

Can Mathematics Difficulties be Prevented in Elementary Students?

A Review of the Literature

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Investigating instances of mathematics difficulties (MD) and disabilities in elementary school-aged students continues to receive increasing amounts of attention. Differences in student performance between struggling learners and their high achieving counterparts are evident as early as kindergarten, and without proper implementation of effective and research based intervention strategies and initiatives, the achievement gap will continue to widen. Moreover, causal links between the early number sense cultivated in the primary years and the successful completion of advanced mathematics courses in high school and college have been established through research (Jordan, Kaplan, Ramineni, & Locuniak, 2009). As stakeholders in education charged with the distinct responsibility to provide high quality instruction to all students, we must become knowledgeable of and choose to employ techniques that make classroom instruction equally accessible to this unique population of learners.

Although *mathematics difficulty* is frequently referenced in current literature related to struggling learners, a consensus on this term's definition has not yet been reached. Researchers seem to agree that students who experience developmental delays when learning mathematics may experience MD, but clarification is still needed when categorizing students by test scores. For example, several studies identify students as having MD if their standardized test scores are below the 26th percentile (Powell & Fuchs, 2010; Bryant, Bryant, Gersten, Scammacca, & Chavez, 2008), while others use a wider range of cut scores in their research (Witzel, Mercer, & Miller, 2013; Jitendra et al., 2013). In several studies, mathematics difficulty is used synonymously to refer to

students with mathematics disabilities. For the purposes of this paper, the definition employed by Mazzocco (2005) when referring to *mathematics difficulty* will be used. Therefore, *MD* will refer to “a broader group of children that includes children with or without math disability—and that math disability be reserved to refer to a presumed biologically based set of math difficulties” (Mazzocco, 2005, p. 321).

Early Identification of Mathematics Difficulty

Early identification of mathematics difficulties may lead to using intervention as a preventive measure instead of a coping mechanism as long as reliable indicators are used during the screening process. Moreover, since “mathematics difficulties are cumulative and worsen with time” (Jordan, Kaplan, Ramineni, & Locuniak, 2009, p. 850), it makes sense to have procedures in place to identify complications soon after they arise.

Providing early intervention to learners may positively affect student progress and reduce the achievement gap. In fact, Clarke, Smolkowski, Baker, Fien, Doabler, and Chard (2011) provide evidence of this in their study on Tier I intervention in kindergarten classrooms, and they appear to be the only study whose data illustrates that students with mathematics difficulty were able to perform comparatively to their typical peers (Mononen, Aunio, Koponen, & Aro, 2014). This could be attributed to the early intervention provided to the students in this study.

Early identification of learning difficulties should not be constricted to kindergarten and first grades, however. In the case of persistent mathematics difficulties, Vukovic and Siegel (2010) realized that certain issues did not surface until children were in the third and fourth grades. In light of this, it is worth investigating whether mathematics difficulties that surface during later grades are affected by different

domains. Including items that target characteristics of late-emerging characteristics may help predict students who will experience difficulty with mathematics in subsequent grades. Using this data to drive instruction through flexible grouping and small group-instruction may actually curtail the development of mathematics difficulty in some children.

Several challenges affect the likelihood of early identification of students with mathematics difficulties through a screening process. Even though research has identified topics in mathematics like number sense and quantitative reasoning where students with MD could benefit from intense intervention, predictive indicators are still difficult to pinpoint. Offering interventions in number sense does not guarantee that the occurrence of mathematics difficulties will decrease or be avoided altogether. Number sense and quantitative reasoning are broad topics, and if predictive indicators were identified based on them, they would have to narrow the focus down to specific aspects in this area.

Gersten and colleagues (2005) realize that we are still in the beginning stages of creating reliable assessment items with the capability of predicting whether students will develop mathematics difficulty in the later grades. Examining areas that are traditionally problematic for students with mathematics difficulty would be a starting point. However, early screening procedures will only be as effective as the items that appear on them. In order to create items that discriminate between students with and without mathematics learning difficulties, the screening items used will have to target numerical skills and cognitive areas where students with MD frequently demonstrate a weakness.

One way to explore problematic areas for struggling learners would be to identify their deficits and offer remediation and coping strategies in those areas. While it holds

true that “deficits in calculation fluency appear to be a hallmark of mathematics difficulties” (Gersten, Jordan, Flojo, 2005, p. 296), working memory and short-term memory also affect students with MD when they complete problem-solving tasks. For example, working memory capacity affected students who received strategic instruction on how to summarize key concepts in word problems before deciding how to solve them. The students who possessed a larger working memory capacity made the most progress when using the paraphrasing strategies used in the study (Swanson, Moran, Lussier, & Fung, 2014). Upon further investigation Vukovic and Siegel (2010) assert that issues with working memory and short-term memory are not predictive indicators of MD. Working memory and short-term memory are recurring characteristics of all learning disabilities, and a deficit in one of these areas does not necessarily correlate with the development of a mathematical difficulty. Instead, it may signal that some other learning disability is present. Screening items, therefore, should not target these areas since they are not considered determining factors of mathematics difficulty.

Lewis (2014) chooses another approach when exploring mathematics difficulty. She proposes that we view MD in terms of cognitive differences rather than deficits, and instead of focusing on the absence of a skill, she asserts that we should focus on the knowledge these students have already formed and use their persistent understandings as a springboard to create screening items that target their view of mathematics. Lewis’s (2014) framework rests on the Vygotskian principle that learners with disabilities develop using different pathways resulting in certain persistent understandings. The tools teachers normally use to facilitate student learning may not be accessible for these learners causing them to be unsuccessful in spite of the interventions in place. In her study, she

compared the persistent understandings that students developed with respect to fractions and was able to identify similar persistent understandings used by both students. When identifying fractions and performing operations on fractions, the two students in this study attended to the fractional complements instead of the fractional amount. Also, when demonstrating their understanding of a half, both students focused on the action of splitting the whole rather than the quantitative amount represented by the fraction.

Further research could determine if these persistent understandings are common to students with mathematics difficulty when working with fractional amounts, and cognitive differences like the previous examples can be used as predictive indicators on screening assessments rather than emphasizing a deficit in quantitative reasoning and a lack of number sense. Using a cognitive differences will allow educators to look for certain lines of thought and reasoning in order to make an informed decision on which students may develop MD in the future.

Components of Effective Intervention

Interventions targeting problematic areas for students that have been identified as at-risk for mathematics difficulties should be designed and implemented carefully. Several studies evaluate the efficacy of interventions and their overall effect on students in elementary school settings (Powell & Fuchs, 2010; Bryant et al., 2008; Witzel, Mercer, & Miller, 2013; Jitendra et al., 2013). Commonalities between these studies are apparent when comparing and contrasting the methodologies presented, and several characteristics of effective intervention are related to the type of instruction, mathematical modeling, and instructional materials.

Small-group instruction. Several methodologies describe the implementation of small-group tutoring sessions (Powell & Fuchs, 2010; Bryant et al., 2008; Witzel, Mercer, & Miller, 2013; Jitendra et al., 2013). This model is beneficial for students because the interventionist is able to devote more attention and time to each child since the group is smaller in size. In my experience, students are more willing to share ideas with each other and model their thought process for other members in a small group setting. This approach to providing remediation was effective for most studies especially those that used small-group instruction in combination with other intervention strategies.

Schematic based-instruction. Using schematic based-instruction also proved to be useful when designing interventions. Allowing students to familiarize themselves with the underlying structure of a word problem enabled them to adapt to novel word problem situations. For example, applying their knowledge of certain problem situations like change, group, and compare schema that require addition or subtraction strategies allowed students to go beyond one-step problems and attempt with some success more complex two-step word problems (Jitendra, 2013).

Explicit Instruction. Using direct instruction with students who experience mathematics learning difficulty has beneficial results because it provides structure and routine. For example, Powell and Fuchs (2010) compared students who received explicit instruction on the proper use of the equal sign and word problem tutoring to students who only received word problem tutoring. The explicit instruction provided students with many opportunities to practice using the equal sign appropriately, and they received reminders that the equal sign shows an equivalent relationship between both sides of an equation. This resulted in the students who received explicit instruction outperforming

other students with MD when solving open number sentences and nonstandard equations (Powell & Fuchs, 2010).

Mathematical Modeling. Visual representations can be used as a transition between concrete representations and abstractions of mathematical concepts. Witzel, Mercer, and Miller (2013) demonstrate this concept in their study focusing on teaching algebraic concepts using a Concrete-to-Representational-to-Abstract (CRA) instruction model. The students who participated in the CRA treatment group were allowed to use concrete objects and pictorial representations before reasoning abstractly about algebraic concepts, and they outperformed students who learned algebraic concepts using traditional abstract methods.

Visual representations can be a viable option for educators to use in their classroom for students as long as these models are accessible. Lewis (2014) describes two students in her study that were unable to use certain visual representations effectively when operating on fractional amounts. Instead, they adapted these tools and fit them into their current understanding of fractions. Because these representations were not accessible to them and their understanding of fractions, they were unsuccessful when using them, and other representations should have been used in their place.

Instructional Materials. The curriculum design also has an impact on the effectiveness of an intervention program. Curriculum materials can actually be considered a Tier I intervention, and “when well designed, their instructional framework helps teachers deliver effective instruction so that all students, including students with MD, gain cognitive access to fundamental content (Doabler, Fien, Walker, & Baker, 2012, p. 208). Clarke et al. (2011) used the Early Learning in Mathematics curriculum for

Tier I intervention, and the overall design of the curriculum offered many benefits to the students because it included explicit instruction and CRA models among other things.

Further Research

Research on mathematics difficulties has been fairly inconsistent. The selection criteria for participants in studies reflect a wide range of definitions that use different cut scores and standardized tests. Using recommendations based on a study that identifies mathematics difficulties using a cut score of the 25th percentile and below may not apply to students in another study that have been identified based on the 40th percentile and below.

Research in this area is also dominated by investigations that focus on number sense, quantitative reasoning, and word problems. Research targeting how students with mathematics difficulties respond to intervention related to data, probability, geometry, and algebraic concepts should also be considered. Requiring students to verbalize their reasoning during interviews could allow researchers to access persistent understandings that students with MD may have in other strands of mathematics besides numbers and operations. Analyzing interview data of different students working through problem sets like this may help locate other cognitive differences shared by children with MD that could be useful during the identification and screening process.

Conclusion

Considerable research still needs to be carried out before we can quickly identify and remediate mathematics difficulty in elementary students. While it is unlikely that we will be able to prevent the occurrence of mathematical difficulties, there is a possibility of

reducing the achievement gaps if students with MD are detected early on and receive the evidence-based instructional support that they need.

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