Access to the Common Core State Standards in Mathematics through Early Numeracy Skill Building for Students with Significant Intellectual Disability

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Abstract: This study investigated the effect of systematic early numeracy skill instruction on grade-aligned 4th and 5th grade Common Core math skill acquisition for three 4th and 5th grade students with a significant intellectual disability. Students were taught early numeracy skills (e.g., number identification, making sets to five items, simple addition) using theme based lessons, systematic prompting and feedback, manipulatives and graphic organizers. Four Common Core math standards were task-analyzed to identify the early numeracy skills needed to access the standard. A multiple probe across students design was used to examine the effects of the early numeracy instruction on the number of steps completed on each of the grade-aligned math standards task-analysis. Results indicated a functional relationship between the early numeracy skill instruction and students independent correct responses on grade-aligned math. Implications for practice and future research are discussed.

In the past couple of years, the introduction of The Common Core State Standards in Mathematics (CCSSM; 2012) has offered the field of math educators a focus of prioritization in math standards and practices to build the importance of math competence in all students in American schools. Aligned with the previous vision of math education (NCTM, 2000; NMP, 2008), the CCSSM address the need to build math competence in ALL students, including those “students who are well below or well above grade-level expectations . . . At the same time, all students must have the opportunity to learn and meet the same high standards if they are to access the knowledge and skills necessary in their post-school lives.”

While the CCSSM may provide new standards for math instruction, in the field of disability the focus to include more grade-aligned math instruction is not new. Within the past decade, the field of severe disabilities has responded to the notion of general curriculum access by developing interventions and practices that not only allow students to “access” the curriculum, but also make measurable educational progress on math objectives typically taught within K-12 math curriculum. The most recent literature review conducted on math instruction for this population of students (Browder, Spooner, Ahlgren-Delzell, Harris, & Wakeman, 2008) found 68 empirical studies that taught math skills to students with moderate/severe intellectual disability with 93% focusing on skills found in Numbers & Operations. In response to the need to extend the research on math instruction that encompasses additional standards of mathematics (i.e., Algebra, Geometry, Data-Analysis & Measurement), recent studies have shown that students with significant intellectual disability can learn math skills that are aligned to the grade level within various standards of mathematics (Browder, Trela, Courtade, Jimenez, Knight, & Flowers, 2012; Jimenez, Browder, & Courtade, 2008). For example, Browder, Jimenez, and Trela (2012) trained four middle school teachers of students with moderate intellectual disability to follow a task analysis to teach grade-aligned math using adapted math problem stories and
graphic organizers. The teachers implemented four math units representing four of the five National Council of Teachers of Mathematics recommended math standards (i.e., Algebra, Geometry, Measurement, and Data Analysis/Probability; NCTM, 2000). A multiple probe across unit design was used to examine the effects of math instruction on the number of steps completed on each math standard task analysis. Results indicated a functional relationship between math instruction and student behavior with an overall increase in independent correct responses. All students showed a significant increase in number of steps performed independently. Additionally, several other research studies have provided support in developing and implementing math instruction for students with moderate/severe disability (Collins, Evans, Creech-Galloway, Karl, & Miller, 2007; Jimenez, Browder, & Courtade, 2008; Neef, Nelles, Ivata, & Page, 2003; Polychronis, McDonnell, Johnson, Riesen, & Jameson, 2004).

The current focus of math instruction for this population is on grade-aligned math achievement. There have been significant research findings in the past decade to support this important emphasis. However, for many students their access to the general curriculum standards may be limited due to lack of prerequisite early numeracy skills (e.g., number recognition, patterning, set making and counting, rote counting, symbol use). For example, instruction for a student with a moderate/severe disability may over focus on number identification during solving an algebra equation or over focus on counting objects during a lesson on data analysis. In 2009, Towles-Reeves, Kearns, Kleinert, and Kleinert with three states and again in 2011, Kearns, Towles-Reeves, Kleinert, Kleinert, and Thomas with seven states, conducted research on students who participate in alternate assessments based on alternate achievement standards (AA-AAS). With similar findings from both studies, Kearns et al. found only 31% of elementary students could count with correspondence and make sets of items to 10, 12% could rote count to five, and only 4% could solve real world problems by using computational procedures.

In response to the need to implement more effective early numeracy math instruction for this population of students, Browder, Jimenez, Spooner, Saunders, Hudson, & Bethune (2012) developed a conceptual framework guided by work in early childhood mathematics. Research suggests that student’s development in mathematical thinking and reasoning begins early in children (within the first five years), even within infancy (Sarama & Clements, 2009). Research has also shown that very young children, even those whose development is delayed, demonstrate complex math skills such as patternning, counting objects, comparing sizes and shapes across objects (Baroody, 1998, 2004; Kilpatrick, Swafford, & Findell, 2001). The conceptual framework developed by Browder et al. was developed on the premise that early numeracy skills, which promote mathematical competence for students without disabilities and with high incidence disabilities, also will produce advanced learning for students with moderate/severe disabilities. Using four components to produce math learning supported by prior research and evidence based practices; (a) target early numeracy skills (Sarama & Clements, 2009), (b) use explicit systematic prompting and feedback (Browder et al., 2008; Gersten & Chard, 1999; Spooner, Knight, Browder, & Smith, 2011), (c) vary daily instruction using story-based lesson (Browder, Jimenez, & Trela, 2012), and (d) promote generalization to grade-level content learning through inclusive embedded instruction (Jameson, McDonnell, Johnson, Riesen, & Polychronis, 2007; Jimenez, Browder, Spooner, & DiBiase, 2012). Browder, Jimenez, Spooner, et al. (2012) conducted a pilot study including eight students with moderate/severe disability. All eight students were explicitly taught early numeracy skills using a story-based approach with systematic prompting and feedback provided by the special education teacher, in small groups within their special education classrooms. Paraprofessionals then accompanied students to general education math classrooms, and correct early numeracy skills performed in the inclusive classroom were recorded for generalization. All eight students showed significant increase in early numeracy skills and even greater application of those skills within the general education classroom.

Possession of early numeracy skills is indic-
ative of mathematic success in later years (Sarama & Clements, 2009). Many students with moderate/severe disability may not have these critical skills due to slow developmental progressions, but more often due to lack of experiences or exposure within their education (e.g., high quality preschool or elementary instruction) (Hart & Risley, 1995; Miller & Mercer, 1997; Sarama & Clements, 2009). While the research conducted by Browder et al. (2012) provides a foundation and framework in providing students solid instruction in early numeracy skill attainment, empirical research is needed to build upon their pilot research. Most recently, Jimenez and Kemmery (2013) investigated the effects of an early numeracy intervention package (Early Numeracy curriculum, 2013) outlined by Browder, Jimenez, Spooner, et al. (2012) on early numeracy skill attainment for elementary students with moderate/severe intellectual disabilities, including autism. A single-subject design across three classrooms was used to evaluate the intervention package. Specifically, three special education teachers used theme-based math lessons with embedded systematic instruction (Early Numeracy curriculum) to promote the early math concept acquisition of five students with significant intellectual disability. Results found a functional relationship between the intervention package and early numeracy skill acquisition. The three teachers who used the curriculum indicated through their social validity that they all felt that by their student’s gaining these early numeracy skills (e.g., number identification, ability to make sets to 5) it increased student ability to complete steps of grade-aligned math skills assessed on Alternate Assessments based on Alternate Achievement Standards (AA-AAS).

While the results of Jimenez and Kemmery (2013) provide evidence that explicit intensive instruction in early numeracy can increase the early numeracy skills of students with significant intellectual disability, evidence is needed that these early numeracy skills do provide greater access to perform grade-aligned math standards. For example, if a student in 4th grade already has number identification, rote counting, and set making skills, it could be assumed that the concept of multiplication would then become one that may be achieved at a greater depth of understanding and application; rather than “grade-aligned math instruction” involving a student identifying the number 3 to solve the multiplication task of $3 \times 4$. While the skill of multiplication may be applied within a real-world problem (needing three groups of four cookies for party goodie bags), conceptual understanding of sets and multiples brings forth a truer meaning of “mathematical achievement” aligned to the essence of the CCSSM.

The purpose of this study was to extend the work on early numeracy skill instruction for students with significant intellectual disability through measuring the impact early numeracy skills have on students ability to enter new learning standards within the CCSSM (e.g., plotting points on a grid in 4th grade) at a level which allows for greater access to the concept of the standard being taught.

**Method**

**Participants and Setting**

Three students, ages 10–11, with significant intellectual disability and IQ scores ranging from 40–45, participated in this study (see Table 1). All three students were served in a separate level, third through fifth grade Life Skills Class in an urban school district in North Carolina. The teacher had 10 years of teaching experience, was licensed in Mentally Handicapped, Emotional/Behavioral Handicapped and Learning Disabilities, had a master’s degree in special education, was completing a doctorate degree in special education, and served as the second author on this study.

Julie was a ten-year-old Caucasian female with an intellectual disability and hearing impairment and an IQ of 40. She began receiving early intervention services at the age of three. Julie had seizures, feeding problems, severe acid reflux, and hydrocephalus, which had caused many medical concerns throughout her schooling years. At the time of the study, she was in good health, wore a cochlear implant, and received hearing impairment services. Prior to participating in this study, Julie could identify numerals 1–10 and create sets up to five, but had a minimal understand-
ing of simple addition and properties of simple figures.

James was an eleven-year-old Caucasian male with an intellectual disability, cerebral palsy, hydrocephalus, and seizures. James had an IQ of 45, as measured by the DAS-II Early Years. He was born pre-maturely and had intense medical conditions and often had extended hospital stays since birth. James began receiving early intervention services at the age of three. At the beginning of the study, James had been relatively healthy and had missed a significantly fewer number of school days; however during the study his health began to get worse and he began to miss several whole/half days of school for doctor visits. Prior to participating in this study, James could recognize numerals 1–8, rote count to 15, and create sets up to five, but had difficulty completing simple addition, measurement, and identifying properties of simple figures.

Matt was an eleven-year-old African American male with an intellectual disability and seizures. Matt had an IQ of 40, as measured by the Bracken Basic Concept Scale 3rd edition-Receptive (BBCS-3; R). He was on medication for seizures, which occurred only at night. While the seizures did not directly impact his time at school, they did seem to often impair his focus the following school day. Prior to this study, Matt could rote count to 10 and identify numerals to 5. Matt could not identify numbers 6–10, create sets, or complete simple addition problems.

All baseline, intervention, and maintenance data collection occurred within the special education classroom. The students were taught individually or in small groups at a separate table in the classroom while daily instruction continued for the remainder of the students in the class. All baseline assessment probes were conducted individually.

### Materials

This study used: (a) the *Early Numeracy* curriculum (Jimenez, Browder, and Saunders; 2013), which utilizes math stories, lesson plans with systematic instruction embedded to support each math concept, graphic organizers, and theme-based manipulatives, (b) a task analysis data collection form which included each of the 7 tasks being assessed (See Figure 1), (c) a flip video camera to record lessons for fidelity and inter-observer agreement, and (d) researcher-made materials (e.g., plot chart and colored chips) used during assessment probes.

### Dependent Variables and Measurement

The dependent variable was the total number of student independent correct responses of the task-analyzed grade-aligned math Com-

### Table 1

Study Participant Demographics

<table>
<thead>
<tr>
<th>Participant</th>
<th>Gender</th>
<th>Age</th>
<th>Ethnicity</th>
<th>Primary/Secondary diagnosis</th>
<th>IQ</th>
<th>Adaptive behavior</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>F</td>
<td>10</td>
<td>Caucasian</td>
<td>MU: Intellectual Disabilities-Moderate &amp; Hearing Impairment</td>
<td>DAS-II: 40</td>
<td>Teacher 55</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Intellectual Disabilities: Moderate</td>
<td></td>
<td>Vineland Teacher 55</td>
</tr>
<tr>
<td>2</td>
<td>M</td>
<td>11</td>
<td>Caucasian</td>
<td>Moderate</td>
<td>DAS-II: 45</td>
<td>Parent 61</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>BBCS-3; R: 40</td>
<td>Vineland Teacher 43</td>
</tr>
<tr>
<td>3</td>
<td>M</td>
<td>11</td>
<td>African American</td>
<td>Moderate</td>
<td></td>
<td>Bayley 3</td>
</tr>
</tbody>
</table>

Note. AE = age equivalence, MU = multiple disabilities

*a* Bayley 3 = Bayley Scales of Infant Development 3rd edition; BBCS-3;R = Bracken Basic Concept Scale 3rd edition-Receptive; DAS-II = Differential Ability Scales-II Early Years; Vineland = Vineland Adaptive Behavior Scales, 2nd edition
mon Core State Standards (CCSS). This process included seven behaviors across four standards: (a) geometry: coordinate planes, (b) geometry: properties of shapes, (c) algebra: analyze patterns, and (d) algebra: operations and whole numbers, addition (See Figures 1a-d). Each of the four standards was task analyzed, and specific skills taught within the Early Numeracy curriculum were highlighted for direct assessment. Generalization was built into the assessment through the use of varied numerals and shapes (e.g., algebra equations requiring sets of 1, 2, 3, 4, or 5 manipulatives).

Students were assessed every other school day. Since occasionally students were absent, the assessment days were not always the same for each student; however each student was assessed after he or she had received two consecutive days of instruction. Each assessment item included a script to ensure fidelity of assessment implementation, and a list of the manipulatives needed to complete the task (e.g., five race cars, ten green and yellow counters, number line). The assessment was organized by each of the CCSS math problem task analysis. Within each task analysis, only the first opportunity to respond to the Early Numeracy skill was assessed, the teacher completed the other steps of the task analysis as a model. Data were scored as “correct response” (+) if the task was completed by the student independently and correct. Data were scored as “incorrect response” (-) if the task was not completed correctly or the student did not respond at all.

**Procedure**

**Research design.** A single subject multiple probe design (Horner & Baer, 1978) across three students with significant intellectual disability was used to measure student progress towards meeting four grade-aligned CCSS math problems. Without teaching the specific math problems, only using the Early Numeracy curriculum, this study investigated the effect student’s early numeracy skill attainment had on their ability to complete selected steps of a task analysis to complete grade-level-aligned math standards. In accordance with the Single-Case design technical guidelines develop for the What Works Clearinghouse (Kratochwill et al., 2010) “a minimum of six phases with at least 5 data points per phase” (baseline, intervention) was followed to meet the criteria of a study that Meets Evidence Standards.

**Baseline.** All three students completed a total of at least five baseline sessions prior to intervention. During baseline phase, student received their typical math instruction while being pulled aside and assessed on the targeted skills. Typical math instruction included whole group math lessons including the use of manipulatives, teacher models, and guided practice. Baseline for all three students was

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**Task Analysis for Geometry—Coordinate Planes**

<table>
<thead>
<tr>
<th>Steps</th>
<th>Teacher Action/Script</th>
<th>Student Action</th>
<th>Early Numeracy Skill</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Teacher provides plot numbers to student. Teacher says “move the chip over ___ spaces”</td>
<td>Student moves the chip ___ spaces</td>
<td>2</td>
<td>+  -</td>
</tr>
<tr>
<td>2</td>
<td>Teacher points to the second number</td>
<td>Student identifies the second number</td>
<td>3</td>
<td>+  -</td>
</tr>
<tr>
<td>3</td>
<td>Teacher moves chip up ___ number of spaces</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Teacher makes the point on the graph</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

Figure 1a. Data Collection Form for Coordinate Places
taken for three consecutive days or until data were stable across students. Before Julie began intervention, she participated in two more baseline probes, and James participated in one more baseline probe. Before James entered intervention phase, he was assessed two more times to assure baseline data had remained stable between assessment probes. In addition to the first of three data points, Matt was assessed before James entered the study as well as on the day before he entered the intervention phase, again to assure that his baseline data continued to remain stable.

**Intervention.** Julie began with Unit 1, Lesson 1 of the *Early Numeracy* curriculum. Each theme-based lesson began with a math story and then progressed through math activities based on the theme and skill set for the unit.

**Table:**

<table>
<thead>
<tr>
<th>Steps</th>
<th>Teacher Action/Script</th>
<th>Student Action</th>
<th>Early Numeracy Skill</th>
<th>Data Collection</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Teacher asks the student to make a set for the first number in the equation. Teacher says “Make a set of __”</td>
<td>Student makes a set of ____</td>
<td>4</td>
<td>+   -</td>
</tr>
<tr>
<td>2</td>
<td>Teacher lines the first set of chips in the first circle.</td>
<td>Student follows along</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Teacher asks the student to make a set for the second number in the equation. Teacher says “Make a set of ____”</td>
<td>Student makes a set of ____</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Teacher puts the second set of chips in the second circle then points to the two sets and shows the student they are different.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Teacher says “Add the counters all together to find out how many.”</td>
<td>Student adds the counters and identifies total</td>
<td>6</td>
<td>+   -</td>
</tr>
<tr>
<td>6</td>
<td>Teacher provides two sets of chips (one equal to the total and one not equal) and says, “Which set is equal to the set you counted?”</td>
<td>Student identifies the set that is equal</td>
<td>5</td>
<td>+   -</td>
</tr>
</tbody>
</table>
The teacher provided systematic instruction as prescribed through each lesson, which included systematic prompting and feedback for each of the designated student responses. Embedded with systematic instruction, the lesson plans provide the teacher with detailed, scripted prompts for how to support student learning using a least to most prompting system or constant time delay for number identification. Each lesson was taught for three days, assessing after every second day of instruction. As soon as Julie showed two data points of consistent growth (i.e., change in level and/or trend), James was introduced to the intervention. Once James showed two data points of consistent growth (i.e., change in level and/or trend), Matt was introduced to the intervention. Since Unit 1 focused on the same objectives throughout each of the 5 lessons, the participants were introduced to the unit at the lesson the group was currently on (e.g., Day 1 of intervention for James may start with lesson 3). The teacher progressed through the lessons in Unit 1 sequentially, and then started back with lesson 1 after the fifth lesson had been taught three times. All students participated in all lessons at least once.

### Task Analysis for Geometry—Property of Shapes

**Grade: 4**

**Common Core Standard:** Draw and identify lines and angles, and classify shapes by properties of their lines and angles.

**Extended Standard:** Identify lines, angles, and properties of a shape (circle, square, rectangle, triangle, and rhombus).

<table>
<thead>
<tr>
<th>Steps</th>
<th>Teacher Action/Script</th>
<th>Student Action</th>
<th>Early Numeracy Skill</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Teacher shows student the side of the shape</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Teacher provides the student with the designated shape and asks the student to count the sides</td>
<td>Student will count the number of sides</td>
<td>1</td>
<td>+ –</td>
</tr>
<tr>
<td>3</td>
<td>Teacher provides the student with a number line and asks student to find the appropriate number</td>
<td>Student points to the number on the number line</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 1c. Data Collection Form for Property of Shapes**

### Task Analysis for Operations and Algebraic Thinking—Patterns

**Grade: 4**

**Common Core Standard:** Generate and analyze patterns.

**Extended Standard:** Analyze patterns.

<table>
<thead>
<tr>
<th>Steps</th>
<th>Teacher Action/Script</th>
<th>Student Action</th>
<th>Early Numeracy Skill</th>
<th>Data Collection</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Teacher presents two sets to the student (one ABAB pattern and one non-pattern)</td>
<td>Student follows along with teacher</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Teacher asks the student to identify the ABAB pattern</td>
<td>Student points to the ABAB pattern</td>
<td>7</td>
<td>+ –</td>
</tr>
</tbody>
</table>

**Figure 1d. Data Collection Form for Patterning**
Maintenance. At least two weeks after the completion of the intervention, a maintenance probe was conducted to measure how well the students retained the skills learned during the study. Individually, each student participated in an assessment probe identical to those during intervention.

Results

Reliability and Procedural Fidelity

Inter observer agreement (IOA) was computed as agreements divided by agreements plus disagreements. The first author took reliability and fidelity data. IOA was taken on 60% of baseline sessions with 93% agreement and a range of 85–100%. IOA was taken on 50% of all intervention sessions with 100% agreement.

Procedural fidelity data were collected throughout the intervention to ensure the lesson content was being taught correctly and to ensure the prompting procedures were done as scripted. The research team member was either present during instruction or lessons were videotaped for review. Fidelity data were collected on 33% of the lessons taught with 100% adherence.

Performance

Visual inspections of the graph show a functional relationship between the introduction of the intervention and a change in level and trend across all three participants (see Figure 2). In addition to the traditional visual inspection of participant’s performance data to determine the presence of a functional relationship, the researchers also conducted a percentage of overlapping data (PND) analysis by (a) drawing a horizontal line across the greatest datum point in the baseline condition for each unit, (b) counting the total number of data points in intervention condition, and (c) dividing the number of data points above the horizontal line in the intervention condition by the total number of data points in the intervention condition (Wolery, Busick, Reichow, & Barton, 2010). Overall, according to guidelines provided by Scruggs and Mastropieri (1998), the results of comparing PND demonstrate a highly effective intervention (0.90–1.0) or effective intervention (0.70–0.89) for all three students (Julie 100%, James 77%, Matt 72%).

Julie. During baseline probe sessions Julie correctly responded to a mean of 3.4 out of 7 assessment items (range = 4–5). During intervention Julie correctly responded to a mean of 6.6 assessment items (range = 5–7). There was an immediate change in level and trend once the intervention was introduced. Julie met mastery the mastery criteria of 7 correct for two consecutive sessions after 8 probe sessions. Data indicated Julie’s ability to maintain the new math skills in the context of grade-aligned CCSS math standards over time. Specifically, Julie maintained the same number of correct responses two weeks after intervention.

James. James correctly responded to a mean of 3.8 out of 7 assessment items (range = 3–5) during baseline probe sessions. During intervention James correctly responded to a mean of 5.88 assessment items (range = 3–7). There was an immediate change in level and trend once the intervention was introduced. James met the mastery criteria of 7 correct for two consecutive sessions after 7 probe sessions. Data indicated James’ ability to maintain the new math skills in the context of grade-aligned CCSS math standards over time. James maintained the same number of correct responses four weeks after intervention.

Matt. During baseline probe sessions Matt correctly responded to a mean of 2.2 (range = 1–3). During intervention Matt correctly responded to a mean of 4.1 (range = 3–6). Although there was not an immediate change in level and trend, he began to increase his number of correct responses on the 2nd assessment probe, with a consistent change in trend after the 5th data point. After completing Unit 1 twice, Matt still did not reach mastery criteria; however, he did show mastery of 6 out of 7 responses for two sessions. Data also indicated his ability to maintain five of the new math skills learned over time, two weeks after intervention.

Social Validity

Parents and students were asked to complete a survey about their participation in the study.
Each parent was asked to complete a four question survey, using a five-point Likert scale (i.e., 1 = do not agree; 5 = strongly agree) for the following topics: (a) feelings towards high quality math instruction, (b) their child’s progress during the study, (c) improved educational outcomes, and (d) recommendations for continued use. All three parents participated in the survey and indicated that they "strongly agreed" that math instruction was important, and that the intervention had improved their student’s math outcomes. All
three parents indicated that they would like to see continued use of the Early Numeracy curriculum to support CCSS math instruction to all four questions.

Student participants were given a 5 question adapted survey to complete. The teacher read each question aloud, then asked the student to indicate their answer using the picture symbols as responses to the following topics: (a) Feelings about learning new math skills, (b) Enjoyment of math lessons, (d) Understanding of math, and (e) Interest in continued instruction using this curriculum (See Figure 3). All three students indicated that they enjoyed the math lessons and felt that the lessons helped them understand math.

Discussion

The findings of this study demonstrated that as students with significant intellectual disability gain proficiency of early numeracy skills they also gain greater access to grade-level aligned math content. This study extends the research of Browder, Jimenez, Spooner et al. (2012) and Jimenez and Kemmery (2013) by investigating the impact of early numeracy skills instruction on grade-aligned math achievement. Both previous studies taught students with moderate intellectual disability and autism new early math skills (e.g., number identification, patterning, rote counting, set making) using the Early Numeracy curriculum. Within both previous studies, students showed significant gains in early numeracy skill attainment from baseline to intervention phase. One note to point out is that the skills being taught were not technically novel and new, as they were skills typically being “taught” by their teachers for many years (K-5); however, students were not able to perform them prior to intervention and showed a significant increase in skill performance after the systematic, explicit instruction using theme-based math lessons with embedded prompting and feedback procedures.

Differing from the previous work on grade-aligned math instruction for this population of students, this study did not attempt to explicitly teach the grade-aligned math standards (e.g., coordinate plotting on a graph), rather investigated the effect student’s early numeracy skills have on their ability to learn new grade-aligned content. For example, as a fourth grade student begins to learn about plotting points on a graph, a student with a moderate intellectual disability who “has already obtained” number skills with fluency, will be able to focus their acquisition of the new math skill on concepts within geometry and measurement, rather than number identification and one-to-one correspondence.

First, the findings of Towles-Reeves et al. (2009) and Kearns et al. (2011) brought great attention to the need to investigate the early numeracy skill instruction of students with significant intellectual disability. Secondly, the conceptual model for early math instruction developed by Browder, Jimenez, Spooner, et al. (2012) focuses on the use of evidence-based instructional practices for teaching academics to this population of students embedded in the research on early numeracy learning trajectories (Sarema & Clements, 2009). Based on this model, research has begun to dive deeper into the conceptual block building of early numeracy and how students with significant intellectual disability learn math (conceptually, not only as a rote response). Lastly, this study begins to investigate the implications of solid, systematic early numeracy instruction based on research based practices, on students overall math careers.

In contrast, we did not assess the early numeracy skills of the students, as outlined by the technical assessment of the curriculum, prior to baseline. While we did report the current level of math achievement, per the teacher/second author, prior to the beginning of the study, it would have been beneficial to see what skills students were able to perform prior to the beginning of instruction with the Early Numeracy curriculum. It is possible that while a student was not able to perform the early numeracy skills (e.g., counting a non-moveable object) within the task-analysis application of the skill (e.g., counting the sides of a shape in geometry) he/she may have already mastered the skill as presented in the Early Numeracy curriculum (e.g., count three cars in a row for the lesson about the speedway). Even though it is possible a student may have already mastered the skill without the ability to generalize, data suggests that the explicit instruction and multiple exem-
1. I liked learning new math when my teacher gave us new kits of materials to use in our lessons.

2. I had fun learning new math skills when my teacher used the materials in her kits and her lesson plans.

3. I thought the math lessons were interesting when my teacher used the new materials and lessons with me.

4. I thought these new math materials and lessons helped me better understand the math work we have been doing in class.

5. I would like to continue to learn new math skills using the new materials and lessons.

Figure 3. Student Social Validity Survey
The plans used within the treatment package did provide students with support to generalize the skills to the Common Core math standards.

A second limitation of the current study is that while all students made gains, the gains for Matt were not as immediate as the other two students. While a significant change in level and trend were noted, the change in level was not immediate. While an immediate change in level would provide stronger evidence that the change in behavior was due to the intervention alone, attention must be given to the learning needs of students with significant intellectual disability. Matt is a student who has typically required more than one or two lessons to learn a new skill; this is not uncommon for many students with intellectual disability. The use of PND data was calculated to help control for a delayed change in level, finding the intervention “effective” at .72 non-overlapping data.

A third limitation is that study was conducted in a separate math classroom for students following an adapted curriculum based on the Common Core State Standards. While the procedures followed in this study may be beneficial to students with significant intellectual disability being served in inclusive math classrooms, the results of this study cannot be generalized to support inclusive math education at this time. As outlined in the conceptual model developed by Browder, Jimenez, Spooner et al. (2012), early numeracy skills should be generalized to provide greater access to the general inclusive classroom through systematic embedded instruction. While generalization was embedded into the general curriculum in this study, the context was a separate setting. Research is needed to investigate the use of explicit early numeracy skill instruction and embedded generalization in typical inclusive math lessons to support student’s ability to participate and show increase math skill/concept achievement in the general education classroom.

Implications for Practice and Future Research

This study provided evidence that students with significant intellectual disability, including those with multiple disabilities, can learn new math skills that will grant them greater access to grade-aligned math achievement. The CCSS provide educators with the standards to build math processes and knowledge over the school age years. While many students with significant intellectual disability are already participating in grade-aligned math instruction, the depth of this instruction may be hindered by student’s ability to fluently perform early numeracy skills. In replicating the treatment package used in this study, educators should consider developing stories that are meaningful to their students, working with general educators and early numeracy standards to explicitly embed trials for students to independently gain mastery of the skills over multiple repeated opportunities. For example, when developing a story about a trip to the Water Park, specific math target goals have been identified (e.g., equal sign and its meaning) and intentional opportunities in the story to find equivalence (e.g., number of tickets = number of people).

Future research is needed to expand early numeracy skills instruction to students with multiple disabilities, especially those with more significant intellectual disability and visual impairments. In this study, students were able to access the curriculum without modifications. Future research should investigate math instruction for students who may need additional modifications in order to access the curriculum (e.g., larger manipulatives, a variety of textures, assistive technology).

Finally, future research is also needed to continue the investigation of early numeracy instruction through the expansion of skill sets needed to access grade-aligned standards within the CCSSM. While the students in this study were able to gain very basic numeracy skill such as number identification and counting sets, some students with significant intellectual disability have already mastered these skills but require assistance with more advanced; yet still prerequisite, math skills, such as addition of two digit numerals, or multiplication of single digit numerals. Within the elementary math classroom, students with and without disability need to have fluency within early numeracy skills to truly “understand math”.

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References


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