WPT: main effect for type of instruction in favor of TBI, $F(1, 83) = 9.30$, $p = .003$, $\eta^2 = .10$, but not for class, F(1, 83) = 1.43, $p = .23$, $\eta^2 = .02$. VPT: main effect for type of instruction in favor of EAI, $F(1, 67) = 17.32$, $p = .000$, $\eta^2 = .21$, but not for class, $F(1, 67) = 0.05$, $p = .83$, $\eta^2 = .00$, or for class by type of instruction, $F(1, 67) = 0.96$, $p = .33$, $\eta^2 = .01$. HPT: main effect for type of instruction in favor of the EAI group, $F(1, 33) = 6.98$, $p = .01$, $\eta^2 = .17$, and for session, $F(2, 33) = 10.32$, $p = .00$, $\eta^2 = .385$, but not for type of instruction by session, $F(2, 33) = 0.289$, $p = .75$, $\eta^2 = .02$.

Bottge, Ma, Gassaway, Toland, Butler, & Choo (2014)	31 public middle schools; Metropolitan Southeast region 15 EAI schools and 16 BAU schools All sessions conducted in resource special education rooms	*N* = 335, MID OHI EBD SLD, gr 6-8, age not reported; 49 Special education teachers responsible for intervention implementation, average 11 yrs special education experience; 2-day summer workshop training conducted by middle school teacher familiar with EAI intervention.	*EAI*: computer-based interactive lessons, video-based anchored problems, and hands-on applied projects, areas of focus include Ratios and Proportional Relationships, Number System, Statistics and Probability, and Geometry *BAU*: teachers followed regular school math textbook-based curriculum, objectives in BAU classrooms paralleled those of the EAI units	Quasi-experimental group design	*FCT*, 18-item, addressed add and subtract simple fractions, mixed numbers with and without renaming, Cronbach's alpha .98, interrater reliability 99%. *PST-R*, 48-item test assesses grade 6-8 concepts in number operations, measurement, problem solving, and representation, internal consistency alpha .90 and interrater reliability 95%. *ITBS:* standardized test subtests that measure operations with whole numbers, fractions, decimals, and combination of these.	FCT: EAI students over BAU students on all 10 subscales. EAI students gained about one standard deviation more than BAU students PST: Significant effect was found in favor of EAI with the ES approaching moderate (0.39). ITBS: statistically significant improvement from pretest to posttest in both instructional groups (ES = 0.56, p < .01).
Bottge, Rueda, Grant, Stephens, & Laroque (2010)	3 public middle schools; Metropolitan region in Pacific Northwest	*N* = 54; LD, EBD, OHI; gr 6-8; age not reported 1 special education teacher at each	*EAI* *Informal Instruction* + *EAI*: three instructional units related to addition/subtraction of fractions using *Bart's Pet Project*, *Fraction of the*	Pretest-posttest cluster randomized experiment.	*FCT*, 18-item, addressed add and subtract simple fractions, mixed numbers with and without renaming, Cronbach's alpha .98, interrater reliability 99%.	*FCT*: Informal group scored significantly more on posttest (16 points). Formal group scored 11 more points on posttest. *PST-R*: Informal group significant improvement

	Self-contained classrooms District 1 14.1% SWD	school; average14 yrs teaching experience, all three taught EAI for one year prior to study. 2-day *EAI* training provided by primary author.	*Cost*, and *Hovercraft Challenge* *Formal Instruction + EAI*: same as previous condition but *Bart's Pet Project* replaced with explicit instruction 24 days of instruction Observations, daily logbooks		*PST-Revised*, 48-item test assesses grade 6-8 concepts in number operations, measurement, problem solving, and representation, internal consistency alpha .90 and interrater reliability 95%. *Iowa Tests of Basic Skills* (ITBS): standardized test subtests that measure operations with whole numbers, fractions, decimals, and combination of these. .	from pre- to posttest (ES = 1.16) *ITBS*: no significant findings between formal and informal group regarding pre-to posttest scores.
Bottge, Rueda, LaRouque, Serlin, & Kwan (2007)	3 public middle and 1 high school self-contained classrooms	N = 100, LD EBD CD S/L OHI, gr 6-12, age not reported; 4 special education teachers, range 3-37 years SPED teaching, 2-day training on EAI implementation.	*EAI* *Kim's Komet Instruction*: video-based anchor problem designed to help students develop informal understanding of pre-algebraic concepts (i.e., linear functions, line of best fit, variable, rate of change, reliability) *BAU* followed the Connected Math Project textbook material addressed survival math skills	Mixed method. Pretest-posttest control group with switching replications.	*Kim's Komet Problem-Solving Test* (KKPST): tests concepts taught in *Kim's Komet* measuring NCTM standards; students have to understand figures, construct and interpret tables/graphs, identify relationships, and make predictions. Items weighted based on contribution to overall solution. Concurrent validity correlation coefficient = .52. *ITBS*: standardized test subtests that measured operations with whole numbers, fractions, decimals, and combination of these.	KKPST: main effects for test wave $F(2,128) = 64.43$, $p < .001$, $\eta^2 = .50$ and test wave-by-instruction interaction $F(2, 128) = 33.32$, $p < .001$, $\eta^2 = .34$ were statistically significant. EAI student mean scores increased significantly compared to control ($t = 5.08$, $p < .001$, Cohen's $d = 1.08$).

Bottge, Rueda, & Skivington (2006)	1 Public charter transition school (CTS), alternative high school for students at-risk for behavior issues 2 connected classrooms administrator, counselors, and special educators on staff	*N* = 17, EBD LD ADHD, gr 9-12, age not reported; court-involved (98%), substance abuse (90%), homeless (24%); 2 CTS teachers and 1 university instructor.	*EAI*	One-group nonequivalent dependent variables design with multiple measures in multiple waves.	*FCT*, 18-item, addressed add and subtract simple fractions, mixed numbers with and without renaming, Cronbach's alpha .98, interrater reliability 99%. *KKPST*: tests concepts taught in *Kim's Komet* measuring NCTM standards; students have to understand figures, construct and interpret tables/graphs, identify relationships, and make predictions. Items weighted based on contribution to overall solution. Concurrent validity correlation coefficient = .52. *ITBS*: standardized test subtests that measure operations with whole numbers, fractions, decimals, and combination of these.	FCS: elevated achievement for wave 2 compared to wave 1 (pre and post instruction), $t(15) = 7.93$, $p < .001$, and for wave 3 compared to wave 1 (maintenance), $t(15) = 6.87$, $p < .001$. KKPST: higher achievement for wave 3 compared to wave 1 (pre and post instruction), $t(15) = 9.21$, $p < .001$, but not for wave 2 compared to wave 1 (no instruction), $t(15) = 1.94$, $p = .07$ ITBS: paired-samples *t*-tests indicated no differences in achievement in computation, $t(16) = 0.07$, $p = 0.94$, or in problem solving, $t(16) = 0.28$, $p = 0.78$.

Bottge, Toland, Gassaway, Butler, Choo, Griffen, & Ma (2015)	24 public middle schools; Metropolitan and rural Southeast region comparable across ethnicity, free reduced lunch, and disability rates (specific numbers not provided) Intervention conducted in 25 inclusive math classrooms	*N* = 248 (*n* = 134 SWD), MID OHI EBD SLD, gr 6-8, age not reported; 25 special education teachers with an average teaching experience of 10.5 years; 2-day 14-hour summer training, recorded sessions so that teachers could access videos during intervention.	*EAI*: computer-based interactive lessons, video-based anchored problems, and hands-on applied projects, areas of focus include Ratios and Proportional Relationships, Number System, Statistics and Probability, and Geometry *Business as usual* (BAU) *Condition*: teachers followed regular school math textbook-based curriculum, objectives in BAU classrooms paralleled those of the EAI units. Teachers and students also used technologies, such as computers and interactive whiteboards, along with manipulatives	Pretest-posttest, cluster-randomized group design	*FCT*, 18-item, addressed add and subtract simple fractions, mixed numbers with and without renaming, Cronbach's alpha .98, interrater reliability 99%. *PST-R*, 48-item test assesses grade 6-8 concepts in number operations, measurement, problem solving, and representation, internal consistency alpha .90 and interrater reliability 95%. *Iowa Tests of Basic Skills* (ITBS): standardized test subtests that measure operations with whole numbers, fractions, decimals, and combination of these.	FCT: interaction term was statistically significant for students with MD, γ_{03} = 11.11, *p* = .03. Statistically significant treatment effect for EAI students without MD for the FCT, γ02 = 8.44, *p* = .001, ES = 0.61. PST: statistically significant treatment effects for EAI over BAU both with MD, γ_{02} = 3.98, *p* = .02, ES = 0.47, and without MD, γ_{02} = 2.65, *p* = .02, ES = 0.38. ITBS: no difference for students with MD by treatment condition, γ_{02} = 0.34, *p* = .46, ES = .08.
Bouck, Bassette, Shurr, Park, Kerr, & Whorley (2017)	1 public middle school; rural Midwest region total school population 439, 26% eligible for free reduced lunch, 8%	*N* = 3, LD, OHI, MID, gr 7-8, 12-14 yrs; 3 members of the research team conducted all intervention sessions in one-on-one format;	*Virtual-representational-abstract* (VRA): app-based virtual manipulative, drawing (representational), and only the math problem (abstract), prompts and cues provided as needed, intervention consisted of nine learning sheets (each stage of VRA had three)	Multiple-probe across participants single-case design	*Researcher-created probe*: probe assessed percent accuracy in solving five problems related to equivalent fractions.	Cora: increased performance on probes from baseline (*M* = 0; range = 0) to intervention (*M* = 80%; range = 40-100%). Drew: increased performance on probes from baseline (*M* = 36.7%; range = 20-40%) to intervention (*M* =

	special education all sessions carried out in the hallway outside of self-contained classroom	training was conducted by primary author and lesson format was modeled.	1-2 sessions per week over 15 weeks Two observers conducted IOA on 33% of all sessions at 100%, implementation fidelity was assessed using intervention checklists			93.3%; range = 80-100%). Evan: increased performance on probes from baseline (*M* = 11.4%; range = 0-40%) to intervention (*M* = 94%; range = 60-100%).
Haydon, Hawkins, Denune, Kimener, & McCoy (2012)	Public alternative school; Midwest United States 1 high school mathematics classroom Alternative school for grades 2-12 with approximately 65 students	*N* = 3; ED; gr 9-12; 17-18 yrs; 1 classroom teacher, 4 yrs teaching experience, masters certification in mathematic instruction;	Mobile learning technology (iPads) and traditional worksheets 40 minutes per day for 15 sessions 94.6% agreement on 100% of classroom observations	Alternating treatment single-case design	Number of correct responses per minute: recorded number of problems answered accurately during each 60-second interval. Active engagement: operational definition involved writing, raising hand, choral responding, reading aloud, talking to teacher/peer about assignment, and placing finger/scrolling on iPad. Momentary time sampling direct observation.	Number of correct responses: All students increased from worksheet condition to iPad condition; average increase was 3.23, 3.93, and 2.55 for Sue, Jim, and Andy respectively. 100% of iPad data points exceeded highest worksheet data point. Engagement: All students displayed close to 100% engagement during the iPad condition (range 98.0%-100%).

Koedinger, McLaughlin, & Hefferenan (2010)	4 public middle schools; metropolitan Northwest region Treatment School A 22% SWD, School B 19% SWD, School C 23% SWD, Comparison School D 19% SWD	N = 1,240; n = 260 SWD; specific disability eligibilities not described; 7th gr; age not reported. 42 classroom teachers were responsible for intervention implementation.	*ASSISTments*: online assessment and tutoring curriculum that broke down requisite skills and content knowledge. Using student performance, program provided remediation when student missed concepts. In addition to the provision of scaffolded remediation, students were able to request hints when they encountered difficulty. Program collected data throughout curriculum used by the teacher to modify instruction	Quasi-experimental group study; no random assignment	*Massachusetts Comprehensive Assessment System (MCAS)*: Comprehensive standardized assessment covering grades 3-8.	A 2 × 2 ANCOVA with condition (treatment vs. control) and student group (regular vs. special education) as factors and pre-test as a covariate revealed main effects for condition, $F(1, 1235) = 12.3$, $p < .001$, and student group, $F(1, 1235) = 119.4$, $p < .001$, and an interaction effect between condition and student group, $F(1, 1235) = 6.6$, $p = .01$.

Saunders, Spooner, & Davis (2018)	1 public middle school; Metropolitan region in the Southeast School served 1,128 students; 38% free and reduced lunch sessions conducted in conference room attached to self-contained classroom	*N* = 3; MID; gr 7-8; 13-14 yrs 2 doctoral students implemented intervention; between 6 and 16 yrs MID experience; training not specifically mentioned.	*Video*-prompting: Video-simulation problems using the *Camtasia* software; 285 real-world math problems filmed and recorded by third author covering additional and subtraction change problems. Videos were narrated and contained: (a) context statement, (b) initial set description, (c) action stated, (d) change amount stated, and (e) question written and read aloud	Multiple-probe across participants single-case design	Researcher-created probes. Visual confirmation of the participants' ability to solve a video-prompted real world problem. Sessions contained 4 addition or subtraction questions broken in to 6 steps for a total of 24 tasks: (a) viewing video problem, (b) identifying initial set, (c) demonstrating the change action, (d) identifying change amount, (e) solving and stating ending amount, and (f) orally stating amount and unit.	Brad: increased performance on probes from baseline (*M* = 10.5; range = 7-13) to maintenance (*M* = 23.25; range = 21-24). Heather: increased performance on probes from baseline (*M* = 4.75; range = 4-6) to maintenance (*M* = 22.7; range = 20-24). Benito: increased performance on probes from baseline (*M* = 3.1; range = 0-6) to intervention (*M* = 16.5; range = 7-24). Visual analysis of data show functional relationship between video-prompting and correct responses.

Sheriff & Boon (2014)	1 public middle school; Rural Southeast sessions conducted in self-contained special education classroom total school size 816 students, 41% free reduced lunch and 13% special education	*N* = 3; MID; gr 6-8; 13-14 yrs; 1 special education teacher and 2 paraprofessional	Computer-based graphic organizers using the *Kidspiration 3* software. Graphic organizers contained text of a word problem and template with boxes and the result set arranged as a math equation 8 weeks IOA on 100% paper-and-pencil probes and 100% sessions observed using procedural checklist	Multiple-probe across participants single-case design	Teacher-generated worksheets containing nine one-step word problems; 3 addition, 3 subtraction, and 3 multiplication problems. Problems only involved one step and did not include any extraneous data.	Sandy: increased performance on probes from baseline (*M* = 2.75; range = 2-3) to maintenance (*M* = 6.5; range = 6-7). Ken: increased performance on probes from baseline (*M* = 1.8; range = 1-2) to maintenance (*M* = 6.67; range = 6-7). Nathan: increased performance on probes from baseline (*M* = 1.88; range = 1-2) to maintenance (*M* = 6.67; range = 6-7). Visual analysis of data show functional relationship between digital graphic organizers and word problem accuracy.

Note. ADHD = Attention Deficit Hyperactive Disorder; DD= developmental disabilities; EBD = Emotional Behavior Disorder; ED = Emotional Disturbance; IOA = inter-observer agreement; MD = Math Disability; OHI = other health impaired; SEND = special education needs and disabilities;; SLD = specific learning disability; SL = speech/ language; SWD = students with disabilities

Table 1.2 *Methodological Rigor by Quality Indicator*

Quality Indicator	Intervention Study						
	Billingsley, Scheuermann, & Webber (2009)	Bottge et al. (2004)	Bottge et al. (2006)	Bottge et al. (2007)	Bottge et al. (2010)	Bottge et al., (2014)	Bottge et al., (2015)
Context and setting	**1/1**	**1/1**	**1/1**	**1/1**	**1/1**	**1/1**	**1/1**
Participants	**2/2**	**2/2**	**2/2**	**2/2**	**2/2**	**2/2**	**2/2**
Intervention agent	1/2	**2/2**	1/2	**2/2**	**2/2**	**2/2**	**2/2**
Description of practice	**2/2**	**2/2**	**2/2**	**2/2**	**2/2**	**2/2**	**2/2**
Implementation fidelity	**3/3**	2/3	**3/3**	2/3	**3/3**	**3/3**	**3/3**
Internal validity	4/6	5/6	**6/6**	**6/6**	**6/6**	**6/6**	**6/6**
Outcome measures/ dependent variables	**6/6**	**6/6**	**6/6**	**6/6**	**6/6**	**6/6**	**6/6**
Data analysis	**1/1**	**2/2**	**2/2**	**2/2**	**2/2**	**2/2**	**2/2**
Quality Indicators Met (%)	6/8 (75)	6/8 (75)	7/8 (87.5)	7/8 (87.5)	**8/8 (100)**	**8/8 (100)**	**8/8 (100)**

Note. All design-appropriate elements for the indicator were met to be scored as Yes. Bold indicates all criteria were met for that quality indicator.

Methodological Rigor by Quality Indicator

Quality Indicator	Bouck et al. (2017)	Haydon et al. (2012)	Koedinger, McLaughlin & Heffernan (2010)	Saunders, Spooner, & Davis (2018)	Sheriff & Boon (2014)	Total of Each Indicator	Interobserver Agreement (%)
Context and setting	**1/1**	**1/1**	**1/1**	**1/1**	**1/1**	**12/12**	**100**
Participants	**2/2**	**2/2**	0/2	**2/2**	**2/2**	11/12	**100**
Intervention agent	1/2	**2/2**	1/2	1/2	**2/2**	8/12	95.83
Description of practice	**2/2**	**2/2**	1/2	**2/2**	**2/2**	11/12	95.83
Implementation fidelity	**3/3**	2/3	1/3	**3/3**	**3/3**	8/12	94.4
Internal validity	**6/6**	**6/6**	4/6	5/6	5/6	7/12	96.29
Outcome measures/ dependent variables	**5/5**	**6/6**	5/6	**5/5**	**5/5**	11/12	98.6
Data analysis	**1/1**	**2/2**	**2/2**	**1/1**	**1/1**	**12/12**	**100**
Quality Indicators Met (%)	7/8 (87.5)	7/8 (87.5)	2/8 (25)	6/8 (75)	7/8 (87.5)		97.6

Note. All design-appropriate elements for the indicator were met to be scored as Yes. Bold indicates all criteria were met for that quality indicator.

(8.3%) was conducted in a public charter transition school (Bottge al., 2006). Through informal interviews with principals and classroom teachers, Bottge and colleagues (2006) were able to provide rich descriptions of the school and classrooms including community descriptions and classroom layout. The public charter transition school was housed in a former school building and the intervention was carried out in two adjoining classrooms; one classroom, used for instruction, had student desks and whiteboard while the next room was used for hands-on activities and projects. The specific context in which the interventions were delivered varied between self-contained classrooms (Bottge et al., 2007; Bottge et al., 2010; Saunders, Spooner, & Davis; Sheriff & Boon), inclusive classrooms (Bottge et al., 2015; Koedinger, McLaughlin, & Heffernan), and the hallway outside of the classroom (Bouck et al.).

Indicator 2: Participants. Eleven of the 12 intervention studies (91.6%; Billingsley, Scheuermann, & Webber, 2009; Bottge et al., 2004; Bottge et al., 2006; Bottge et al., 2007; Bottge et al., 2010; Bottge et al., 2014; Bottge et al., 2015; Bouck et al., 2017; Haydon et al., 2012; Koedinger, McLaughlin, & Heffernan, 2010; Saunders, Spooner & Davis, 2018; Sheriff & Boon, 2014) met the requirements for participant data because they reported specific disability categories for SWD and the method for determining disability status was explicitly stated. All 12 studies (100%) focused primarily on high incidence disabilities (e.g., EBD, LD, OHI, MID); however, the specific population varied across the studies. Looking at only one disability eligibility, two studies (16.6%; Saunders, Spooner & Davis; Sheriff & Boon) included participants with MID and one study (8.3%; Haydon et al.) conducted their intervention with students with EBD. Eight studies (66.6%) were conducted with a combination of students with LD and EBD and six of those studies (50%) also included students with OHI (Bottge et al., 2004; Bottge et al., 2006; Bottge et al., 2007; Bottge et al., 2010; Bottge et al., 2015; Bouck et al.). For more information regarding participant data, please see Table 1.1.

Indicator 3: Intervention Agent. Seven studies (58.3%; Bottge et al., 2004; Bottge et al., 2007; Bottge et al., 2010; Bottge et al., 2014; Bottge et al., 2015; Haydon et al., 2012; Saunders, Spooner & Davis, 2018; Sheriff & Boon, 2014) met the intervention agent requirements and provided information regarding the role of the intervention agent and specific certification or training that was provided before implementation. Bottge and colleagues provided a 2-day training session to participating teachers in order to familiarize them with the EAI instructional condition. Furthermore, in the study conduced in 2014 and 2015, the training sessions were recorded and those recordings were made available to the teachers for reference throughout the implementation stage of the study. While seven studies (58.3%) incorporated professional development provided by the primary researcher (Bottge et al., Haydon et al.), one study (8.3%; Koedinger, McLaughlin, & Heffernan, 2010) utilized the computer-based program training sessions embedded within the ASSISTments program. Bouck and colleagues (2017) provided training by the primary researcher who also modeled appropriate lesson delivery.

Of the studies that did not meet this particular standard, three studies (25%; Billingsley, Scheuermann, & Webber, 2009; Bottge et al., 2006; Saunders, Spooner, & Davis, 2018) provided descriptions of the role of the teacher as the intervention agent and cursory demographic information (e.g., years of experience); however, researchers failed to describe any certification or prior training that was needed for appropriate intervention implementation.

Indicator 4: Description of Practice. Eleven studies (91.6%; Billingsley, Scheuermann, & Webber, 2009; Bottge et al., 2004; Bottge et al., 2006; Bottge et al., 2007; Bottge et al., 2010; Bottge et al., 2014; Bottge et al., 2015; Bouck et al., 2017; Haydon et al., 2012; Saunders, Spooner & Davis, 2018; Sheriff & Boon, 2014) provided information that met the CEC requirements for description of practice while one study (Koedinger, McLaughlin, & Heffernan, 2010) failed to provide information regarding the daily procedures of the intervention condition using the ASSISTments program. Researchers in the 11 studies were clear and explicit in their explanations of procedures carried out by the teacher; similarly, information was provided regarding the particular applications or programs that were used during the computer- or technology-mediated instructional conditions. Haydon et al. (2012) described the face-to-face instruction provided by the teacher including the content that was taught (e.g., counting coins, money mathematics, fractions, numerical patterns, order of operations) and the length of time of each instructional section (e.g., same 40-minute instructional period each day and ranged between 26-40 minutes). Furthermore, they explained the iPad conditions and described how the students used the various applications (i.e., iTouch MATH, CoinMath, enVision MATH). Bottge and colleagues provided descriptive information regarding the technology-mediated curricula (i.e., Fraction of the Cost, Kim's Komet, Fractions at Work, Hovercraft Project), how the teachers and students used the materials, and where to locate more information about each program. For more information regarding intervention procedures, refer to Table 1.1.

Indicator 5: Implementation Fidelity. Nine studies (75%; Billingsley, Scheuermann, & Webber, 2009; Bottge et al., 2006; Bottge et al., 2007; Bottge et al., 2010; Bottge et al., 2014; Bottge et al., 2015; Bouck et al., 2017; Saunders, Spooner & Davis, 2018; Sheriff & Boon, 2014) met all the criteria for information regarding implementation fidelity. Five studies (Billingsley, Scheuermann, & Webber; Bottge et al., 2015; Bouck et al.; Saunders, Spooner, & Davis; Sheriff & Boon) used observation checklists throughout the duration of the intervention, in all conditions, to determine if each component of the intervention was being delivered appropriately. Checklists were used in an effort to ensure adherence to planned procedures. In the remaining Bottge et al. studies, researchers used observation notes, teacher logbooks, and video recordings of instructional sections to ensure EAI procedures were being carried out with fidelity.

Of the three studies that did not meet the requirements for implementation fidelity (33.3%; Bottge et al., 2004; Haydon et al., 2012; Koedinger, McLaughlin, & Heffernan, 2010), Haydon et al. did provide information regarding observation checklists that were used in 100% of sessions to measure intervention component adherence; however, they failed to report findings in regards to the dosage and exposure to the intervention conditions. Similarly, although Koedinger and colleagues mentioned that implementation fidelity was measured throughout the intervention phase of the study, they failed to provide description of specific methodology (e.g., checklists, observations) or data regarding adherence and procedural integrity. In the same way, Bottge et al. (2004) mentioned the use of classroom observations to measure implementation fidelity; however, specific findings were not reported in regards to dosage, exposure, or curriculum adherence.

Indicator 6: Internal Validity. Two single-case studies (Bouck et al., 2017; Haydon et al., 2012) and five group studies (Bottge et al., 2006; Bottge et al., 2007;

Bottge et al., 2010; Bottge et al., 2014; Bottge et al., 2015) met the standards for internal validity. Haydon and colleagues worked closely with the teacher to determine when to provide instruction and when to offer the paper-and-pencil worksheet as opposed to the iPad worksheet. The classroom teacher and the researchers assessed the curriculum and content of each condition worksheet for adherence to the lesson objectives. Additionally, even though they implemented a single-case design alternating treatments design study, they further controlled for internal validity by randomizing the order of conditions within each phase. Similarly, Bouck and colleague used a multiple-baseline across participants design study; this particular design keeps students in the baseline phase until the previous student shows growth in the intervention, thus limiting their exposure to intervention conditions. In the group studies that met all internal validity elements, Bottge et al. controlled for access to the EAI condition and randomized assignment by teacher (2007), school (2014), and conducted a non-randomized one-group with multiple measures design (2006) using the *Fractions of the Cost, Kim's Komet Challenge*, and *The Iowa Test of Basic Skills* (Form A; University of Iowa, 2001). Reasons for not meeting these requirements ranged from high attrition rates (Bottge et al., 2004), non-randomization of schools (convenience sample of schools already using ASSISTments program; Koedinger, McLaughlin, & Heffernan, 2010), and failure to control for maturation and cumulative exposure to mathematics concepts that were being learned outside of the intervention (Billingsley, Scheuermann, & Webber, 2009).

Indicator 7: Outcome Measures/Dependent Variables. Eleven studies (91.6%; Billingsley, Scheuermann, & Webber, 2009; Bottge et al., 2004; Bottge et al., 2006; Bottge et al., 2007; Bottge et al., 2010; Bottge et al., 2014; Bottge et al., 2015; Bouck et al., 2017; Haydon et al., 2012; Saunders, Spooner & Davis, 2018; Sheriff & Boon, 2014) provided explicit and descriptive information regarding the first four elements of this indicator; all researchers provided evidence to the importance of effective instruction for SWD and establishing evidence-based practices when using technology for instruction. Similarly, all outcome measures were extensively described including frequency of administration and the intervention effects on each measure. One study (8.3%; Koedinger, McLaughlin, & Heffernan, 2010) failed to include any interobserver agreement (IOA) data or curricular validity measures. Seven studies (70%; Billingsley, Scheuermann, & Webber, 2009; Bottge et al., 2004; Bottge et al., 2006; Bottge et al., 2007; Bottge et al., 2010; Bottge et al., 2014; Bottge et al., 2015) provided interrater reliability data ranging from 86-99% agreement in addition to social and concurrent validity findings.

Indicator 8: Data Analysis. All 12 studies (100%) provided adequate information regarding data analysis. The five single-case studies (Billingsley, Scheuermann, & Webber, 2009; Bouck et al., 2017; Haydon et al., 2012; Saunders, Spooner & Davis, 2018; Sheriff & Boon, 2014)) provided appropriate single-case graphs representing the outcome data for each dependent variable for each participant. Additionally, two single-case studies (Billingsley, Scheuermann, & Webber; Haydon et al.) presented mean scores for each participant in each condition and provide data pertaining to the percent increase of on-task behavior and academic achievement. Two group studies (Bottge et al., 2004; Koedinger, McLaughlin, & Heffernan, 2010) utilized ANCOVA analysis procedures with graphical representations of the data combined with pairwise comparisons of outcome measure data. Two group studies (Bottge et al., 2006; Bottge et al., 2007) used two-way

ANOVA methods of data analysis and provided effects sizes through paired sample t-tests. Bottge and colleagues (2010; 2014) conducted hierarchical linear modeling procedures controlling for student characteristics (e.g., gender, grade, ethnicity) and teacher variables (e.g., gender, teaching experience). Lastly, Bottge and colleagues (2015) utilized a two-level multilevel model of analysis, at the student and teacher level, to evaluate the effectiveness of the treatment on student performance. For a list of all studies and CEC indicators met, see Table 1.2.

Discussion

The purpose of this systematic review of literature was two-fold: (a) to identify experimental, quasi-experimental, and single-case design BL mathematics intervention studies that affected the academic achievement of secondary-level SWD, and (b) to determine the methodological rigor of the BL mathematics intervention studies conducted with SWDs. Although previous literature reviews and meta-analyses have been conducted regarding the use of CBI and SWD (Kagohara et al., 2013; Vasquez & Straub, 2012) and a comparison of face-to-face, online, and BL (Means, Toyoma, Bakia, & Jones, 2013), this review examined the use of BL mathematics interventions with secondary-level SWDs. This analysis contributes to the literature base that suggests BL as an intervention to improve academic and behavioral outcomes for SWD. In addition to identifying and synthesizing findings across the 12 intervention studies, the studies were assessed using the standards for rigorous research in special education set forth by the Council for Exceptional Children (2014).

BL Mathematics Interventions for SWD

Teachers can utilize BL math instruction to assist with the processes of differentiation and personalization of content instruction. Using BL, which can be presented in a variety of formats (Staker & Horn, 2012), allows teachers the opportunity to modify instruction in various conditions of instruction (e.g., CBI, teacher-led). Although variations exist regarding the way in which CBI and technology-based strategies were used to deliver BL, findings from these studies inform researchers and educators of the benefits of BL regardless of the specific BL format used. Mirroring findings from previous literature reviews in the area of CBI and SWDs (Kagohara et al., 2013; Vasquez & Straub, 2012), all three studies that implemented BL studies utilizing CAI tools for instruction and assessment (Billingsley, Scheuermann, & Webber, 2009; Koedinger, McLaughlin, & Heffernan, 2010; Haydon et al., 2012) found positive gains in mathematics achievement for SWD at the secondary level. It is interesting to note that all three of these studies utilized a method of personalization of content delivery based on student assessment data. The importance of personalized and differentiated instruction was addressed in previous research (Barbour & Reeves, 2009; Halverson et al., 2017). In order for personalization to be effective, material should be connected to each learners' interests, passions, and aspirations (Masthoff, Grasso, & Ham, 2014). Classroom teachers can accomplish this by using strategies that improve student-teacher relationships, having discussions with students, or by having students complete interest inventories. Once student interests and preferences have been identified, teachers can create context personalization (Hogheim & Reber, 2017) by infusing various topics within teacher-led instruction or independent or group assignments, giving students the ability to choose their learning topic while still addressing specific content. Specifically in BL, online- and

CBI content may not lend itself to easy modification as the lessons have been pre-recorded. Considering this, when designing BL interventions, teachers can utilize context personalization in teacher-led instruction and independent practice stations.

When choosing BL mathematics interventions for SWDs, it may be beneficial to identify curricula that provide content modification based on individual performance. In one reviewed study (Haydon et al., 2012), researchers used student pre-assessment data to personalize the math achievement measures so that they were measuring deficit areas that each student presented. iPad-based applications were chosen for each student to be used during the CBI portion of the study; applications (e.g., iTooch Math, Coin Math) targeted specific skills but did not modify instruction within the program based on student performance. On the other hand, two studies (Billingsley, Scheuermann, & Webber, 2009; Koedinger, McLaughlin, & Heffernan, 2010) utilized CBI software that assessed student performance and modified the content instruction based on student pre-assessment data. Koedinger and colleagues were interested in the ASSISTments program, a web-based cognitive tutoring program, designed for middle school students, that assessed student performance and provided modified instruction based on individual strengths and weaknesses. While teacher-led and independent practice stages of BL would be the appropriate places to relate content instruction to the individual interests of the student, specific CBI programs can be used that personalize and modify content instruction that address student deficits.

The reviewed literature supports previous findings that suggest BL is associated with positive gains in student on-task behavior (Barbour & Reeves, 2009; Halverson et al., 2017). Three of the 12 studies (25%) included data related to on-task behavior and academic engagement. These three studies (Bottge, Rueda, LaRouque, Serlin, & Kwan, 2007; Bottge, Rueda, & Skivington, 2006; Haydon et al., 2012) found that students were more engaged and were more motivated to complete work during the BL conditions. Bottge and colleagues (2006) used EAI that incorporated project-based and hands-on learning. Project-based learning has the potential to improve the academic engagement of SWD because it allows seamless integration of content material and authentic, real-world learning experiences (Carr & Jitendra, 2000; Hall & Miro, 2016). It is interesting to note that these three studies reported increases in participant engagement during BL conditions while simultaneously reporting improvements in mathematics achievement. Increasing the amount of time students are engaged with their work by creating various stations (station-rotation BL) that target student interests, while incorporating project- or activity-based assignments, has the potential to increase math achievement.

Findings from this literature review support previous claims that BL has the potential to improve the math achievement of SWDs by increasing on-task behavior while simultaneously promoting academic achievement (Henrie, Bodily, Manwaring, & Graham, 2015; Wook & Kim). Eight studies in this literature review (66.6%; Billingsley, Scheuermann, & Webber, 2009; Bottge et al., 2004; Bottge et al., 2006; Bottge et al., 2007; Bottge et al., Bottge et al., 2010; Bottge et al., 2014; Bottge et al., 2015; Haydon et al., 2012) specifically looked at the effects of BL interventions on measurable mathematics achievement outcomes. Increases were found in basic mathematic functions (e.g., addition, subtraction, multiplication, division; Haydon et al.), fraction computation (Billingsley, Scheuermann, & Webber; Bottge et al., 2004; Bottge et al., 2006; Bottge et al., 2007; Bottge et al., Bottge et al., 2010; Bottge et al., 2014; Bottge et al., 2015), and problem-solving skills (Bottge et al., 2010; Bottge et al., 2014; Bottge et al., 2015) during the BL format. Studies that focused on mathematics achievement found improving results for SWD in the BL conditions when compared to BAU. Teachers who are looking to improve the fraction computation and problem solving skills of SWD should use the BL intervention used by Bottge and colleagues (2004: 2006; 2007; 2010; 2014; 2015), EAI.

CEC Quality Indicators

This literature review examined studies against the standards for evidence-based practices in special education (CEC, 2014). This analysis of current literature gives the reader an idea of strengths and weaknesses of studies, highlighting common errors across various publications. Only three studies (25%; Bottge et al., 2010; Bottge et al., 2014; Bottge et al., 2015) met all eight indicators of scientific rigor. Of the remaining intervention studies, the three most commonly missed requirements were implementation fidelity (Bottge et al., 2004; Bottge et al., 2007; Haydon et al., 2012; Koedinger, McLaughlin, & Heffernan, 2010), internal validity (Billingsley, Scheuermann, & Webber, 2009; Bottge et al., 2004; Koedinger, McLaughlin, & Heffernan; Saunders, Spooner, & Davis, 2018; Sheriff & Boon, 2014), and intervention agent information (Billingsley, Scheuermann, & Webber; Bottge et al., 2006; Bouck et al., 2017; Koedinger, McLaughlin, & Heffernan; Saunders, Spooner, & Davis). By providing clear description of research methodology, researchers are able to guide educators and future researchers in the replication process.

One central component of scientific research is replication, the process by which positive findings from specific studies are reproduced by other researchers (Makel et al., 2016; Cook et al., 2015). Through the systematic replication of intervention studies, by examining the same research questions with different participants and data (Cook, Lloyd, Mellor, Nosek, & Therrien, 2018), researchers are able to verify positive findings by ruling out methodological error or chance (Makel et al.). Once an intervention has undergone multiple replications and similar positive findings have been noted, the research community can confidently support the practical application of that intervention (What Works Clearinghouse, 2014). In order to ensure that they are including enough information for effective replication, special education researchers need simply to turn to the eight indicators (i.e., context and setting, participants, intervention agent, description of practice, implementation fidelity, internal validity, outcome measures, data analysis) set forth by the Council for Exceptional Children (2014). Within this literature review, the only intervention that was replicated was EAI; however, the replications were carried out by the same primary author (Bottge). Additionally, some authors failed to provide enough information regarding implementation fidelity (Bottge et al., 2004; Bottge et al., 2007; Haydon et al., 2012; Koedinger, McLaughlin, & Heffernan, 2010), internal validity (Billingsley, Scheuermann, & Webber, 2009; Bottge et al., 2004; Koedinger, McLaughlin, & Heffernan, 2010; Saunders, Spooner, & Davis, 2018; Sheriff & Boon, 2014), and intervention agent (Billingsley, Scheuermann, & Webber, 2009; Bottge et al., 2006; Bouck et al., 2017; Koedinger, McLaughlin, & Heffernan; Saunders, Spooner, & Davis). When certain details about the intervention are withheld, it makes it difficult for researchers and educators to replicate specific findings.

Regarding implementation fidelity (Sanetti & Kratochwill, 2009), variations may exist in the type of information being provided. One measure of implementation fidelity commonly used in math intervention research is adherence (e.g., ensuring that specific actions are taken by the interventionist; Codding, Hilt-Panahon, Panahon, & Benson, 2009). Conversely, researchers can provide details regarding the amount of intervention exposure each participant receives (O'Donnell, 2008). In this literature review, 4 out of 12 (33%) authors failed to explicitly describe dosage and exposure (Bottge et al., 2004; Bottge et al., 2007; Haydon et al., 2012) or they failed to conduct IOA measures throughout the duration of the study (Koedinger, McLaughlin, & Heffernan, 2010). Without knowing how long interventions were carried out or the specific schedule of BL implementation, researchers and educators may have a hard time replicating the findings of those studies (Sanetti & Kratochwill). Additionally, in order to ensure that implementation procedures were carried out as described, researchers often use additional observers to verify procedural integrity (i.e., IOA; Brittle & Repp, 1984; Kratochwill et al., 2013). However, if IOA data were not provided, researchers and practitioners cannot be certain that the prescribed procedures will yield positive results.

Another required component of effective special education intervention research is information related to internal validity (CEC, 2014). Internal validity refers to the conclusions drawn between the independent and dependent variables of an intervention and whether or not there was a causal treatment effect (Kazdin, 2011; Shadish, Cook, & Campbell, 2002). Common threats to internal validity are: (1) history, (2) maturation, (3) testing, (4) instrumentation, (5) statistical regression, (6) selection, (7) attrition, and (8) selection-maturation interaction (Shadish, Cook, & Campbell). In this literature review, five out of 12 studies (41.6%; Billingsley, Scheuermann, & Webber, 2009; Bottge et al., 2004; Koedinger, McLaughlin, & Heffernan, 2010; Saunders, Spooner, & Davis, 2018; Sheriff & Boon, 2014) did not meet the standards for internal validity. Regarding instrumentation, one single-case study (Billingsley, Scheuermann, & Webber) failed to show three demonstrations of intervention effect in three different times. Because they were not able to replicate the findings at three different points in the intervention, authors failed to account for the impact of changing the instrument. Internal validity concerns specific to group design studies were high levels of attrition (Bottge et al., 2004) and non-randomized school assignment with great variations in school populations (Koedinger, McLaughlin, & Heffernan; Saunders, Spooner, & Davis; Sheriff & Boon). When conducting BL interventions with SWD, researchers and teachers must make sure that specific interventions have shown positive results for their particular students and the findings can be generalized (Cook & Cook, 2017). For example, a teacher might find a particular intervention that showed improvements in the math achievement of students with LD; however, findings from this intervention might not generalize to his or her students with EBD. Similarly, if the population of SWD in a given school is highly transient and students are moving in and out of the facility, a teacher may search for BL interventions that are shorter in duration. Knowing these details could greatly impact the success, or failure, of a given intervention.

Another quality indicator specific to special education research was information regarding the role of the intervention agent and the type of training/professional development provided to participating teachers (CEC, 2014). To effectively replicate studies, researchers and educators benefit from clear procedural descriptions of the specific actions taken by the intervention agent. When formalized mandatory training was provided to the teachers (Bottge et al., 2004; Bottge et al., 2007; Bottge et al., 2010; Bottge et al., 2014; Bottge et al., 2015; Haydon et al., 2012; Sheriff & Boon, 2014), BL procedures were carried out with fidelity and findings were attributed directly to the intervention. Researchers have suggested that outcomes are positively affected if explicit training is provided to the intervention agent (Cook, Tankersley, & Harjusola-Webb, 2008). When making the decision to implement new mathematic interventions with SWD, teachers should make sure that they are fully informed and receive appropriate training for intervention implementation. All participants, including staff and students, should receive training on how to use the intervention.

BL Intervention Studies and Quality Indicators

Movement in the field of special education research has been towards the use of EBPs (IDEA, 2004), thus requiring improved quality of research and literature reviews (Cook & Odom, 2013; Talbott, Maggin, Van Acker, & Kumm, 2018). Before a particular strategy can be classified as an EBP, individual studies assessing that strategy should be methodologically sound. In order for a study to be considered methodologically sound, it should meet all eight quality indicators (CEC, 2014). Once studies have been determined to be methodologically sound, and there are a sufficient number of quality replication studies, the strategy can be considered an EBP. Using the eight quality indicators, interventions can be placed on the EBP continuum: (a) evidence-based practice, (b) potentially evidence-based practice, (c) mixed evidence, (d) insufficient evidence, and (e) negative effects (CEC). In this literature review, one strategy (i.e., EAI) emerged as an EBP that can be used with secondary-level SWD in math instruction. Three replication studies (Bottge et al., 2010; Bottge et al., 2014; Bottge et al., 2015) examined the use of station-rotation BL through EAI and met all eight quality indicators. All three group studies saw significant growth in mathematics achievement for EAI groups over comparison groups.

Although only three studies (Bottge et al., 2010; Bottge et al., 2014; Bottge et al., 2015) met all eight quality indicators of special education evidence-based research, five studies (Bottge et al., 2006; Bottge et al., 2007; Bouck et al., 2017; Haydon et al., 2012; Sheriff & Boon, 2014) were close and met seven indicators. Even though these studies cannot be considered methodologically sound, positive findings were noted for SWD regarding word-problem accuracy (Sheriff & Boon), fraction computation and accuracy (Bottge et al., 2006; Bottge et al., 2007; Bouck et al.), and basic operations including money-math, fractions, and patterns (Haydon et al.). Of the remaining studies that only met six quality indicators or less (Billingsley, Scheuermann, & Webber, 2009; Bottge et al., 2004; Koedinger, McLaughlin, & Heffernan, 2010; Saunders, Spooner, & Davis, 2018), two single case studies (Billinglsey, Scheuermann, & Webber; Koedinger, McLaughlin, & Heffernan) found mixed results regarding participant math achievement while one group study (Bottge et al., 2004) did not find significant interaction differences between classes. Intervention studies that were designed and implemented with higher scientific rigor saw greater gains in their participants. Studies that met at least seven of the quality indicators also found improved intervention effects on academic achievement and student engagement. In an effort to contribute to the research base in special education, researchers should strive to design and implement studies with these rigorous standards in mind.

Limitations

There were some limitations included in this literature review. First, given the varied nature and definitions of BL (Stake & Horn, 2012), the search terms used were specific to BL and may not have captured all studies that could be classified as BL. Given the rapidly progressing nature of educational technology (Dziuban, Graham, Moskal, Norberg, & Sicilia, 2018), there may have been studies that could be considered BL but were not discovered with this search. In this review, only one study (Bottge et al., 2015) specifically mentioned BL in the title. More intervention studies may have been located if the search terms were expanded.

Additionally, the review was limited to peer-reviewed journal publications and did not include grey literature or dissertations. Again, considering the rapidly evolving nature of BL and educational technology (Dziuban, Graham, Moskal, Norberg, & Sicilia, 2018), current dissertation studies may not have undergone peer-review for journal publication. By not including dissertation studies, there may have been relevant BL studies that were not included in this analysis.

Future Directions

More research is needed in the area of BL for SWD. Through the use of intervention review and CEC quality indicators, one strategy, EAI (Bottge et al., 2010; Bottge et al., 2014; Bottge et al., 2015), was identified as an EBP in math instruction for SWD. These three studies specifically focused on fraction computation and problem-solving skills. However, secondary-level SWD often struggle with basic mathematics operations that affect their ability to master higher-level concepts (Hughes, Maccini, & Gagnon, 2003). Researchers need to expand the area of focus and diversify the areas of mathematics that are addressed with BL interventions.

Future research with BL should focus on specific disability eligibilities. For example, students with ASD may require a different instructional approach than students with LD or EBD. In this literature review, there was great variation in the participant eligibilities. Five studies (Billingsley, Scheuermann, & Webber, 2009; Bottge et al., 2004; Bottge et al., 2007; Bottge et al., 2014; Bottge et al., 2015) included four or more disability eligibilities while only three studies (Haydon et al., 2012; Saunders, Spooner, & Davis, 2018; Sheriff & Boon, 2014) focused on one eligibility (i.e., MID). If future research studies contain multiple disability categories, researchers should disaggregate data for each eligibility.

Future research in the area of BL math instruction should include rich description of the BL format used. Only two authors (Billingsley, Scheuermann, & Webber, 2009; Bottge et al., 2015) specifically mentioned BL in their description of the intervention; even then, they failed to define the specific format of BL that was used (e.g., station-rotation, flipped-classroom). Staker and Horn (2012) clearly define various BL formats that range in level of teacher-led instruction, CBI, and independent practice. Some models of BL may be better suited to particular populations or settings. In order to replicate studies and to establish BL as an evidence-based practice with specific populations, researchers need to describe clearly the types of BL assessed.

Only three of the studies (Bottge et al., 2006; Bottge et al., 2007; Haydon et al., 2012) focused on the outcome variable related to academic engagement and on-task behavior. Researchers indicate that increasing the on-task behavior of SWD can have positive impacts on their academic achievement (Arthanat, Curtin, & Knotak, 2013; Bryant et al., 2015). Given that students with high incidence disabilities often struggle to remain focused during classroom instruction (Aron & Zweig, 2003; Lehr, Moreau, Lange, & Lanners, 2012; McCall, 2003), it is imperative that researchers determine whether or not the use of BL results in greater levels of on-task behavior. Future intervention studies, regarding the use of BL interventions for math instruction with SWD, should incorporate dependent measures related to on-task behavior or academic engagement.

Previous research has shown that the use of technology-mediated instruction (Flower, 2014) and CAI (Billingsley, Scheuermann, & Webber, 2009) can positively impact math achievement. Unfortunately, many of the findings of this literature review were limited to fraction computation (Bottge et al., 2004; Bottge et al., 2007; Bottge et al., 2010; Bottge et al., 2014, Bottge et al., 2015; Bouck et al., 2017) and real-world problem solving (Bottge et al., 2010; Bottge et al., 2014; Bottge et al., 2015; Haydon et al., 2012; Saunders, Spooner, & Davis, 2018). Limited information can be gleaned from these studies related to proficiency and understanding of other mathematics concepts (e.g., algebraic concepts, geometry). Future research in this area should examine the use of BL with advanced level math skills like algebra and geometry.

Finally, when designing and implementing future interventions in this area, researchers should consult the quality indicator standards for evidence based research in special education (CEC, 2014). When presenting information for peer-review and journal publication, authors should make sure to provide rich description regarding the various components of the study (i.e., context and setting, participants, intervention agent, description of practice, implementation fidelity, internal validity, dependent variables, data analysis). Based on this literature review, researchers should pay particular close attention to information about the intervention agent, implementation fidelity, and internal validity. While improving the scientific rigor of studies ultimately had positive impacts on student achievement (Bottge et al., 2010; Bottge et al., 2014; Bottge et al., 2015), having rich description of study components makes for easier replication by educators and researchers.

Conclusions

This extensive review of the literature provided some conclusions regarding the use of BL with SWD. The main take-away from this review was that there was a need for further analysis of BL on the mathematics achievement of secondary-level students with high incidence disabilities. Although BL was shown to positively impact math achievement in fraction computation, problem-solving skills, and more research is needed in other areas of math content. In addition to mathematics achievement, one area that needs more analysis is the effect of BL on the academic engagement of SWD. Additionally, no studies in this review measured teacher engagement and whether or not the teacher was more or less engaged during BL conditions. Finally, this literature review showed a preference to the station-rotation model of BL instruction.

Reference

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2 IMPROVING STUDENT ON-TASK BEHAVIOR AND TEACHER ENGAGEMENT THROUGH STATION ROTATION BLENDED LEARNING

Students with disabilities (SWD), when compared to their typically developing peers, display deficits in mathematics achievement (Cortiella & Horowitz, 2014; Wagner, Newman, Cameto, Levine, & Garza, 2006). These deficits in mathematics achievement and basic skill retention are of particular concern given their importance to academic success, high school graduation, job attainment, and independent living (Kena et al., 2015). National studies looking specifically at the mathematics performance of 8^{th} and 12^{th} grade general education students indicated that only 29% of students were performing at or above proficient grade-level standards (Kena et al.). Conversely, SWD have been reported to dramatically underperform their non-disabled peers with only 8% of students performing at or above proficiency levels (National Center for Education Statistics, 2013). In order to understand and address the growing mathematics achievement gap between SWD and typically developing students without disabilities, it is important to recognize the characteristics of SWD that directly impact their academic performance.

Students with high incidence disabilities (e.g., emotional behavior disorder [EBD], learning disabilities [LD], other health impairments [OHI], mild intellectual disability [MID]) present various social and behavioral characteristics that impede their access to general education mathematics instruction (Powell, Fuchs & Fuchs, 2013; Ralston, Benner, Tsai, Riccomini, & Nelson, 2014). This particular population of SWD display low levels of mathematics achievement due to limited strategic knowledge of concepts combined with attention and memory problems (Mattison, Hooper, & Carlson, 2006; Wagner & Cameto, 2004) as well as language difficulties (Nelson, Benner, & Cheney, 2005). Additionally, they have been shown to present lower levels of academic engagement and on-task behavior, simultaneously engaging in increased incidences of negative behavior and aggressive outbursts (Wook & Kim, 2016). Exacerbating the issue, many students with high incidence disabilities, particularly those with EBD, often struggle with comorbid conditions such as bipolar disorder, depression, oppositional defiance, and schizophrenia (Wagner, Kutash, Duchnowski, Epstein, & Sumi, 2005). In an effort to address the various social and behavioral characteristics of SWD, school systems have used alternative education schools (AES).

AES provide specialized academic and behavioral supports to students who struggle to meet the rigorous demands of the general education setting (Gagnon & Bottge, 2006; Lehr & Lange, 2003; U.S. Department of Education, 2002). These settings typically provide smaller class sizes, individual instruction, and lower student-teacher ratios (Lehr & Lange, 2003). Unfortunately, many students served in AES engage in negative behaviors that greatly diminish their access to classroom instruction. In order to meet instructional needs of SWD in AES, educators should utilize evidence-based practices that promote student academic engagement, ultimately yielding positive results pertaining to academic achievement.

Student Academic Engagement

When considering the myriad of academic deficits for students in AES, one critical issue facing these students is that they struggle with remaining on task (Lehr, Tan, & Ysseldyke, 2009). Failure to remain academically engaged can lead to negative impacts on learning and academic achievement (Lehr, Tan, & Ysseldyke; Wilkerson, Afacan, Yan, Justin, & Datar, 2016). Improving academic engagement for SWD in AES has been shown to positively impact behavior in the classroom, social relationships, academic achievement, and successful post-school endeavors (Allsopp & Haley, 2015; Dennis et al., 2016; Myers, Wang, Brownell, & Gagnon, 2015; Watt, Watkins, & Abbitt, 2016). Academic engagement is often described as cognitive investment, active participation, and emotional commitment to learning endeavors (Zepke & Leach, 2010). Non-academic skills and behaviors such as attending, compliance, and the looking at instructional material are referred to as promoting or enabling skills (DiPerna, Volpe, & Elliott). These skills can ultimately be changed and shaped using engaging instructional styles, effective methods of classroom management, and a reduction of competing stimuli. Considering the diverse academic needs of students in AES who require differentiated instruction, coupled with the growing use of online- and computer-based instruction (Gulosino & Miron, 2017; Halverson et al., 2017; Means, Toyoma, Murphy, & Bakia, 2013), it is important to understand that student engagement does not occur in a vacuum and can be directly related to the engagement of the classroom teacher.

Teacher Engagement

Researchers examining teacher engagement have found a positive relationship between the level of teacher engagement, student academic engagement, and overall achievement (Giangreco, Broer, & Edelman, 2001). Teachers who are more engaged with SWD express attitudes of high levels of ownership and responsibility for the education of those students (Giangreco, Broer, & Edelman). Additionally, teachers who display high levels of engagement are knowledgeable about their students' functioning levels across curricular areas, learning outcomes, and activities (Giangreco, Broer, & Edelman;

Klassen, Yerdelen, & Durksen, 2013; Stearns, Morgan, Capraro, & Capraro, 2012). Specifically, when tying in the principles of the social-motivational theory (Deci, Vallerand, Pelletier, & Ryan, 1991), it has been shown that students are more academically engaged when teachers display active participation and engagement in the learning environment. In an effort to identify strategies that promote positive learning environments and increase the engagement of both teachers and students, researchers have identified a variety of instructional dimensions that yield positive results for students. These strategies, known as high-leverage practices (HLP), can be implemented in the classroom to ensure that evidence-based practices are being used appropriately across content areas, grade levels, and ability levels.

Increasing opportunities to respond, and corrective feedback, are two HLP that have been linked to increased on-task behavior of students (Adamson & Lewis, 2017). A growing body of research regarding opportunities to respond (OTRs) has been strongly correlated with increased on-task behavior for students with behavior and learning difficulties (Adamson & Lewis, 2017; Haydon et al., 2010). OTRs are loosely defined as teacher-delivered (or computer-delivered) prompts that elicit a specific response from the student. Appropriate student responses can take many forms and can include, but are not limited to: choral or group response, academic probing or questioning, presentation of demands, and/or writing (or clicking) the answer to specific questions (Simonsen et al., 2008). Early efforts from the Council for Exceptional Children (CEC; 1987) reported an effective level of OTR delivery for students with high incidence disabilities at a minimum of 4 to 6 prompts per minute of instruction. In a follow-up study to the CEC findings, examining a variety of instructional strategies and student performance at the elementary level, Stichter and colleagues (2009) found that a minimum of 3.5 OTRs were needed to significantly increase student academic engagement and achievement. Considering these guidelines from the CEC and Stichter et al., researchers were then tasked with determining what types of OTRs were most effective for students with disabilities.

Two studies conducted within the last decade compared the use of three different methods of OTR with elementary school students (Haydon et al., 2010) and high school students (Adamson & Lewis, 2017) with disabilities. In the earlier study, Haydon and colleagues compared the use of individual, choral, and mixed responding conditions with six elementary-level students with behavior difficulties. Ultimately, researchers found that students displayed lower rates of disruptive behavior and higher rates of on-task behavior under the mixed response condition. Similarly, Adamson and Lewis (2017) conducted an alternating treatment design study with three high school students with behavior difficulties comparing the use of three OTR strategies: guided-notes, class-wide peer tutoring, and response cards. All OTR strategies resulted in increased time-on-task and reduced disruptive behaviors; visual analysis of student results showed that the use of response cards had the greatest impact on student outcomes. Although these findings are promising for students with disabilities, little research exists regarding the rate and types of OTR present in technology-mediated and blended learning (BL) environments.

Another HLP, which has been shown to improve the on-task behavior of students with disabilities, is the use of immediate and corrective feedback (Thurlings et al., 2013). Ultimately, the purpose of corrective instructional feedback is to provide guidance for students' learning, improve engagement, and increase academic achievement (McLeskey et al., 2017). In order for feedback to be effective, it must be (a) clearly stated in a timely manner that is specific and explains the content, (b) focuses on the interpretation of content and does not simply address misunderstandings, and (c) highlights the goal of learning and how to make progress towards that goal (Hattie & Timperley, 2007; McLeskey et al.). Extensive research has been conducted that reports the positive effects of corrective performance feedback on the academic achievement of students (Eckert, Dunn, & Ardoin, 2006; Markelz & Taylor, 2016). Eckert and colleagues examined the effects of correct and incorrect response feedback on the reading fluency of three students with LD; results indicated higher rates of achievement increase for those students who received correction with feedback when compared to correction without feedback.

Student On-task Behavior During Technology-Mediated Mathematics Instruction

One such instructional intervention that shows potential to increase on-task behavior and achievement for SWD is technology-mediated instructional (TMI) interventions (Flower, 2014; Haydon et al., 2012). Through the use of TMI such as iPads (Flower), iPad-based worksheets (Haydon et al.), computer-based and computer-assisted instruction (Wook & Kim, 2017) researchers have noted increased on-task behavior and problem-completion/fluency. Haydon and colleagues, in an alternating treatments design single case study, compared the use of iPad-based mathematics worksheets to traditional paper-and-pencil worksheets for three students with EBD in a public alternative high school. Assessing for academic engagement, fluency, and correct completion of mathematics problems, researchers found that participants showed higher rates of on-task behavior in the iPad condition (M = 98.6) compared to the traditional worksheet condition (M = 81.4). It was also noted that student accuracy in the iPad condition improved from 0.66 correct responses to 3.24 correct responses. In a follow-up analysis, Flower conducted an alternating treatments design study with three elementary-level students with EBD in an alternative therapeutic residential school. Comparing traditional independent paper-and-pencil practice to iPad enriched independent practice conditions, the researcher noted higher levels of on-task behavior for all participants during the iPad condition (increase from *M* = 32.62 % during baseline to *M* = 95.11 %). In addition to increased time-on-task for all participants, social validity responses revealed a strong preference for the iPad condition over the traditional condition for student participants and the teacher. The findings from the aforementioned studies revealed promising results regarding TMI and SWD in alternative education schools (AES); however, varying results are noted for SWD in general education settings.

Wook and Kim (2017) conducted an extensive review of 20 studies that used mobile technology and computer-based instruction for SWD (i.e., high incidence disabilities, autism spectrum disorder, developmental disabilities) in literacy, mathematics, science, and other subjects. Although strong effects were noted for participant academic achievement in mathematics, only five of the 20 studies (25%; Arthanat, Curtin, & Knotak, 2013; Bryant et al., 2015; Cumming & Rodriguez, 2013Haydon et al., 2012; Neely et al., 2013) specifically focused on academic engagement; three studies (Arthanat, Curtin, & Knotak; Bryant et al.; Haydon et al.) observed both on-task behavior and academic achievement while two studies (Cumming & Rodriguez; Neely et al.) assessed only on-task behavior. In each of these five studies, researchers were unable to identify evidence regarding the correlation between on-task behavior, task-completion, and accuracy of response. Limited findings can be drawn between the increased time-on-task for SWD and improved academic achievement in mathematics. However, promising results have been noted for SWD using TMI environments and blended learning (BL).

Blended Learning

BL is defined as a formal education program where a student learns, in part, through online or computer-based instruction with varying components of student control over time, place, path and pace; this computer-based instruction is then coupled with supervised instruction in a brick-and-mortar school building (Staker & Horn, 2012). BL is grounded in the constructivist theoretical framework. In the station-rotation model of BL students are exposed to multiple modes of instruction, engaged in diverse components of problem solving, interdisciplinary curriculum, open-ended questions, hands-on activities, group work, and interactive group activities (Bottge et al., 2014; Pace & Mellard, 2016; Staker & Horn). The station-rotation model is implemented within a given course or subject. Students rotate on a set schedule, or at the teacher's discretion, between various classroom-based learning modalities. At least one station during implementation is online- or computer-based instruction. Other classroom activities may include small-group or full-class instruction, individual remediation, paper-and-pencil assignments, or group projects (Staker & Horn).

Much of the research in the area of BL has been limited to university- and college-level courses (Xu, 2010) and the K-12 public education settings with typically developing students without disabilities (Lo & Hew, 2017). Few studies have been conducted in the last decade related to the use of various models of BL and SWD in the public school system. In a recently conducted systematic review of the literature

(Johnson, Pressley, Houchins, Varjas, Jiminez, & McKinney, 2019), 12 BL mathematics studies were identified that were conducted with SWD. Three studies (25%) assessed mathematics achievement for SWD using online- and computer-based curricula for instruction and practice (Billingsley, Scheuermann, & Webber, 2009; Haydon et al., 2012; Koedinger, McLaughlin, & Heffernan, 2010). Seven studies (58.3%; Bottge et al., 2004; Bottge et al., 2006; Bottge et al., 2007; Bottge et al., 2010; Bottge et al., 2014; Bottge et al., 2015; Saunders, Spooner, & Davis, 2018) examined the use of multimedia-based interventions and video-prompting to improve the mathematics achievement of SWD. Two studies (16.6%) utilized strategy instruction to improve mathematics achievement utilizing virtual manipulatives (Bouck et al., 2017) and computer-based graphic organizers (Sheriff & Boon, 2014). Although all four of the studies conducted by Bottge and colleagues and the analysis by Billingsley et al. observed the effects of BL models of instruction on the mathematics achievement of SWD, they failed to assess the on-task behavior of their student (or teacher) participants. Two Bottge et al. studies (2006; 2007) discussed outcomes of student motivation and academic engagement; however, results were obtained through qualitative procedures of classroom observation and informal discussions with principals and participating teachers.

Perceptions of Blended Learning

Although the use of BL has increased exponentially in the last few decades (Lo & Hew, 2017; Xu, 2010), more research is needed to determine if teachers and students perceive it as a valuable and effective method of instruction for SWD. Based on current research, three areas have emerged that can contribute to positive perceptions of technology-mediated learning environments and BL: (a) computer self-efficacy, (b) instructor characteristics, and (c) facilitating conditions (Dang, Zhang, Ravindran, & Osmonbekov, 2016). Computer self-efficacy relates to an individual's own perception of their ability to complete computer-related tasks (Rosson, Carroll, & Sinha, 2011). It has been shown that students with higher self-efficacy displayed more positive feelings about learning, expressed feelings of accomplishment, and enjoyed completing learning tasks (Roca, Chiu, & Martinez, 2006). Similarly, it has been shown that characteristics of the instructor such as timeliness of response and general attitude toward technology can positively influence the BL experience (Selim, 2007; Sun et al., 2008). These instructor characteristics can ultimately influence the students' willingness to accept the BL format as they can motivate and guide the students in this new learning modality. With respect to technology-mediated environments and the BL context, facilitating conditions include system quality, information quality, and service quality (Al-Busaidi, 2012). Facilitating characteristics of an effective BL learning model would require an effective working computer system, a program or curriculum that provides appropriate content instruction, and availability of assistance and troubleshooting when necessary.

Purpose

The primary purpose of this study was to determine if the use of station-rotation BL has an effect on the on-task behavior of students with high incidence disabilities in alternative school settings and teacher engagement. Secondary and tertiary purposes of this study were to determine the impacts of BL on teacher and student perceptions of the intervention and overall mathematics achievement for participating students. The following research questions were asked: (1) Is there a functional relation between the use of BL in mathematics and the increased level of on-task behavior for secondary-level students with behavior difficulties in alternative schools? (2) Is there a functional relation between the use of BL and increased engagement of teachers in AES during mathematics instruction? (3) Is there a functional relation between the use of BL in mathematics and improved mathematic achievement for secondary-level students with behavior difficulties in AES? (4) What are the perceptions of secondary-level alternative school mathematics teachers regarding the use of BL when compared to business-as-usual instruction? (5) What are the perceptions of secondary-level alternative school students with behavior difficulties regarding the use of BL when compared to business-as-usual instruction? Considering previous research in this area (Billingsley, Scheuermann, & Webber, 2009; Lo & Hew, 2017), it was hypothesized that station-rotation BL would have a positive effect and increase student on-task behavior and teacher engagement, improve student mathematics achievement, and improve student and teacher perceptions of BL.

Method

Setting

The study was carried out in a public K-12 therapeutic AES for SWD in an urban school district in the southeastern United States. The school provided comprehensive special education and therapeutic supports to those students who were removed from their home schools. The school provided both academic and behavioral supports to approximately 100 students who all have an Individualized Education Plans for various disability eligibilities. All students exhibited difficult behaviors that negatively affect academic engagement. This study was conducted in one middle school-level mathematics classroom. The middle school provided special education services to approximately 30 students with EBD, learning disability (LD), and other health impaired (OHI) which includes students with attention deficit hyperactive disorder (ADHD). Classrooms were usually comprised of 5-10 students, one special education teacher, and one paraprofessional.

Participants

Teacher. One middle school-level mathematics teacher was selected for participation in this study. The school administration identified potential teachers for participation in the study. The participating teachers had full or provisional certification in special education. Additionally, the teacher provided consent to participate in the study and agreed to attend a brief instructional meeting, conducted by the primary investigator, in order to learn the specific parameters of BL. Demographic data were collected for the participating teacher (see Appendix A and Table 2.1).

Students. In order to be considered for participation in this study, students met the following criteria: (a) the student had a history of mathematic difficulties as identified by the classroom teacher; (b) the student had a primary disability eligibility of EBD as identified by the classroom teacher and supported by Individualized Education Plan (IEP) documentation; (c) the student had the physical ability to independently navigate and manipulate online and computer-based technologies as identified by the classroom teacher; (d) the parent/guardian provided consent; and (e) the student provided assent. To account for potential attrition and absenteeism (Foley & Pang, 2006; Lehr et al., 2009; Wilkerson et al., 2016), five students were recruited for participation in the study. Student demographic information, provided by the classroom teacher, was collected on all participants and included: age, gender, grade level, primary and secondary disabilities, and length of time in alternative school setting (see Appendix B and Table 2.2).

Demographics. Teacher demographic data can be found in Table 2.1 and student demographic data are presented in Table 2.2. The teacher, a young African-American female, had extensive experience teaching in AES with students with EBD specifically. Her university-level training focused on instruction for SWDs traditionally found in AES. The students, who were also African-American, were all in 8th grade and were receiving special education services with the eligibility of EBD.

Design

A concurrent multiple baseline across participants study (Kazdin, 2011) was conducted. The multiple baseline across participants design lent itself to identifying a functional relation between the use of BL and increased on-task behavior, mathematics achievement, and teacher engagement. The multiple-baseline design showed the effect of an intervention when the behavior, or dependent variable, changed as the intervention was introduced; students who remained in the baseline phase did not exhibit any change in behavior until the intervention was introduced (Kazdin). At the beginning of the study, all students were in the baseline phase (receiving business-as-usual instruction) and on-task behavior data, generated by the Edgenuity program, was collected for each student for a minimum of three data points. A minimum of three data points were collected during each phase of the study for each participants in order to meet the *What Works Clearinghouse* standards for single case design (Kratochwill et al., 2013). Horizontal and vertical visual analysis of data was used to assess whether or not three demonstrations of the intervention effect were achieved. For each participant, horizontal analysis of graphs showed a change in trends between each phase (i.e., baseline, intervention, maintenance) and the observer was able to see if there was improvement between baseline and intervention and if that improvement continued during maintenance phases. Similarly, vertical analysis allowed for comparison across participants as it allowed for visual confirmation that the effects of the intervention (positive or negative) were occurring for students in the intervention phase but not for those still in baseline phase (Kazdin).

During the baseline phase of the study, all students continued to receive business-as-usual instruction in the classroom, which consisted of Edgenuity online-instruction. Student on-task behavior and teacher engagement was assessed in 10-minute increments. To ensure that one observer could collect data on all participants, each 50-minute class period was divided into three 10-minute student observations and one 10-minute teacher observation. The specific order of each observation was randomized each day, using a random number generator, in order to reduce repetitive timing of observations ultimately reducing threats to internal validity. Once a minimum of three data points were collected in the baseline phase of the study, one student was selected to move in to intervention while the other students remained in baseline. Stability in baseline data was not a requirement if the student was exhibiting negative behaviors that were impeding access to quality instruction (i.e. low levels of on-task behavior). The second student was moved into the intervention phase when the first student displayed a stable trend line over three data points. At that time, the second student was moved in to the intervention phase, the third student remained in baseline. During any given class period, three students were observed and the teacher was observed once. After three replications of the intervention effect had been noted (minimum of three data points that were higher than the baseline data), the intervention was terminated. The researchers returned after 5 days to observe maintenance data. During maintenance, instruction continued as planned and the observers monitored student on-task behavior, teacher engagement, and math achievement on Tuesday and Thursday. All three initial student participants remained in the study and completed all phases of observation.

Independent Variable:

Blended learning condition. Students used the Edgenuity program (Edgenuity Inc. n.d.) for online content instruction or through face-to-face lecture instruction from the classroom teacher. Students rotated through the following three stations: (a) computer-led content instruction, (b) teacher-led small-group instruction, and (c) independent paper-and-pencil seatwork. Each student cycled through the stages of the intervention condition in the same order during each mathematics period. The preset schedule was documented on the weekly lesson plans provided by the teacher (see Appendix C) and was available in the classroom in a lesson plan binder; observers were able to verify the specific stations being used and the content being addressed in each station. Each station lasted 15 minutes for a total of 45 minutes.

Baseline condition. During the baseline phase of the study, students continued to receive regular classroom instruction. The business-as-usual mathematics instruction in the classroom was comprised of the students using the Edgenuity online programming without a teacher rotation. Students independently navigated the curriculum based on the instructional path indicated by the program. At the beginning of the school year, students were placed in the appropriate grade-level mathematics course; their trajectory through the material was based on pre-assessments and performance on weekly lessons. All students were enrolled in their grade level math course for the given semester (e.g., 8th grade math semester A, 8th grade math semester B) and each course followed the scope and sequence of the state standards. Each individual lesson was broken down into smaller sections that included, but were not limited to: (a) introduction warm-up, (b) content instruction, (c) assignment/independent practice, (d) review, and (e) assessment quiz. During baseline instruction, the student was responsible for clicking the link for the appropriate lessons and requesting help from the teacher. The classroom teacher only provided assistance or remediation if the student made a request.

Dependent Variable:

On-task behavior. Percent of time on-task behavior was collected in two different ways: (a) on-task and idle time generated by the Edgenuity computer-based program and (b) observation of duration of on-task behavior during teacher-led and independent practice stations. On-task behavior was collected during all phases of the study (i.e., baseline, intervention, maintenance) at the same time every day and marked on a researcher-created data-tracking sheet (see Appendix D). During the teacher-led small group instruction station, on-task behavior was operationally defined as (a) the student remained in the designated area during instruction (designated area was defined as the area within the classroom where the teacher-led instruction was occurring), (b) the student read or wrote the appropriate lesson material, and (c) the student provided content-specific responses to opportunities to respond from the teacher when prompted. Additionally, during the independent practice station, on-task behavior was defined as (a) student was reading or writing appropriate materials related to the activity/assignment and (b) student remained in the designated area (area within the classroom where the independent practice was occurring). Duration of response (Kazdin, 2011), conducted over 10-minute sessions for each student, was used to determine the total number of minutes and seconds of on-task behavior for each participating student. On-task behavior was collected in 10-minute segments in baseline during the regularly-scheduled mathematics class. In order to calculate percentage of time on-task during baseline, the total amount of time on-task was divided by 10 minutes and multiplied by 100. During intervention, on-task behavior was observed for 7-minute sections in the teacher-led and independent stations, which were combined with 15-minute computer-based on-task behavior. During intervention, percentage of time on-task was calculated with a total amount of 22 minutes. Observers monitored the student during the lesson and kept a running timer as long as the student was displaying on-task behavior; the timer was paused when and if the student was off-task and continued running the timer when the student was again showing on-task behavior. The means and standard deviations were calculated for each student during all phases of the study using statistical analysis software (e.g., Microsoft Excel, SPSS). Using methods of calculating effect sizes in single case design studies (Parker & Vannest, 2009; Pustejovsky, 2015), the calculation of non-overlap of all pairs (NAP) was carried out by the primary investigator. NAP was determined by comparing pairs of data between different phases. NAP was the percent of all pairs where treatment phase improves over baseline and ties count as 0.5 (Pustejovsky, 2015).

Teacher engagement. Teacher engagement was assessed during all three phases of the study. A researcher-created observation tool was used to determine the level of teacher engagement during instructional periods. Teacher engagement included a frequency count of opportunities to respond and corrective feedback. Opportunities to respond were defined as a presentation of a verbal or physical stimulus, prompting a student for a response (Adamson & Lewis, 2017). Additionally, corrective feedback was based on the opportunities to respond chain of command (presentation of a prompt or stimulus to respond, student provides response, teacher provides verbal praise or feedback regarding the accuracy of response). Corrective feedback included any act of providing student with feedback, verbal or physical, regarding their performance on assignment or activity (must have been in response to a student response or answer) and the response from the teacher must have been correct. When corrective feedback did not include the full chain of events, they were not counted as instances of corrective feedback. Teacher engagement was assessed using frequency-counting methods (Kazdin, 2011) in 10-minute intervals during baseline and 7-minute intervals during intervention using a researcher-created data tracking sheet (see Appendix D).

Mathematic achievement. AIMSweb math probes were used to assess for growth in mathematics achievement. Math achievement was assessed using the AIMSweb Math Concepts and Applications (M–CAP; see Appendix E); a brief, standardized test of math operations that are part of the typical curriculum at Grades 1 through 8, with national norms for Grades 1 through 12. Reliability coefficients of the M-CAP from first grade through eighth grade, using a norm referenced sample of 6,550 students, ranged from 0.97 to 0.99. Criterion validity, when compared to End of Grade standardized assessments, were also very high $r(295) = 0.660$, $p < .01$ (Pearson, 2012). M-CAP probes assessed numbers, operations, algebra, geometry, and linear equations. Probes could be administered individually, small-group, or whole class and take 8 minutes for administration. Math probes were administered by the primary investigator every Tuesday and Thursday. Each student was first administered eighth grade math probes to determine their instructional level. If students scored at the frustration level (grades 2-3 scores less than 14; grades 4-5 scores less than 24; grades 6+ scores between 0 and 19), they were then administered probes at the lower grade level. Lower grade level probes were administered until instructional level was determined (grades 2-3 scores between 14 and 31; grades 4-5 scores between 24 and 49; grades 6+ scores between 20 and 39). Students took grade-level M-CAP math probes at their own instructional level. Based on preliminary norms, the expected realistic weekly growth on math probes for grades 1, 2, and 3 would be 0.30 digits; 0.45 digits for grade 6; and 0.70 digits for grade 4 and 5 (Fuchs & Fuchs, 1993). The principal investigator (PI) administered the probes at the end of the class session on Tuesdays and Thursdays and each student had 8 minutes to complete each probe.

Social Validity. In order to determine the teacher perceptions of BL after the intervention, the participant were asked to complete a brief questionnaire (see Appendix F) pertaining to the areas of computer self-efficacy, instructor characteristics, and facilitating conditions (Dang, Zhang, Ravindran, & Osmonbekov, 2016). The teacher questionnaire contained the following questions, which were answered using a 5-point Likert scale: (1) How comfortable do you feel in using the computer for instruction? (2) Can you use the Edgenuity system effectively? (3) Are you excited to be using BL methods in your classroom? (4) Do you feel that you are able to respond to student questions and concerns in a timely manner? (5) Do you have appropriate technology that works? (6) Do you feel that the content instruction through the Edgenuity curriculum is appropriate for your students? (7) How likely are you to continue using BL in your classroom?

Similarly, the student participants were administered a questionnaire (see Appendix G) after the intervention, pertaining to their perceptions and understanding of BL in the areas of computer self-efficacy, instructor characteristics, and facilitating conditions (Dang et al., 2016). Using a 5-point Likert scale, students responded to the following questions: (1) Do you feel comfortable using the computer for school-based learning? (2) Do you feel successful when completing lessons on the computer? (3) Does your teacher have a positive attitude towards computers and computer-based instruction? (4) Does your teacher respond quickly to questions you have while using Edgenuity? (5) Do your classroom computers work well? (6) Do you feel that the lessons on Edgenuity are effective in teaching you new material?

Treatment fidelity. Researchers assessed treatment fidelity to ensure that implementation matched the design of the intervention condition (Dane & Schneider, 1998). A researcher-created checklist (see Appendix H) was used to measure adherence to intervention implementation and exposure of the intervention components. Exposure data was collected to ensure that the predetermined parameters of the intervention were carried out (e.g., duration of classroom lessons, correct students in each condition, lesson content matched the weekly lesson plan). During the BL condition, observers monitored whether or not the teacher was using the appropriate stations (i.e., teacher led small group, computer-led instruction, independent seat work).

Interobserver agreement. During the three phases of the study, the PI and one additional researcher conducted IOA (Brittle & Repp, 1984; Kratochwill et al., 2013) on 30% of observations in regards to student on-task behavior, teacher engagement, and implementation fidelity. Prior to the start of the study, the PI provided a brief training to the additional researcher concerning the operational definitions of on-task behavior, teacher engagement, and implementation procedures. Observation IOA schedule was predetermined based on the schedule of the additional researcher to ensure that 30% of sessions were observed together across all phases of the study.

Procedures

Approval to conduct the research study was collected from both the university Institutional Review Board and the school system administration prior to the implementation of the intervention. The school administration identified potential teacher candidates for participation in the study; the PI spoke with potential teacher candidates and described the parameters of the intervention study. After the participating teacher had provided consent for participation, they worked with the PI to identify students in their mathematics class that met the inclusion criteria for the study. The PI met with all potential student participants individually during their homeroom period and discussed the intervention that was to be carried out. The first five students who returned signed assent forms and signed parental consent forms were selected for participation in the study.

Teacher training. The PI provided the participating teacher with a 1-hour training session on the station rotation BL model of instruction prior to the baseline phase of the study. The teacher and the PI went over the BL manual (Staker & Horn, 2012) and covered specific material about the station-rotation model. The teacher and the PI discussed the parameters of each of the intervention condition stations (i.e., baseline teacher-led small-group instruction; intervention condition including computer-led content instruction, independent paper-and-pencil seatwork) to ensure that the teacher knew what each condition looked like for each day of instruction. Additionally, the teacher and the PI navigated the Edgenuity program (Edgenuity Inc. n.d.) to verify that the teacher knew: (a) how to log in to the system, (b) how to track student progress and to observe results of embedded assessments, and (c) how to override student lessons and to move students ahead/back to specific lessons. In addition to Edgenuity program (Edgenuity Inc. n.d.) knowledge, the teacher and the PI went over the weekly lesson plan summaries (see Appendix C) that were to be completed by the teacher. The teacher was responsible for providing their regularly created lesson plans as well as documenting the type of face-to-face lectures to be used, which students were in baseline and intervention phases of the study, and the general plan for rotation between stations. The PI checked the weekly lesson plans to ensure that the teacher was aware of the students that were moving between baseline and intervention phases. The teacher and the PI practiced creating a weekly lesson plan for the intervention phase of the study. Finally, the training addressed possible high-leverage practices and strategies that could be used with SWD (see Appendix I).

At the end of the training session, the PI administered an assessment to the teacher to verify that the contents of the training session were mastered. The assessment (see Appendix J) contained definition questions pertaining to the appearance of the station rotation model of BL, the specific intervention conditions that were to be used in the classroom during the study, appropriate completion of the weekly lesson plan summaries, and navigation of the Edgenuity program (Edgenuity Inc. n.d.). Components of the training were addressed and retaught with the teacher until they were able to score 100% on the assessment.

Student training. The PI met with the students for a brief 30-minute training session to ensure that they were able to independently navigate the Edgenuity program (Edgenuity Inc. n.d.). The students were assessed as to whether or not they could independently turn on the computer, login to their Edgenuity program account, select the appropriate coursework for the day, and appropriately click responses and answers when prompted by the program. The PI marked each student as pass or fail using a researcher-created checklist (see Appendix K). Students received independent remediation until they were able to receive 100% on the assessment checklist as determined by the PI.

Interobserver training. One additional personnel member, familiar with special education research, was trained to perform IOA procedures. The PI trained the additional researcher on the study design and the methods of observing student on-task behavior and teacher engagement. Both researchers discussed how to use two timers in order to time each 10-minute segment and to collect duration data for the observed behavior. Both researchers discussed the operational definitions of on-task behavior and engagement. In addition to the on-task behavior and teacher engagement observations, the additional researcher was responsible for collecting fidelity of implementation data. The PI and additional researcher discussed the parameters of each condition including the specific stations used in the BL condition. After training, the additional researcher completed a short quiz (see Appendix L) verifying that they were familiar with the definitions and the parameters of the intervention conditions. Once they had achieved 100% on the quiz, both researchers conducted a practice observation day in the classroom. Observations were repeated until a minimum of 90% agreement was met for student and teacher observations and implementation fidelity; 95% agreement was reached during the first classroom observation.

Baseline. Prior to collecting data in the baseline phase, the PI administered various grade-level AIMSweb probes to each participant until instructional level scores were obtained; students were then administered instructional level probes for the duration of the study.

During the baseline phase of the study, students entered their mathematics classrooms and participated in business-as-usual mathematics instruction. Students participated in mathematics content instruction and practice through the Edgenuity online curriculum. During the baseline phase of the study, the PI and one additional researcher collected data pertaining to the following dependent variables in 10-minute intervals: on-task behavior and teacher engagement. For all observational data assessments, the additional researcher was responsible for conducting IOA on at least 30% of all data points. The mathematics achievement probes were administered to the students twice a week, once on Tuesday and once on Thursday (avoiding Mondays and Fridays as these tend to be days with high levels of absenteeism in AES).

Each student had, at minimum, three data points of on-task behavior in the baseline phase. Through visual analysis of dependent variable outcomes, the first student participant was ready for the intervention phase of the study after three data points when data revealed a stable trend which necessitated the need for intervention (low trend line of on-task behavior; Horner, Swaminathan, Sugai, & Smolkowski, 2012). The remaining participants stayed in baseline until the student in the intervention phase displayed improvement over a minimum of three data points. Once a stable trend line was established in the intervention phase, the next student was moved in to intervention; this process was continued until all student participants were moved in to intervention.

Intervention. Once the student moved in to intervention, the teacher used the BL station-rotation model of instruction to provide content instruction and supplemental/independent practice. The students cycled through the stations (i.e., computer-led content instruction, teacher-led small-group instruction, independent paper-and-pencil seatwork) on a predetermined schedule. The students remained in each of the three stations for 15 minutes; at the conclusion of the 50-minute class period the student had cycled to all three stations. During the intervention phase of the study, the PI and one additional researcher observed student on-task behavior and teacher engagement in 7-minute increments during the teacher-led and the independent practice stations. Additionally, the PI administered the AIMSweb mathematics probes to the student on Tuesday and Thursday of each week. Once the student displayed a stable trend line with a minimum of three data points of on-task behavior (Kratochwill et al., 2013), the next student was moved from baseline to intervention. Student participants remained in intervention until the third student showed progress over baseline; the study was terminated for all three students once the third student displayed growth over baseline.

Maintenance. One week after the completion of the intervention phase of the study, the PI returned to the class to collect two additional data points of on-task behavior for each participating student. Two data points of teacher engagement were also collected during this time. Observational recording were similar to that during the intervention phase of the study; students and teacher were observed for 7-minute segments during teacher-led and independent practice combined with 15-minute computer generated times.

Results

On-task Behavior. Analysis of on-task behavior graphs, and the comparison of mean scores within and across each phase, revealed a functional relationship between the use of blended learning and on-task behavior across all three participants. Table 2.3 summarizes the mean scores, standard deviations, and PND for each student during both phases of the study. During baseline phase (i.e., business-as-usual), Tamla's on-task behavior ranged from 43.5% to 60.5%. Once in intervention, Tamla's on-task behavior ranged from 65% to 88%. Unicorn's on-task behavior ranged from 36% to 51.7% in the baseline phase of the study. Finally, Justice's on-task behavior ranged from 29.6% to 55% in baseline and 56% to 66% in intervention. Using horizontal visual analysis, it is apparent that all three students exhibited an increase in the level of on-task behavior when comparing baseline to intervention phases. Additionally, two students (Unicorn and Justice) exhibited decreasing trends in baseline and all three students showed increasing trends during intervention (See Figure 2.1). Furthermore, two students (Tamla and Justice) displayed high levels of variability in their baseline data; their on-task behavior stabilized with increasing trends once they were moved in to intervention.

Teacher Engagement. Figure 2.2 shows the frequency of opportunities to respond and corrective feedback provided by the teacher during each phase of the study. While in baseline, the teacher relied solely on computer-based instruction thus resulting in zero instances of opportunities to respond or corrective feedback. When one student was placed into intervention, OTRs ranged from 9 to 11 instances and corrective feedback ranged from 5 to 6 instances. When two students were present in intervention, OTRs ranged from 7 to 10 instances while corrective feedback ranged from 5 to 7. Finally, when all three students were receiving instruction, OTRs ranged from 6 to 8 instances and corrective feedback was between 4 and 6. When looking at the mean scores across all three intervention conditions, we can see a slight decrease in OTRs as more students are added to the intervention group; the instances of corrective feedback remained relatively the same throughout.

Math Achievement. Regarding math achievement, the findings from the AIMSweb CBM probes revealed a positive impact related to the type of instruction for two out of three participants. Fuchs and Fuchs (1993) reported realistic expected weekly growth on math curriculum based measurements; weekly rates of improvement (ROI) for the AIMSweb M-CAP probes were 0.25 for grade 2, 0.25 for grade 3, and 0.14 for grade 4 ("AIMSweb Benchmark Targets," 2012). After pretesting for instructional level, it was determined that Tamla was at the second grade instructional level. During the baseline phase of the study, his average AIMSweb score was 10; his average score during intervention was 11 points (overall improvement 1.0). Given the overall study duration of three weeks, we would have expected to see an increase of 1.08 (0.36 ROI x 3 weeks = 1.08). Unicorn, on the other hand, pretested at the fourth grade instructional level; her scores from baseline to intervention increased from an average of 20 to 28 (overall improvement 8.0). After three weeks in the study, her expected increase would have been 0.42 (0.14 ROI x 3 weeks = 0.42), which she exceeded. Finally, at the third grade instructional level, Justice improved his average scores from 22 in baseline to 24 in intervention (overall improvement 2.0); his expected growth was 0.75 (0.25 ROI x 3 weeks = 0.75).

Social Validity. At the end of the study, the participating teacher completed a social validity questionnaire, which consisted of seven questions with 5-point Likert-type scale responses ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). Table 2.4 shows the teacher's answers to each of the questions. Her highest scores were found in questions related to her willingness to continue using BL in the classroom and her overall comfort with using the Edgenuity system; her lowest scores were in response to questions about whether or not the classroom had appropriate technology for BL implementation and if the content instruction through the Edgenuity system was appropriate for her students.

Similarly, all three participating students completed a social validity questionnaire, which consisted of six questions with 3-point Likert-type scale responses ranging from 1 (*strongly disagree*) to 3 (*strongly agree*). Average responses to each social validity question can be found in Table 2.5. The highest scores from the students related to questions about their comfort levels using the Edgenuity and computer-based systems and if the Edgenuity system was effective in content instruction. On the other hand, their lowest reported scores were in response to questions about the time it took for the teacher to respond to their computer-based problems or if the computer technology worked well in the classroom.

Fidelity. Interobserver agreement was collected during on-task behavior observations, teacher engagement observations, and math achievement probes. During student on-task behavior IOA was 93%, IOA during teacher engagement observations was 96%, and AIMSweb probe grading was 100%.

Discussion

The purpose of this study was to determine if the use of station-rotation BL had an effect on the on-task behavior of students with high incidence disabilities and teacher engagement in an alternative school. Additionally, we wanted to see if the use of BL had an impact on the mathematics achievement of SWDs. Finally, we wanted to look at social validity by assessing teacher and student perceptions of BL after implementation.

Regarding the first research question pertaining to whether or not there was a functional relation between the use of BL and increased on-task behavior for students, results of the study found that there was a functional relation between BL and on-task behavior. These findings were consistent with prior research in the area of BL (Bottge et al., 2006; Bottge et al., 2007) in that it can be an effective strategy to increase the on-task behavior of SWDs in math. Furthermore, studies that utilized the station-rotation model of BL (Bottge et al., 2014; Pace & Mellard, 2016) saw significant improvements of student on-task behavior. Much like the findings from previous literature reviews (Means, Toyama, Murphy, & Bakia 2013; Means, Toyama, Murphy, Bakia, & Jones, 2009), students were much more engaged with the lesson when there was a combination of computer-based instruction, face-to-face instruction, and independent practice.

Similar to previous findings (Means, Toyama, Murphy, Bakia, & Jones, 2009), results from this study provided evidence against using only computer-based curricula to provide instruction to SWDs. Studies in BL and hybrid courses have reported that students feel a greater sense of community with classmates and teachers when compared to purely online conditions (Chavis, Hogge, McMillan, & Wandersmann, 1986). Students have reported that being connected to their peers is the most important aspect of developing a sense of community (Wighting, 2006). During the baseline phase of the study, students were independently using the computer and had little interaction with peers or the participating teacher. During intervention, the students were in teacher-led instruction condition with other students. Additionally, during the independent practice condition, the teacher was walking around and providing assistance and feedback to each student. Student engagement increased when they were able to interact with the teacher and with other students.

Another potential reason for limited student engagement during online instruction might have been a lack of interest in the material being presented. Online curricula are designed typically without individual student interests in mind. Students are more likely to be engaged in content instruction when it aligns with their interests and personal strengths (Barbour & Reeves, 2009; Halverson et al., 2017). Specifically looking at K-12 online synchronous instruction, Yong and Ping (2008) found that students were not intrinsically motivated to participate in online learning games or learning activities. Additionally, they needed continuous prompting from the teacher in order to remain engaged with the online material. When examining the Edgenuity lessons that the students were using, the material was presented using simple mathematic language and examples. Based on student feedback, the Edgenuity lectures did not include any themes or activities that would captivate their attention. However, during the teacher-led and independent practice conditions of this study, the teacher incorporated word-problems and activities that were aligned with the student interests (e.g., video games, basketball). Student on-task behavior improved during the teacher-led and independent practice conditions.

During this intervention study, teacher engagement improved under the BL condition. Although previous research does not explicitly state that BL improves teacher engagement, there is evidence that supports that increasing OTR (Adamson & Lewis, 2017; Haydon et al., 2010) and corrective feedback (Hattie & Timperley, 2007; McLeskey et al., 2017; Thurlings et al., 2013) can result in increased student on-task behavior and academic achievement. During the training session, the participating teacher was provided examples of effective instructional components that included OTR and corrective feedback. The chance to engage in effective instruction increased when the teacher pulled the students off the computer for teacher-led and independent practice conditions. Although the rate of OTRs did not reach the recommended 3.5 instances per minute (Stichter et al., 2009), it was evident that even minimal increases of OTR had an immediate impact on the on-task behavior of SWD who participated in this study. During the teacher-led and independent practice stations, the students received more interaction form the teacher in the form of OTRs and corrective feedback.

Although not specifically addressed by research regarding OTR, previous findings have shown that classroom engagement decreases in larger classrooms (Blatchford, Bassett, & Brown, 2011). Looking specifically at the amount of academic instruction provided by the teacher in special education classrooms for students with EBD, results showed a higher percentage of time for instruction during individual instruction when compared to group instruction (Van der Worp-van der Kamp, Bijstra, Pijl, Post, & Minnaert, 2018). Of interesting note, OTR decreased as each student was added to the intervention; these findings imply that teachers may be able to provide better instruction with individual students at different times as opposed to all students at the same time.

When available, teachers can also utilize co-teachers or classroom paraprofessionals to oversee different stations (Giangreco, Broer, & Edelman, 1999; Giangreco, Broer, & Edelman, 2001), thus reducing the teacher-to-student ratio in each station. Within each classroom, teachers need to identify the correct balance between teacher-led instruction, CBI, and independent practice.

The third research question focused on whether or not there was a functional relation between the use of BL in mathematics and improved mathematic achievement for secondary-level students with behavior difficulties in AES. There were mixed findings regarding the functional relation between the mathematics achievement of secondary-level students and the use of BL instruction. Two students exceeded expected weekly growth and one student was very close to meeting that expectation. These results are consistent with prior research (Bottge et al., 2004; Bottge et al., 2006; Bottge et al., 2007; Bottge et al., 2010; Bottge et al., 2014; Bottge et al., 2015), which found that BL could positively impact the mathematics achievement of SWDs. Although student scores increased, they were only assessed over the course of three weeks. It would be interesting to see if the growth rate remained consistent over a greater amount of time.

Additionally, the students were completing AIMSweb probes at their own personal instructional grade levels; however, their content instruction was implemented at the eight-grade level. The Edgenuity system was being used to deliver grade-level content instruction and was not used for skill remediation. Although improving basic computation fluency has been linked to better performance on advanced skills (Fuchs et al., 2014; Powell & Fuchs, 2014), students who are not able to automatically retrieve basic computation facts may still struggle with more complex procedures. Building fluency and automaticity requires practice and prolonged exposure; in order to see higher gains on math probes, teachers may consider carrying out BL interventions over the course of a full semester or a full year.

This study looked specifically at teacher and student perceptions of BL (see Table 2.4 and 2.5 for individual item responses and means). Mirroring prior research in the area (Rosson, Carroll, & Sinha, 2011), findings from the social validity questionnaires revealed that higher ratings of computer self-efficacy corresponded to higher rates of confidence in completing the computer-based instruction. Regarding timeliness of teacher response (Selim, 2007; Sun et al., 2008), it was interesting to note that the teacher indicated that she felt confident that she was providing feedback in an appropriate amount of time; however, the students reported unsatisfactory ratings for the teacher's response time. According to McLeskey and colleagues (2017), feedback from the teacher should be tied to specific learner goals, should be timely, and should address steps needed for content mastery. One potential reason for the variation in response between the teacher and the students would be a lack of structure or expectation that is agreed upon by the teacher and the students. The student responses regarding timeliness of feedback were related to the CBI condition specifically; teachers (and paraprofessionals where available) should monitor student CBI performance and provide corrective feedback when appropriate. All participants could benefit from discussing the feedback expectations before starting the intervention.

Prior research also stressed the importance of system quality and working technology for BL implementation (Al-Busaidi, 2012). When looking at all of the factors that contribute to effective BL implementation (i.e., learner, instructor, technology, classmate, course, organization), there are three characteristics that made up the technology component: (a) system quality, (b) information quality, and (c) service quality (Al-Busaidi). System quality, including accessibility and ease of use were significantly linked to successful BL implementation (Al-Busaidi; Levin et al., 2013). In this study, although technology was appropriate for use during this study, there were concerns related to outdated monitors with dull color and slow Internet connection. Anecdotal observations and findings from this questionnaire revealed that both the teachers and the students agreed that the current technology was not in optimal condition for the purpose of instruction.

Limitations and Future Directions

The first limitation in this study specifically pertained to the measurement of on-task behavior during the computer-based instruction phase. Although specific criteria were used to measure on-task behavior during teacher-led and independent practice stations, we relied solely on the Edgenuity program report of student engaged time and idle time. Idle time from the program simply measured the latency time between presentation of material and when the student clicked a response. However, the computer program was not able to discern the particular reason for delay; the program was not able to tell whether or not the student was taking time to think or working on problems using paper and pencil. Future research in this area may seek to combine computer-generated engagement time with observable and measurable characteristics. Classroom observations of CBI conditions could be conducted to assess whether or not the student is truly off-task or if they are actually engaged with the work. This data could be used to validate the accuracy of the computer-generated idle time reports.

Similarly, another limitation of this study was the method of calculating percentage of on-task. During baseline, the total number of minutes observed for each participant (students and teacher) was 10 minutes. However, once in intervention, students were observed for a total of 22 minutes (15 minutes on the computer and 7 minutes in teacher-led or independent practice station) and the teacher was observed for 7 minutes. Although percentage of time on-task was being calculated for the students, the total number of minutes was greater during intervention when compared to baseline. By increasing the total number of minutes during intervention, the overall percentage of time on-task could have been deflated. Future research in this area should measure time on-task consistently across phases, ensuring that the total number of minutes is the same in baseline and intervention phases.

Another limitation to this study was the use of AIMSweb math probes to measure math achievement. Although the probes were administered at each student's instructional level, one student showed minimal gains after exposure to the intervention condition. One potential reason substantial growth was not seen could be related to the amount of time students were exposed to intervention. The total study only lasted four and half weeks over 21 sessions. Future research in this area may want to increase the exposure time and allow students to develop skills that will ultimately impact their math achievement scores. On the other hand, skills that were being taught during computer-based instruction and during the teacher-led component were on the 8th grade level. Significant growth may have been seen if the probes directly reflected the material that was taught. Researchers may want to create their own probes that measure the skills that were taught during instruction.

The last limitation of this study was specific to the social validity questionnaires that were administered to the students and the teacher. Although the results of the questionnaires provided insight into the perceptions of BL, the questionnaire was not administered as a pretest before the study. If researchers were to replicate this study, the questionnaire should be administered as a pretest and posttest in order to quantify a change in perception after using the BL intervention.

Conclusion

The station-rotation BL model of instruction is intended as a strategy to increase the on-task behavior of SWDs with behavior difficulties. BL gives teachers the ability to break up the monotony of everyday instruction by personalizing and differentiating instruction. Furthermore, station-rotation BL provides multiple modes of instructional delivery to ensure that students are exposed to high quality instruction. Previous research reported that on-task behavior of SWDs would increase under the BL condition (Bottge et al., 2006; Bottge et al., 2007); more specifically, the station-rotation BL format had positive impacts on math achievement and student on-task behavior (Bottge et al., 2014; Pace & Mellard, 2016). Although a functional relation was noted for students on-task behavior and BL, more work is needed to establish a correlation between math achievement and BL. Additionally, we can see that the use of BL promotes greater engagement on the part of the teacher; however, strategic planning is required when multiple students are present in the teacher-led station to ensure that the appropriate frequency of OTRs and corrective feedback. Ultimately, barring ineffective technology, the teacher and students reported positive perceptions of BL for math instruction.

Through further research, BL can emerge as a trusted strategy to increase the on-task behavior and math achievement of SWD.

Table 2.1
Teacher Demographics

	Teacher 1
Sex	Female
Racial/Ethnic Group	African American
Grade Teaching	6th – 8th
Years Teaching	12
Years in AES	6
Years in Education Setting	12
Highest Level of Education	Masters
Current Certifications	Special Education. K-12

Table 2.2
Student Demographic

Student Name	Sex	Racial/Ethnic Group	Grade	Age	Disability
Tamla	M	AA	8^{th}	14	EBD
Unicorn	F	AA	8^{th}	15	EBD
Justice	M	AA	8^{th}	14	EBD

Note: AA= African American; EBD= Emotional Behavioral Disorder

Table 2.3

Means, Standard Deviations, and PND of On-Task Behavior

	Baseline		Intervention		
Student	Mean	SD	Mean	SD	NAP (%)
Tamla	53.8	6.4	81.2	6.2	100
Unicorn	42.5	5.1	71.2	12.4	90
Justice	41.7	7.8	60	3.3	100

Note. SD = Standard Deviation; NAP = Non-overlap of all pairs statistic

Table 2.4
Social Validity Teacher Responses

Question	Teacher Response
1. How comfortable do you feel in using the computer for instruction?	5
2. I can you use the Edgenuity system effectively.	5
3. I am excited to be using Blended Learning methods in my classroom.	4
4. Do you feel that you are able to respond to student questions and concerns in a timely manner?	4
5. I have appropriate technology that works for Blended Learning implementation.	1
6. I feel that the content instruction through the Edgenuity curriculum is appropriate for my students.	2
7. I am likely to continue using Blended Learning in my classroom.	4

Table 2.5
Social Validity Item Responses

Item	Tamla	Unicorn	Justice	Mean
1. Do you feel comfortable using the computer for school-based learning?	2	3	3	2.66
2. Do you feel successful when completing lessons on the computer?	1	2	2	1.66
3. Does your teacher have a positive attitude towards computers and computer-based instruction?	2	2	2	2
4. Does your teacher respond quickly to questions you have while using Edgenuity?	1	1	1	1
5. Do your classroom computers work well?	1	1	1	1
6. Do you feel that the lessons on Edgenuity are effective in teaching you new material?	2	2	2	2

Figure 2.1

Percentage of On-Task Behavior for Students Across Conditions

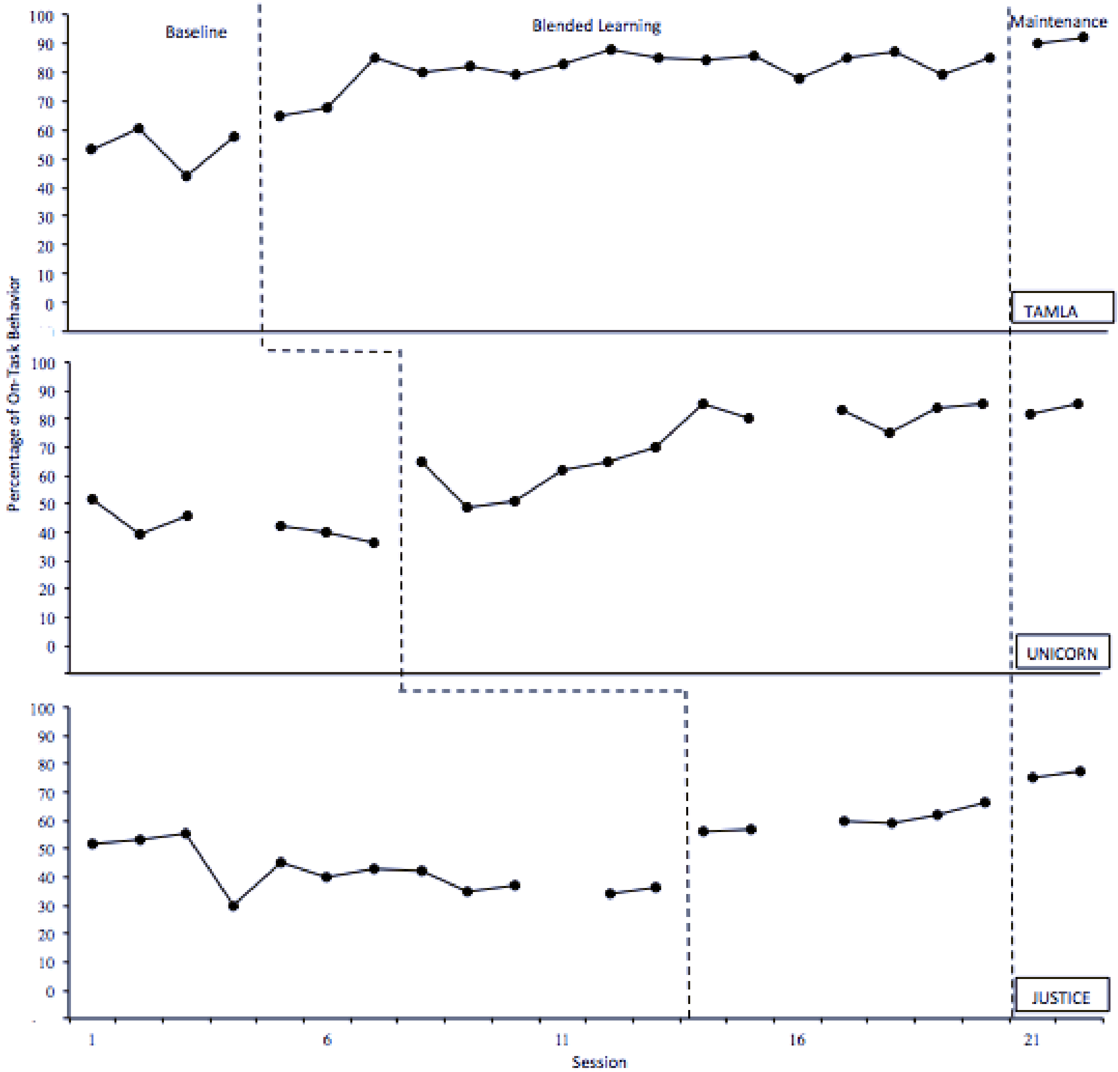
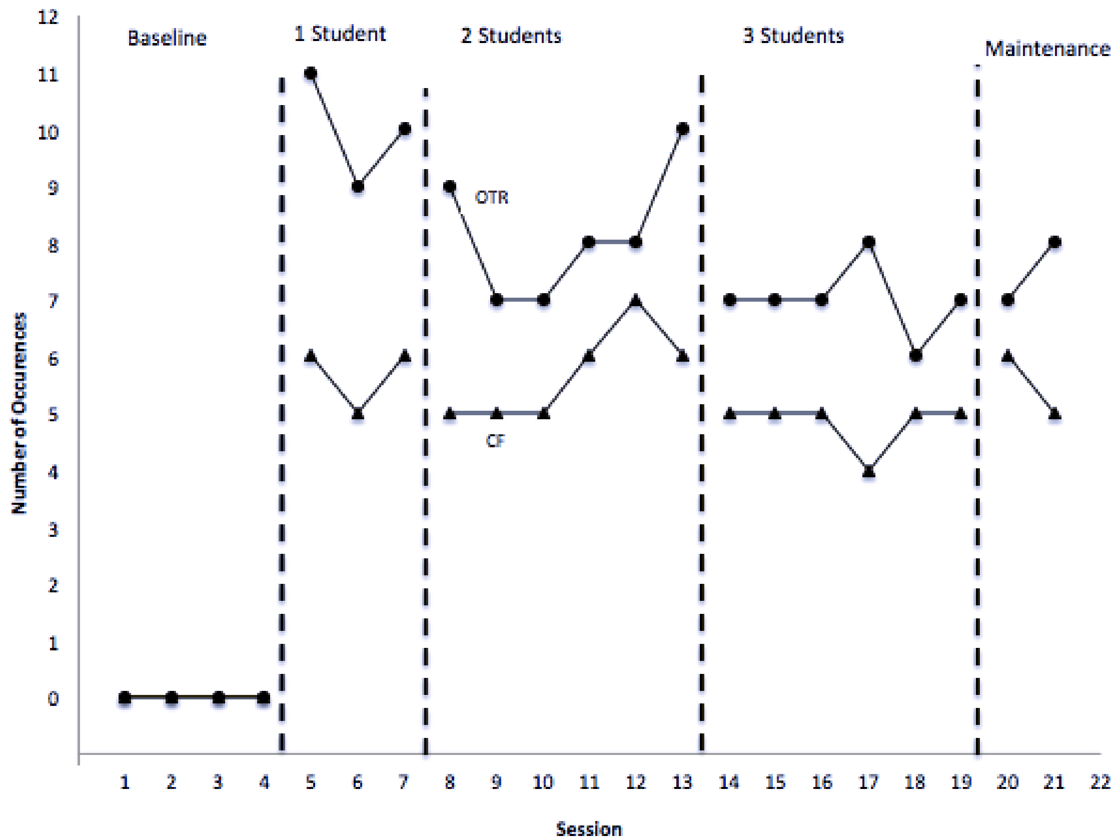


Figure 2.2

Frequency of Opportunities-to-Respond and Corrective Feedback



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APPENDICES

Appendix A

Teacher Demographics

Directions: Please CIRCLE ALL answers directly on this form.

1. What is your sex? Circle only <u>ONE</u> answer.

   A. Female   B. Male

2. What is your racial/ethnic group? Circle only <u>ONE</u> answer.

   A. American Indian   B. Black/African American   C. Hispanic

   D. Asian   E. White/Caucasian   F. Multi racial/ethnic

3. What grade are you currently teaching? Circle all that apply.

   A. 6th   B. 7th   C. 8th   D. 9th   E. 10th   F. 11th

   G. 12th

4. How many years have you been teaching? Circle only <u>ONE</u> answer.

A. 1 – 5   B. 6 - 10   C. 11 - 15   D. 16 -20   E. 21 - 25
F. 26 – 30   G. 31 or more

5. How many year`s have you been teaching in an AES? Circle only <u>ONE</u> answer.

A. 1 - 5   B. 6 - 10   C. 11 - 15   D. 16 -20   E. 21 - 25
F. 26 – 30   G. 31 or more

6. How many years have you worked in an alternative educational setting? Circle only <u>ONE</u> answer.
A. 1 - 5   B. 6 - 10   C. 11 - 15   D. 16 -20   E. 21 - 25
F. 26 – 30   G. 31 or more

7. How many years have you worked with students with disabilities? Circle only <u>ONE</u> answer.
A. 1 - 5   B. 6 - 10   C. 11 - 15   D. 16 -20   E. 21 - 25
F. 26 – 30   G. 31 or more

8. What is your highest level of education? Circle only <u>ONE</u> answer.

A. Bachelors   B. Masters   C. Specialist   D. Doctoral

9. In what areas do you currently hold a teaching certificate (i.e. Special Education, Middle School Science etc.)

____

Appendix B

Student Demographics

Directions: Please CIRCLE ALL answers directly on this form.
Student Name______________________________

1. What is the student's sex? Circle only ONE answer.

   A. Female   B. Male

2. What is the student's age in years? Circle only ONE answer.

   A. 13   B. 14   C. 15   D. 16   E. 17   F. 18

   G. 19   H. 20   I. 21

3. What is their racial/ethnic group? Circle only ONE answer.

   A. American Indian   B. Black/African American   C. Hispanic

   E. Asian   E. White/Caucasian   F. Multi racial/ethnic

4. In what grade is the student currently enrolled? Circle only ONE answer.

   A. 6^{th} B. 7^{th} C. 8^{th} D. 9^{th} E. 10^{th} F. 11^{th}

   G. 12^{th}

5. What is the primary special education eligibility for the student? Circle ONE answer.

   A. EBD   B. LD   C. OHI   D. MID

Appendix C

Weekly Lesson Plans

Teacher:_______________________________
Date Range:____________________________
Standard(s):____________________________
Students in Baseline:___________________
Students in Intervention:_________________

Monday	Tuesday	Wednesday	Thursday	Friday
If blended learning used, check the type of teacher-led instruction used. Check all that apply. ○ EI ○ Modeling ○ Manipulatives ○ EIR ○ Choice-making ○ Functional tasks ○ Shortened assignments ○ EAI ○ Other__________	**If blended learning used, check the type of teacher-led instruction used. Check all that apply.** ○ EI ○ Modeling ○ Manipulatives ○ EIR ○ Choice-making ○ Functional tasks ○ Shortened assignments ○ EAI ○ Other___________	**If blended learning used, check the type of teacher-led instruction used. Check all that apply.** ○ EI ○ Modeling ○ Manipulatives ○ EIR ○ Choice-making ○ Functional tasks ○ Shortened assignments ○ EAI ○ Other____________	**If blended learning used, check the type of teacher-led instruction used. Check all that apply.** ○ EI ○ Modeling ○ Manipulatives ○ EIR ○ Choice-making ○ Functional tasks ○ Shortened assignments ○ EAI ○ Other____________	**If blended learning used, check the type of teacher-led instruction used. Check all that apply.** ○ EI ○ Modeling ○ Manipulatives ○ EIR ○ Choice-making ○ Functional tasks ○ Shortened assignments ○ EAI ○ Other___________
Activating Strategies (Content/Process) ○ Teacher-led ○ Edgenuity ○ Independent	Activating Strategies (Content/Process) ○ Teacher-led ○ Edgenuity ○ Independent	Activating Strategies (Content/Process) ○ Teacher-led ○ Edgenuity ○ Independent	Activating Strategies (Content/Process) ○ Teacher-led ○ Edgenuity ○ Independent	Activating Strategies (Content/Process) ○ Teacher-led ○ Edgenuity ○ Independent

Teacher-led Instruction ○ small-group ○ Whole class	**Teacher-led Instruction** ○ small-group ○ Whole class	**Teacher-led Instruction** ○ small-group ○ Whole class	**Teacher-led Instruction** ○ small-group ○ Whole class	**Teacher-led Instruction** ○ small-group ○ Whole class
Computer-based Instruction	**Computer-based Instruction**	**Computer-based Instruction**	**Computer-based Instruction**	**Computer-based Instruction**
○ Teacher-led ○ Independent	○ Teacher-led ○ Independent	○ Teacher-led ○ Independent	○ Teacher-led ○ Independent	○ Teacher-led ○ Independent
Independent Practice ○ Edgenuity ○ Computer-based activity ○ Independent worksheet	**Independent Practice** ○ Edgenuity ○ Computer-based activity ○ Independent worksheet	**Independent Practice** ○ Edgenuity ○ Computer-based activity ○ Independent worksheet	**Independent Practice** ○ Edgenuity ○ Computer-based activity ○ Independent worksheet	**Independent Practice** ○ Edgenuity ○ Computer-based activity ○ Independent worksheet
One-on-one Instruction/Remediation	**One-on-one Instruction/Remediation**	**One-on-one Instruction/Remediation**	**One-on-one Instruction/Remediation**	**One-on-one Instruction/Remediation**
Formative: ***Summative*:**	***Formative:*** ***Summative*:**	***Formative:*** ***Summative*:**	***Formative:*** ***Summative*:**	***Formative:*** ***Summative*:**
Closing/Wrap Up:	**Closing/Wrap Up**	**Closing/Wrap Up**	**Closing/Wrap Up**	**Closing/Wrap Up**

Notes	**Notes**	**Notes**	**Notes**	**Notes**

Appendix D

Student On-Task Behavior/Teacher Engagement Duration Recording Sheet

Observer____**Date**___________________

Instructions. Start timer 1 at the beginning of the session and let it run the entire 10-minutes. Start timer 2 when the student is on-task. Pause timer 2 when the student is not on-task and restart the timer when the student is on-task. Write down the total time for each student.

Definitions.

Student On-Task Behavior: **Always present** (a) remaining in seat or designated area; (b) the student refrains from calling out or making inappropriate noises; **Present during computer-based instruction/practice** (c) the student is looking at the computer or teacher during instruction; (d) the student is viewing the appropriate program on the computer; **Present during teacher-led and independent seat work** (e) the student is watching the teacher during face-to-face instruction; and (f) the student is reading or writing the appropriate material while completing seat work. (Circle the condition for each student. Baseline [B], Intervention [I], or Maintenance [M])

Teacher Engagement: **Present during teacher-led instruction** (a) teacher is delivering math instruction related to the lesson plan; **Present during CBI and independent seat work** (b) teacher is monitoring student progress on computer using Edgenuity program; (c) teacher is walking around and monitoring student work during independent seat work; or (d) teacher is providing feedback to student regarding their work.

Date	Total Time	% of Time	Date	Total Time	% of Time	Date	Total Time	% of Time
Student 1 B I M			Student 1 B I M			Student 1 B I M		
Student 2 B I M			Student 2 B I M			Student 2 B I M		
Student 3 B I M			Student 3 B I M			Student 3 B I M		
Teacher			Teacher			Teacher		

Date	Total Time	% of Time	Date	Total Time	% of Time	Date	Total Time	% of Time
Student 1 B I M			Student 1 B I M			Student 1 B I M		
Student 2 B I M			Student 2 B I M			Student 2 B I M		
Student 3			Student 3			Student 3		

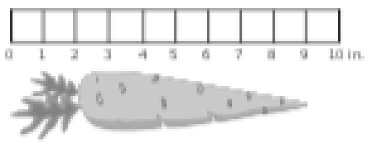
B I M			B I M			B I M		
Teacher			Teacher			Teacher		

Appendix E

Sample Mathematics Probe

Student: Teacher: Date:

1 How long is the carrot?



________ in.

2 Write the answer in each blank.

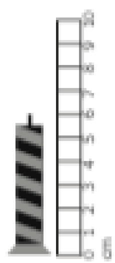
Of these numbers

957 401 685 593

________ is the smallest

________ is the largest

3 What is the height of the candle?



________ cm

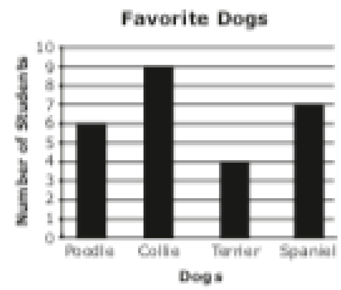
4 Graham has 5 goldfish and Morris has 9 goldfish. How many goldfish do Graham and Morris have in all?

____

5 Write the answer in the blank.

9 + 32 + 15 = ________

6 Use the graph to answer the question.

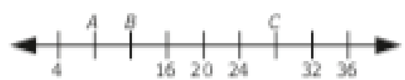


How many students like spaniels? ________

7 Write + or − in the blank.

79 ________ 25 = 54

8



What number does *C* stand for?

____

What number does *B* stand for?

____

Appendix F

Teacher Perception Questionnaire

Name___________________________

Date____________________________

Circle only ONE answer for each question.

1. How comfortable do you feel in using the computer for instruction?

   a. Very comfortable
   b. Somewhat comfortable
   c. Neither comfortable nor uncomfortable
   d. Somewhat uncomfortable
   e. Very uncomfortable

2. I can you use the Edgenuity system effectively?

   a. Strongly disagree
   b. Somewhat disagree
   c. Neither agree nor disagree
   d. Somewhat agree
   e. Strongly agree

3. I am excited to be using Blended Learning methods in my classroom?

   a. Strongly disagree
   b. Somewhat disagree
   c. Neither agree nor disagree
   d. Somewhat agree
   e. Strongly agree

4. Do you feel that you are able to respond to student questions and concerns in a timely manner?

   a. Strongly disagree
   b. Somewhat disagree
   c. Neither agree nor disagree
   d. Somewhat agree
   e. Strongly agree

5. I have appropriate technology that works for Blended Learning implementation?

   a. Strongly disagree
   b. Somewhat disagree
   c. Neither agree nor disagree
   d. Somewhat agree
   e. Strongly agree

6. I feel that the content instruction through the Edgenuity curriculum is appropriate for my students?

   a. Strongly disagree
   b. Somewhat disagree
   c. Neither agree nor disagree
   d. Somewhat agree
   e. Strongly agree

7. I am likely to continue using Blended Learning in my classroom?

   a. Strongly disagree
   b. Somewhat disagree
   c. Neither agree nor disagree
   d. Somewhat agree
   e. Strongly agree

Appendix G

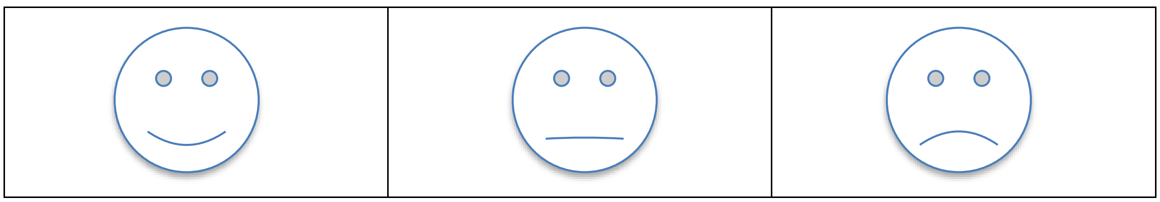
Student Perception Questionnaire

Name___________________________

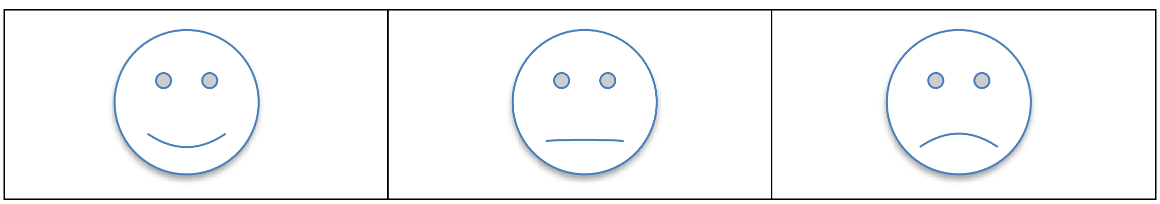
Date____________________________

Circle only ONE answer for each question.

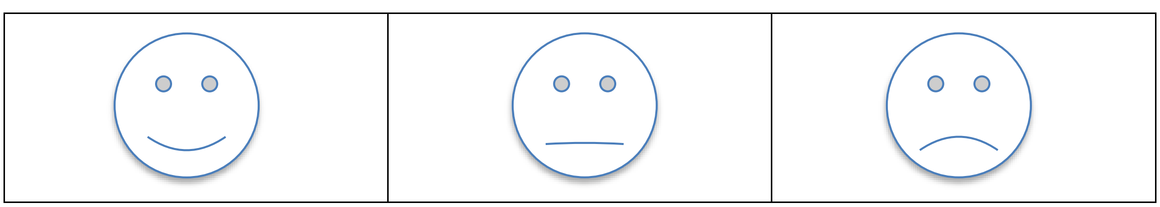
1. Do you feel comfortable using the computer for school-based learning?



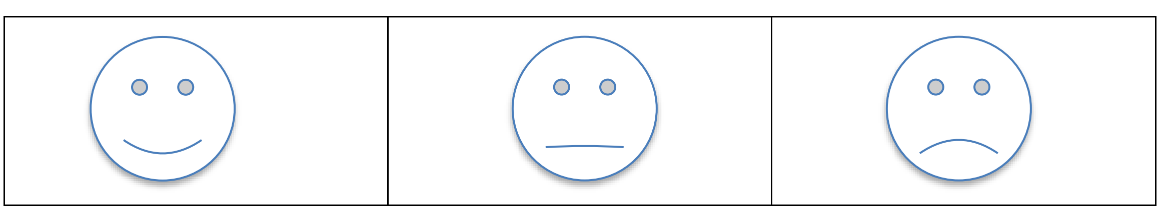
2. Do you feel successful when completing lessons on the computer?



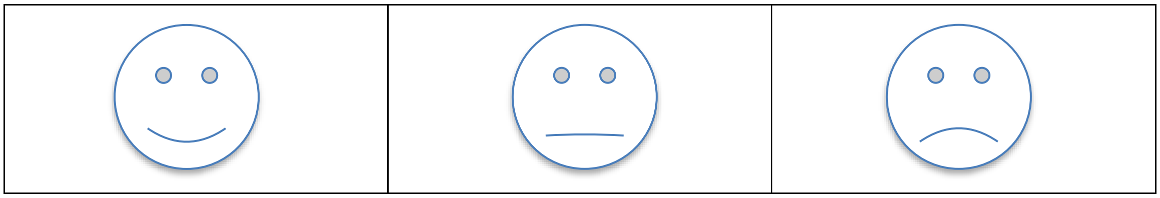
3. Does your teacher have a positive attitude towards computers and computer-based instruction?



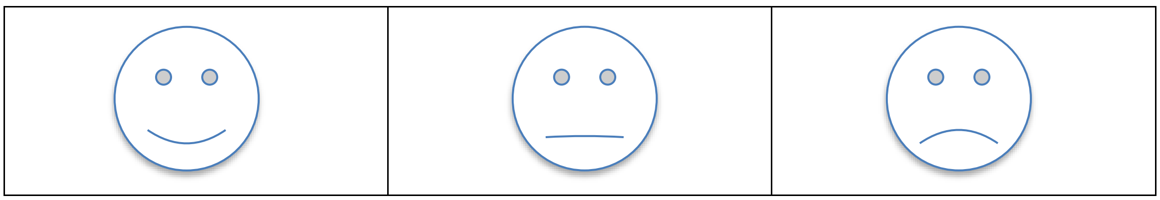
4. Does your teacher respond quickly to questions you have while using Edgenuity?



5. Do your classroom computers work well?



6. Do you feel that the lessons on Edgenuity are effective in teaching you new material?



Appendix H

Implementation Fidelity Checklist

Completed by:___________________________

Date:____________________________

	YES	NO
Does the lesson content match the weekly lesson plan?		
Are the correct students receiving baseline instruction?		
Are the correct students receiving BL intervention?		
Are the baseline students only receiving instruction from the Edgenuity program?		
Are the intervention students rotating between different modality groups? (a) teacher-led small-group instruction (b) computer-led content instruction (c) independent paper-and-pencil seatwork	 ________ ________ ________	 ________ ________ ________
Did the mathematics class period last at least 50 minutes?		

Appendix I

Instructional Approach Table

Intervention	Description
Explicit Instruction	System of instruction including specific step-by-step procedures that account for student mastery, immediate feedback, student practice, and gradual fading of teacher direction.
Modeling with Corrective Feedback	The teacher completes the assignment and students mimic the teacher. The teacher observes the student as they complete the assignment and provides corrective feedback to the student when they answer incorrectly.
Manipulatives (Concrete-Representational-Abstract)	Use of tangible (or digital) items to represent math concepts (e.g., plastic tiles used for counting).
Explicit Inquiry Routine	Analysis of specific mathematical concepts that can be used for small instructional lessons. The scaffolded inquiry phase allows students to present their understanding to teachers, peers, and themselves. Finally, students visually represent their understanding through illustration.
Choice-making	Teacher presents the student with two or more assignment options. The teacher than asks the student which assignment they want to complete first and allows them to do so.
Functional Tasks	Tasks involve content or materials that students express having an interest in and/or that lead to functional outcomes (e.g., college application essay, job application completion).
Shortened Assignments	The number of questions participants are required to answer in a given assignment is reduced.
Enhanced Anchored Instruction	The teacher situates video-based problems in real-world contexts that support generative learning. The teacher then gives students the opportunity to practice skills by solving similar problems in real-world contexts.

Appendix J

Teacher Training Assessment

Date_______________________

During the baseline condition of the study, who provides instruction to the student?

a. classroom teacher
b. computer/Edgenuity
c. both

During the station-rotation Blended Learning model of instruction, who is responsible for delivering the content instruction?

a. classroom teacher
b. computer/Edgenuity
c. both

During the Blended Learning condition what medium are the students using to complete their independent work?

a. Paper-and-pencil
b. computer/Edgenuity
c. both

During the baseline condition what method are the students using to complete their independent work?

a. Paper-and-pencil
b. computer/Edgenuity
c. both

Match the potential teacher-led methods of instruction, which can be used in the Blended Learning intervention, with their correct descriptions.

Intervention	Description	Answer
A. Explicit Inquiry Routine	System of instruction including specific step-by-step procedures that account for student mastery, immediate feedback, student practice, and gradual fading of teacher direction.	
B. Functional Tasks	The teacher completes the assignment and students mimic the teacher. The teacher observes the student as they complete the assignment and provides corrective feedback to the student when they answer incorrectly.	
C. Manipulatives (Concrete-Representational-Abstract)	Use of tangible (or digital) items to represent math concepts (e.g., plastic tiles used for counting).	
D. Enhanced Anchored Instruction	Analysis of specific mathematical concepts that can be used for small instructional lessons. The scaffolded inquiry phase allows students to present their understanding to teachers, peers, and themselves. Finally, students visually represent their understanding through illustration.	

E. Direct Instruction	Teacher presents the student with two or more assignment options. The teacher than asks the student which assignment they want to complete first.	
F. Modeling with corrective feedback	Tasks involve content or materials that students express having an interest in and/or that lead to functional outcomes (e.g., college application essay, job application completion).	
G. Choice-making	The number of questions participants are required to answer in a given assignment is reduced.	
H. Shortened Assignments	The teacher situates video-based problems in real-world contexts that support generative learning. The teacher then gives students the opportunity to practice skills by solving similar problems in real-world contexts.	

Appendix K

Student Edgenuity Knowledge Checklist

Name:________________________

Date:______________________________

Score:_____________________________

Does the student know how to:

(a) independently turn on the computer?

a. YES

b. NO

(b) login to their Edgenuity program account?

a. YES

b. NO

(c) select the appropriate coursework for the day?

a. YES

b. NO

(d) click responses and answers when prompted by the program?

a. YES

b. NO

Appendix L

Interobserver Training Quiz

Name:________________________________

Date:__________________________________

Circle the best answer for each question.

1. What are the two behaviors that you will be observing in the classroom?

   a. Number of questions asked and engagement
   b. Student on-task behavior and teacher engagement
   c. Number of hand-raises and computer-use
   d. Conversations with teacher and off-task behavior

2. How many 10-minute segments will you be observing during each class period?

   a. 1
   b. 2
   c. 3
   d. 4

3. How many different students will you observe during one full math period?

   a. 1
   b. 2
   c. 3
   d. 4

4. Which characteristic is **NOT** included in the operational definition of student on-task behavior?

   a. the student remains in seat or designated area
   b. the student is looking at the computer or teacher during instruction
   c. the student is watching the teacher during face-to-face instruction
   d. the student refrains from calling out or making inappropriate noises
   e. none of the above

5. Which characteristic is **NOT** included in the operational definition of teacher engagement?

a. teacher is delivering math instruction related to the lesson plan
b. teacher is walking around and monitoring student work during independent seat work
c. teacher is catching up on grading assignments
d. teacher is monitoring student progress on computer using Edgenuity program
e. none of the above

Georgia State University
Department of Communication Sciences and Disorders
Informed Consent

Title:	*Improving Student Academic Engagement and Mathematics Achievement Through Station-Rotation Blended Learning*
Principal Investigator:	Dr. David Houchins
Student Principal Investigator:	Zachary G. Johnson, M.Ed.

I. <u>Purpose:</u>

You are invited to participate in a research study. The purpose of this study will be to examine the effectiveness of the station-rotation blended learning models of instruction on student math achievement, on-task behavior, and teacher engagement. You are invited to participate because you are a math teacher in an alternative school setting. A total of 8 participants will be recruited for this study: 1 teacher and 7 students. The intervention will be conducted during your regularly scheduled 50-minute math class and will continue for approximately 15 weeks.

II. <u>Procedures:</u>

If you decide to participate, you will work with the researchers to provide regularly scheduled math instruction using blended learning. You will use the station-rotation blended learning instructional strategy using the Edgenuity online curriculum and face-to-face instruction. You will use the station-rotation blended learning instruction for approximately 11 weeks. There will also be seven days before the intervention and one follow-up day after the intervention. If you decide to participate in the study, we will conduct a one-hour interview at the end of the study. The interview will not be audio-recorded or video taped.

III. <u>Risks:</u>

In this study, you will not have any more risks than you would in a normal day of school.

IV. <u>Benefits:</u>

Participation in this study will hopefully benefit you personally and your students. Overall, the hope is that you gain information about effective blended learning strategies of math instruction to be used for students with disabilities in alternative schools.

V. <u>Voluntary Participation and Withdrawal:</u>

Participation in research is voluntary. You do not have to be in this study. If you decide to be in the study and change your mind, you have the right to drop out at any time. Whatever you decide, you will not lose any benefits to which you are otherwise entitled.

VI. Confidentiality:

We will keep your records private to the extent allowed by law. Dr. David Houchins and Zachary Johnson, M.Ed. will have access to the information you provide. Information may also be shared with those who make sure the study is done correctly (GSU Institutional Review Board, the Office for Human Research Protection (OHRP)). The information you provide will be stored in a locked cabinet and digital voice recordings will be stored on password- and firewall-protected computers. The key (code sheet) to identify each research participant will be stored separately from the data to protect your privacy as the teacher participant. Your name and other facts that might point to you will not appear when we present this study or publish its results. You will not be identified personally.

VII. Contact Persons:

Please contact Dr. David Houchins at 404-413-8338 and/or dhouchins@gsu.edu if you have questions, concerns, or complaints about this study. You can also call if you think you have been harmed by the study. Call Susan Vogtner in the Georgia State University Office of Research Integrity at 404-413-3513 or svogtner1@gsu.edu if you want to talk to someone who is not part of the study team. You can talk about questions, concerns, offer input, obtain information, or suggestions about the study. You can also call Susan Vogtner if you have questions or concerns about your rights in this study.

VIII. Copy of Consent Form to Subject:

We will give you a copy of this consent form to keep for your reference.

If you are willing to volunteer for this research and participate in the follow-up interview please sign below.

____________________________ _______________

Participant Date

____________________________ _______________

Principal Investigator or Researcher Obtaining Consent Date

Georgia State University
Department of Communication Sciences and Disorders
Parent Permission

Title: *Improving Student Academic Engagement and Math Achievement Through Station Rotation Blended Learning*
Principal Investigator: Dr. David Houchins
Student Principal Investigator: Zachary Johnson, M.Ed.

I. Purpose:
Your child is invited to participate in a research study. The purpose of this study will be to examine the effectiveness of blended learning models of instruction on student math achievement and on-task behavior. Your child has been invited to participate because he/she is a student in the classroom of the teacher who has selected to participate.

II. Procedures:
If your child decides to participate, he/she will do no more than what is expected of them on a normal day of instruction. Researchers will be collecting information about their academic achievement and behaviors in the classroom during regularly scheduled math lessons. After the study, your child will participate in a one-hour interview about their experience during the study. The interview will not be audiotaped or video recorded.

III. Risks:
In this study, your child will not have any more risks than in a normal day of school. However, if he/she does not want to continue participation for any reason, they may choose to remove their permission for researchers to record their data in the classroom.

IV. Benefits:
Participation in this study may or may not directly benefit your child academically or behaviorally; however, researchers and school personnel will learn effective strategies and tools to help them provide more interesting and engaging lessons in math classrooms.

V. Voluntary Participation and Withdrawal:
Participation in research is voluntary. You have the right to take your child out of the study at any time. If you decide your child can be in the study, you can change your mind at any time. You have the right to stop at any time. Your child's grade will not be affected in anyway.

VI. Confidentiality:
Specific information collected about your child will include age, grade, disability status, special education eligibility, classroom grades, and classroom behavior. We will keep your child's records private to the extent allowed by law. Dr. David Houchins and Zachary Johnson will have access to the information collected. Information may also be shared with those who make sure the study is done correctly (GSU Institutional Review Board, the Office for Human Research Protection [OHRP]). We will use a made-up name in place of your child's name on study records. The code that connects the made-up name to your child's name will be kept in a locked file cabinet separate from the data. Once the

data are entered into the computer the code will be destroyed. The data will be stored in a locked cabinet and a password- and firewall-protected computer. Your name, your child's name, and other facts that might point to you or your child will not appear when we present this study or publish its results. You and your child will not be identified personally.

VII. Contact Persons:

Contact Dr. David Houchins at (404) 413-8338 or dhouchins@gsu.edu if you have questions, concerns, or complaints about this study. You can also call if you think you have been harmed by the study. Call Susan Vogtner in the Georgia State University Office of Research Integrity at 404-413-3513 or svogtner1@gsu.edu if you want to talk to someone who is not part of the study team. You can talk about questions, concerns, offer input, obtain information, or suggestions about the study. You can also call Susan Vogtner if you have questions or concerns about your rights in this study.

VIII. Copy of Consent Form to Subject:

We will give you a copy of this consent form to keep. If you are willing to give your child permission to be in this study, please sign below.

_______________ ________________________ ____________

Child's Name (Print) Parent Signature Date

______________________________ ________________

Principal Investigator or Researcher Obtaining Consent Date

Georgia State University

Student Assent

Title: *Improving Student Academic Engagement and Math Achievement Through Station Rotation Blended Learning*

Main Researcher: Dr. David Houchins

Student Researcher: Zachary Johnson, M.Ed.

I. Purpose:

You are being asked to join a research study. The reason for this study is to look at the effects of blended learning on your math grades and your behavior. You are being asked to join because you are a student in the classroom of the teacher who has been picked.

II. Procedures:

If you decide to join the study, you will do no more than what you do on a normal day of school. If you choose to join the study, we will interview you for about one hour at the end of the study. We will also collect information about your school grades and behaviors in the classroom.

III. Risks:

In this study, you will not have any more risks than in a normal day of school.

IV. Benefits:

This study will help researchers and your teacher to learn the best of way of combining computers with your class lessons and to have lessons that are more interesting and engaging.

V. Participation:

Participation in this study is your choice. You do not have to be in this study. If you decide to be in the study, you can change your mind. You have the right to stop at any time. Your grade will not be affected in anyway. If you are willing to be in this study and have your behavior observed and collected, please sign below:

______________________ ________________________ __________________

Student Name (Print) Student Signature Date

_______________________________ ___________________

Main Researcher or Student Researcher Date