Teacher Perspectives on Math E-Learning Tools for Students with Specific Learning Disabilities

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ABSTRACT
Students with specific learning disabilities (SLD) typically struggle in their K-12 math classes, limiting the likelihood of success in STEM fields. Private tutoring is reported to be effective at helping them succeed in math, but it is not a scalable solution. While many recent e-learning tools have aimed at personalizing math support in ways that might be scalable, there remains much to be done. To better understand the gaps between current tools and the particular needs of students with SLD (and of their teachers), we conducted semi-structured interviews with 10 middle school math teachers. Our findings shed light on both the learning challenges faced by students with SLD and on the instructional challenges their teachers experience with e-learning tools. Further, we came to appreciate the importance of harnessing teacher perspectives in the design of effective e-learning tools for special students.

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Learning Disabilities; Special Ed; STEM Ed; EdTech

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• Applied computing~Education • Human-centered computing~Accessibility

INTRODUCTION
K-12 math education lays the foundations for STEM education and careers. Persistently poor math performance in school and on standardized tests diverts students from pursuing further study or careers in STEM-related fields. Unfortunately, results from the math portions of the National Assessment of Educational Progress (NAEP) [16] show many US students performing dismally—and this holds even more true for students with specific learning disabilities (SLD). For example, in 2013, only 26% of students with SLD reached the *Basic* level performance in 8th grade [20].

Over 2.3 million students in the US are identified as SLD, which is a high-incidence disability [3]. Examples of SLD include dyslexia, dyscalculia, and dysgraphia. Common symptoms of dyslexia include slow reading and spelling difficulties. Dyscalculia is marked by varying degrees of difficulty with math concepts, calculating, number sense, number language, and problem-solving. Dysgraphia primarily affects writing. SLD derive predominantly from disorders that involve understanding or using language [19].

Studies [8, 10, 18] have demonstrated that many students with SLD are able to achieve math proficiency when given appropriate intervention adapted to their processing differences and learning progress. Currently, positive outcomes are most likely when a well-trained tutor employs 1-to-1 alternative intervention intensively over time [6, 15, 21]. However, such tutoring is not affordable for many families—nor is it scalable.

To reduce the access barriers to personalized math interventions, researchers have developed tools such as intelligent tutoring systems (ITS) [2, 5, 9, 11, 13, 23] and educational games [1, 4, 12, 22], few of which are designed for students with SLD [11, 22, 23].

In this study, we sought to explore remaining gaps between the personalized support of current tools and the math needs of students with SLD. Towards that end, we interviewed 10 US middle school teachers experienced in teaching math with SLD students within the real-world constraints of math classrooms. We anticipated that these teachers would offer valuable insights into the instructional challenges their students posed.

INTERVIEW STUDY
Ten teachers participated in the interview study (7 female, 3 male). Their ages ranged between 25 and 62 years. They had between 1.5 and 35 years of experience in teaching special-ed students. We required that participants be state-certified in both general and special education, have taught math with 5th-8th grade to students with disabilities, including SLD in special classes or integrated co-teaching (ICT) classes. Participants were recruited through social media and email.

The semi-structured interviews included questions related to the following topics:

- Challenges that students with SLD showed in learning math and attempted teaching solutions: *e.g., Could you tell me about the challenges that students with SLD experience? How have you addressed their needs?*

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- Information about student work that teachers need to know to help students with SLD: *e.g., Besides correctness rate, what else do you need to know in order to help students with SLD?*
- Educational technology (EdTech): *e.g., Do you use any software to help students learn mathematical concepts? Is software like IXL suitable for students with SLD?*

Interviews were conducted face-to-face or remotely over the phone, Skype or Google Hangouts and lasted 40-60 minutes. Interviewees received a $20 Amazon gift card. All interviews were audio recorded then transcribed. Based on the transcriptions, we used an open-coding technique [17] to find common themes shared across interviews. In the findings, we include quotes from interviewees identified by ID numbers following the letter P for "participant" (e.g. P1).

FINDINGS

Teachers worked to propel learning mostly during classroom periods. Compared with homework and afterschool learning, all participants gave classroom interaction the highest priority: *"I think homework is a tricky subject. […] is it a lot of learning? No, I'm pushing a lot of learning in class."* (P6) because *"students don't get a lot of support at home."* (P2)

Participants spent a lot of class time and effort addressing two main student challenges: first, students' difficulty understanding vocabulary and math problems. P7 explained that *"they struggle to figure out what it is that they need to do because they really don't understand what's been asked […] They can't take the words and turn it into 'oh, I need to do this,' 'oh, I'm asked to do this.'"* Second, students' weak math foundation. P3 reflected that "*A lot of their numbers sense and foundational skills are low. You can't really rely on, 'oh, they learned this last year.'"*

Teachers had viable strategies to teach math to students with SLD. All of our participants emphasize the importance of using multimodal instruction when students are struggling to "visualize" mathematical concepts or operations through language-based communication: "*Fifth grade is really heavy with fractions. So, using fraction tiles is really helpful for these students to see visually.*" (P9)

To help students with SLD interpret written math problems, many participants taught their students to highlight and organize important information in the word problem before rushing to solve it: *"So we do close reading with the students, including underline, highlight."* (P7) and "*I have CUBES charts* [7] *they used to break the problem down."* (P10)

E-learning tools did not provide enough information about students' (mis)understandings or connect with teachers' efforts in a useful way. The majority of e-learning tools provided only (in)correctness as an outcome, so teachers had too little feedback to effectively modify their teaching: *"I need to see how they were progressing and if not then I needed to see how I could break it down and either re-teach it or teach it in a different way or at what point students were getting stuck.*" (P1)

Many tools in current use do not help teachers see students' work process. Most input is typed, which is cumbersome, and obscures typical student difficulties. As a result, some teachers chose not to assign work digitally: "*We want to see the work so bad that we don't want them to type.*" (P4)

Many e-learning tools provide immediate feedback with the step-by-step breakdown presented in a large chunk of text and lines of formulas: *"It's just a string of steps and words so like, it's possible that students might see that and be intimidated by like, how many words there are."* (P3) Also, when students make a mistake, they are frequently asked to retry the same question without probing whether they had trouble understanding it.

DISCUSSION

Prior work [11, 22, 23] with e-learning tools for students with SLD has rarely considered how teachers—as active users—integrate the use of e-tools. As a result, our participants could not connect their teaching strategies with these tools, nor could they ascertain what tripped up their students. Because teachers push most learning in the classroom, if teachers cannot easily integrate these tools within the classroom environment, students will not be able to benefit from them.

Based on our findings, we provide design recommendations for effective and inclusive e-learning tools. Given the teachers' emphasis on multimodal pedagogies [14], e-learning tools would be more inclusive if they provided virtual manipulatives (e.g., number lines, fraction tiles) for teachers to carry them over into classroom practice. Hints, when provided, assume that students understand what the problem is asking and focus on helping them do the math. More inclusive tools would also provide scaffolding for reading and interpreting problems.

In addition, e-learning tools should help teachers trace a student's mis-thinking. They could include voice recording, handwriting, sketching, and *moveable* virtual manipulatives. If students make consistent error patterns, experience a prompt as unclear, or are becoming frustrated, then the tool should help the student pinpoint the breakdown and diagnose students' related math fundamentals. Teachers could then draw on this diagnostic information to adjust instructions—particularly for fortifying students' math foundation.

CONCLUSION

Our study of 10 special education teachers revealed that e-learning tools are not sufficiently effective or inclusive for the large number of students with SLD. We have provided specific guidelines and advocate future work on effectiveness of e-learning tool design that expands the target audience from students to teachers-of-students. In doing so, we anticipate accelerating EdTech adoption and its ongoing use in classrooms. In the larger frame, such changes can increase math learning and enjoyment for many more students.

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