Increasing Number Sense Using Intervention and Assessment

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Introduction

Mathematics is a multi-dimensional subject area that encompasses many complex ideas. It is built on a hierarchy of skills that begin to form at a very young age. One of the earliest forms of math understanding is the idea of number sense. Number sense is the understanding of numbers and their relationships between each other and the ability to use numbers and operations in flexible ways. To fully understand math concepts, number sense needs to be developed. Westenskow, Moyer-Packenham, and Child (2017) stated "mathematics is a discipline in which new concepts are built upon previously learned concepts; thus incorrect or insufficient knowledge of basic concepts limits future mathematical growth" (p. 1). When looking at school-aged children, 5 to 10 percent of students show signs of having a math disability. Students who do not exhibit signs of number sense have a more difficult time building higher-level math concepts, leading them to struggle in math.

The purpose of my study was to determine if explicit math instruction in the area of number sense would increase student achievement. My capstone project was centered around two second-grade students who received special education services. The data that I collected from my students indicated a need in mathematics, specifically in number sense. Assessing number sense understanding and implementing appropriate interventions helped my students develop a deeper understanding of math concepts and make gains in their overall academic achievement. The literature I reviewed is organized thematically into two main topics: assessment and intervention. This research was intended to guide my number sense assessments and student-based interventions I used in my classroom.

Assessment

Before deciding if number sense interventions were needed, pre-test assessments to determine number sense understanding were necessary. In order to gauge number sense, there are a variety of different assessment measures that can be completed. One approach to pre-test assessments are Curriculum-Based Measurements (CBMs). CBMs are assessments that align with curriculum standards (Koellner, Colsman, & Risley, 2014). CBMs give a baseline of understanding as well as allow teachers to monitor student progress throughout instruction. An example of a CBM program directly related to mathematics, as well as other content areas, is AIMSWeb. "AIMSWeb CBM is a fluency measure that evaluated students' grade-level computation skills, including basic facts and double-digit addition and subtraction problems with or without regrouping" (Dennis, Sorrells, & Falcomata, 2016, p. 99). AIMSweb probes are used nationally for screening, baseline, and monitoring progress of math computation and fluency skills (Valenzuela, Gutierrez, & Lambros, 2014). Each probe is nationally normed at grade level. AIMSWeb is used in many school districts and is simple for grade-level teachers and/or specialists to navigate. AIMSweb and other CBMs that align with number sense include assessments that involve number comparison, sequencing, and fluency.

Number comparison assesses whether a child can quickly and accurately identify which number has the larger or smaller value when given two numbers. Studies have shown that there is a relationship between number comparison and math achievement. "Fast and/or accurate comparison of numbers is related to better performance on general mathematical achievement test" (Maertens, Smedt, Sasanguie, Elen, & Reynvoet, 2016, p.2). From this research, I knew that

if my students could quickly differentiate the values between two numbers, they were more likely to show better math understanding.

Number sequencing refers to the ability to receptively or expressively place a number in the correct position based on the number line. This assessment shows if a child has a flexible understanding of numbers and the number line system, which directly relates to number sense understanding (Bryant, Bryant, Gersten, Scammacca, & Chavez, 2008; Dyson, Jordan, & Glutting, 2011; Westenskow et al., 2017). Number fluency is when students complete one-digit or two-digit addition or subtraction within a certain time restraint. This assessment looks at the number of problems completed accurately within the time limit to gauge number sense understanding (Bryant et al., 2008).

In addition to CBMs, I knew that I needed to administer a mindset or disposition survey to my students before implementing number sense interventions. Research has shown that students who struggle with math have negative feelings about the subject. “These feelings inhibit mathematics development, and students become locked into the cycle of failure. In contrast, students with a positive mindset or disposition see mathematics as useful, worthwhile and attainable” (Westenskow et al., 2017, p. 2). It was important to identify if my students had poor feelings toward mathematics, so I could focus on changing the students’ disposition to foster positive feelings towards the subject, leading to higher math achievement.

Interventions

The results of the pre-test assessment my students took were used to develop appropriate intervention plans for each student. “Teachers need access to assessments that support appropriate instruction” (Koellner et al., 2014, p.110). For number sense to be developed,

instruction needs to be purposeful and meaningful. Targeted instruction will support numeracy skills and lead to a deeper understanding of mathematics, leading to greater achievement (Dyson, Jordan, Beliakoff, & Hassinger-Das, 2015).

After collecting pre-test data, interventions needed to be implemented. To increase number sense, my students needed different interventions based on their needs identified by the assessments. No matter what the assessment data showed, one of the most important aspects to all implemented interventions was the use of explicit instruction. This means that all interventions were taught using a gradual release method. "This entails modeling, guided practice, corrective feedback, and including cumulative reviews throughout the intervention" (Valenzuela et al., 2014, p. 146). Providing clear models and multiple opportunities throughout my intervention instruction led to higher engagement and achievement rates. Another aspect of explicit instruction is the think-aloud strategy (Valenzuela et al., 2014). Think-alouds were not only an important part of explicit instruction, but they were also a teaching tool that were used to gauge my students' understanding and growth.

Chris Pflaum, a math interventionist, puts a lot of emphasis on student explanation of concepts. Her theory is that if a student can talk about a concept in logical and mathematical terms, they have a deep understanding of number sense (C. Pflaum, personal communication, December 12, 2018). To get my students to discuss math concepts out loud using academic language, I had to model and practice verbally with my students. This brings back the importance of using explicit instruction during number sense intervention. One way I promoted think-alouds in my classroom was by presenting a problem to my students and building connections between what they noticed about the problem and their number sense understanding

(Westenskow et al., 2017). Using story problems as ways to facilitate student discussion about numbers helps to not only build number relationships, but also to build understanding of math operations. Word problems that have students solve and discuss combining parts, separating parts, and finding missing parts are beneficial ways to teach appropriate vocabulary, operations, and number connections (Dennis et al., 2016). Guiding my students to discuss novel strategies and their connections to what they already knew allowed opportunities to practice the intervention while verbalizing their understanding, which helped me formatively assess the students during instruction.

For my students to be able to discuss number relationships, it was necessary for them to learn what numbers are and what they are made of. Place value interventions focus on building understanding of the base 10 numeration system (Dennis et al., 2016; Dyson et al., 2015; Dyson et al., 2011). Instead of being given a number with no explanation, numbers were told to my students in terms of what they are made up of. Place-Value activities are "designed to facilitate students' understanding of multi-digit number structure and to familiarize students with the regularity of the system, the value of each position in multi-digit numbers, and trades between values" (Dennis et al., 2016, p. 99). These activities include giving students a number and having them break the number apart using words (15 as one ten and five ones) or building the said/shown number with manipulatives. Popular manipulatives used to teach place-value include straws, cubes, and base-10 blocks (Bryant et al., 2008; Koellner et al., 2014). When my students understood what numbers represented, they were able to discuss numbers with a deeper understanding, which helped to generate number sense.

Manipulatives were valuable visuals for my students to use when developing number sense. In addition to place-value manipulatives, hundreds charts and number lines are additional visuals that can be used to develop number sense and teach number concepts and relationships (Bryant et al., 2008). These manipulatives teach children that "the next number in the count sequence is *always* one more than the previous number" (Dyson et al., 2011, p. 172). Number line and hundreds chart manipulatives give a concrete visual that shows patterns between numbers, which builds number relationships. Activities that involve indicating positions of a number on a number line or hundreds chart builds numerical understanding (Maertens et al., 2016; Shumway & Moyer-Packenham, 2019).

Engaging interventions helped my students stay motivated and higher their morale. Using board games to teach number sense has shown improvements in math achievement, engagement, and confidence (Dyson et al., 2011; Dyson et al., 2015; Maertens et al., 2016; Shumway & Moyer-Packenham, 2019; Westenskow et al., 2017). Board games can be utilized to practice newly learned number sense concepts. Game boards that have linear number representations help to develop one-to-one correspondence, quantity discrimination, estimation, and number identification skills (Dyson et al., 2011). One example of a research-based board game that increases number sense is the Great Race Game. "The child spins a spinner and moves +1/-1 or +2/-2 spaces on a colorful 1-10 number list while saying a number sentence" (Dyson et al., 2015, p. 346). The Great Race helps children understand the relationships between numbers. Electronic games have also been researched and shown effective in increasing number sense (Maertens et al., 2016). Games were rewarding confidence-boosters for my students to use while they increased number sense and practiced pre-taught skills.

Continuous assessment of mathematic achievement was vital while giving my students targeted number sense interventions. The CBMs that were used for pre-assessment information were used for the duration of the interventions as a formative assessment to track progress. Daily discussions of number concepts and relationships were also used as a formative assessment. Anecdotal notes were taken every time my students verbalized their numerical understanding. Their mathematical discussions helped me to track their progress (C. Pflaum, personal communication, December 12, 2018). Keeping track of my students' overall morale regarding math was a qualitative assessment that helped to identify their individual growth (Westenskow et al., 2017). Multiple assessments were used daily to track number sense understanding, and the assessments were used to change instruction when needed.

Conclusion

Number sense is a necessary element to mathematics achievement. To combat the staggering statistics of math learning disabilities, targeted interventions in number sense are crucial. Explicit instruction, math discussions, story problems, manipulatives, visual representations, and board games are all research-based interventions that increase number sense understanding. The interventions I implemented included multiple factors depending on student need (Maertens et al., 2016). The literature I read and reviewed stated that using only one intervention may decrease the chances of increasing number sense. It was important that I implemented many strategies and interventions throughout my instruction so my students had the opportunity to grow as much as they could. Using assessment data to inform decision-making about interventions that were used was a significant aspect to the teaching process. Early number

sense intervention allowed my students to have the opportunity to receive appropriate instruction where they had deficits, leading them to become confident and accurate mathematicians.

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