Title:
Diagnostic Learning Progressions Framework: Developing an Embedded Formative and Summative Assessment System to Improve Learning Outcomes for Elementary and Middle School Students with Mathematics Learning Disabilities.

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Background / Context:
Description of prior research and its intellectual context.

This project is designed to develop and validate a formative and summative classroom assessment system, embedded with Universal Design for Learning (UDL) principles, for evaluating and promoting conceptual understanding of pre-algebra constructs for elementary and early middle school students with mathematics learning disabilities (MLD). Students with disabilities are among those most likely to have difficulties in math, often lacking knowledge, skills, and understanding foundational to mathematics. Although the concepts, goals, scope, and sequence of curricula are explicit in key resources such as the National Council of Teachers of Mathematics standards and even the Common Core State Standards, a *coherent (and empirically validated) conception of how learning progresses* is lacking, as are *valid and reliable formative and summative assessments* that provide meaningful, timely, and actionable diagnostic feedback on performance. The specific needs of *diverse learners* are ignored when the assessment content is presented similarly for all learners. In this project, we *hypothesize* that theoretically and empirically based learning progressions, serving as the foundation for building and validating UDL assessment materials for students with MLD, will be a powerful tool for improving the diagnostic and instructional utility of assessment data and facilitate access to science, technology, engineering, and mathematics (STEM) content for diverse learners.

Purpose / Objective / Research Question / Focus of Study:
Description of the focus of the research.

In collaboration with two other research organizations, we integrate principles of the BEAR Assessment System (Wilson, 2005) with Universal Design for Learning principles (Rose & Meyer, 2002) to develop and validate learning progressions and an aligned, universally designed formative and summative classroom assessment system for promoting conceptual understanding of number sense/operations for students with Math Learning Disabilities (MLD).

This research will help to create an effective and validated formative assessment system for meaningfully and validly diagnosing and promoting student learning outcomes on constructs central to number sense and operations for whole numbers up to and including elementary fractions. The assessment system will offer a powerful tool that will provide teachers cutting edge research and empirically based resources for validly monitoring student knowledge and progress, meaningfully interpreting evidence about student learning from formative assessments (including what students know and do not know about the target constructs), and successfully using formative data to adjust subsequent instruction. These tools will enable teachers to intervene with students who are struggling mathematically. Although developed specifically for students with learning disabilities in math, the system will be useful to all those who seek ways to assess and enhance students' conceptual understanding of early foundational math and facilitate access to STEM content for diverse student populations.

Setting:
Description of the research location.

The project setting is public elementary and middle schools in two of the country's largest and most diverse school districts in the Washington, D.C., metropolitan region and/or Baltimore, Maryland, one private school for students with learning disabilities located in Washington, DC, and one small school district right outside of Boston, MA.

Population / Participants / Subjects:
Description of the participants in the study: who, how many, key features, or characteristics.

The population is elementary and early middle school General Education (GE) and MLD students and their teachers. MLD students and their teachers are sampled from grades 1 through 8; GE students and teachers are sampled from kindergarten through grade 3. To date, 14 schools have been sampled to identify 65 MLD students and 50 GE students, in addition to 25 teachers who work with MLD students as well as GE students in inclusive classrooms. By the third year of the project, we expect to identify 400-450 MLD students and 150 GE students. In this project, teachers bring their unique perspectives about students' learning challenges and developmental patterns. They collaborate with our interdisciplinary design team and onsite coordinator to help identify and screen participants for inclusion in the study and provide critical feedback on learning progressions, assessment items, and scoring exemplars which aim to inform our understanding of students' skills and knowledge in mathematics. Intrusion on regular classroom time is minimal. Children are involved in this project in three ways; they respond to short assessments about their understanding of target math concepts once per year (taking no more than 25 minutes for completion); a small subsample of children participate in think aloud interviews and/or exit interviews while they answer items or immediately thereafter (taking no more than 25 minutes for completion); a small subsample of children contribute samples of their work from the classroom, homework, and/or notebooks to provide supportive evidence about their level of functioning on the target construct. Teacher and student participation is by consent only.

For inclusion, students with MLD must: (1) be identified under IDEA as having a Specific Learning Disability (LD),[1] (2) be eligible for or receiving Special Education (SPED) services, (3) have an individualized education plan (IEP) with goals in mathematics, (4) have standardized math test scores below the 25th percentile, (5) score in the lowest performance level in math on the Maryland state assessment, (6) have deficits in mathematics as their primary deficit, (7) not be English language learners.

Intervention / Program / Practice:
Description of the intervention, program, or practice, including details of administration and duration.
For Track 2, this may include the development and validation of a measurement instrument.

Drawing on key principles of the BEAR Assessment System (BAS), we are developing a theoretically grounded and empirically validated learning progression of how students with MLD

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[1] At the discretion of each state, young children are more likely to be diagnosed with a developmental delay rather than a specific LD or may have IEPs but not a diagnosis. Hence, we consider grade 1 and 2 students who are developmentally delayed and/or with IEPs for inclusion in our study, providing that they meet other stated criteria for MLD.

learn constructs important to number sense and operations for whole numbers and elementary fractions. This learning progression guides the development of formative and summative tasks and items to assess the students' knowledge and understanding relative to the learning progression. Because one size does not fit all, we integrate UDL principles into the assessment design. Finally, we plan to measure assessment reliability and validity to ensure high-quality evidence.

Research Design:
Description of the research design.

We employ an iterative model of theoretically and empirically based design, development, and validation of all assessment components (i.e., learning progressions, assessment items, and scoring exemplars). We iteratively collect, analyze, and synthesize data from the literature, interdisciplinary experts, teacher panels, and students to develop and finalize all products.

Data Collection and Analysis:
Description of the methods for collecting and analyzing data.
For Track 2, this may include the use of existing datasets.

Data sources will include research synthesis of how students develop important concepts in number sense, interdisciplinary feedback from our team of experts, data from the administration of newly developed assessment items and cognitive think aloud interviews, students' artifacts from the classroom, existing data about students' performance on state and standardized math achievement tests, data from the Number Knowledge Test, and the teacher-administered Learning Disabilities Diagnostic Inventory. Teacher feedback about products will also be critical to its iterative development.

To validate the assessment system, we will use quantitative and qualitative data analysis techniques. Qualitative methods will include synthesizing findings from the literature, interdisciplinary team discussions, teacher and expert panels, and think-aloud child interviews. Quantitative methods for determining psychometric properties and answering research questions will be unidimensional and multidimensional item response models, linear logistic test models, and repeated measures analysis of variance.

Findings / Results:
Description of the main findings with specific details.

Data collection has been completed and analyses are underway and will be completed by August 2011. At SREE in September 2011, I will report on some of our early observations, lessons learned, and initial findings during our Year 1 research and development activities, highlighting specificities and changes to our process that result from working with our target population of students – those with and without MLD. I will also present examples of our current learning progressions and assessment items.

Conclusions:
Description of conclusions, recommendations, and limitations based on findings.

This project is innovative in two significant ways: (a) it applies a learning progressions methodology (BAS), for the first time, to developing formative and summative assessments for students with Mathematics Learning Disabilities (MLD) and (b) it integrates BAS and the principles of UDL for the first time to design and develop a formative and summative classroom assessment system. Because of these innovations, this project extends our knowledge in the field and provides a model for future assessment design and development for special education students using an integrated learning progressions and UDL framework.

This project has strategic value that emerges from (a) its emphasis on students with MLD, who are more likely to struggle in math, and the applicability of its resources and benefits to all learners; (b) the synergy and joint expertise in assessment, measurement, developmental psychology, cognitive science, special education, neuroscience, teaching, and learning our team brings to meet this challenge; (c) its harnessing of the affordances of online assessment delivery; and (d) its emphasis on the development of research and empirically based resources intending to facilitate teachers' use of diagnostic assessment data for understanding students' difficulties, informing instruction, and improving student learning. The empirically based materials that are being developed (i.e., learning progressions, aligned assessment items, and scoring exemplars) will help identify gaps, limitations, and discrepancies in current theory and practice about how learning in mathematics develops, particularly for those with MLD. The research will contribute to increasing the specificity and coherence of state and nationally developed standards in mathematics and the assessments aligned to those standards. Moreover, our work will allow all learners to work toward the same learning goals (albeit using different strategies and accounting for different abilities) and will spur new thinking about standards and performance expectations for the general education and special education populations.

The project has a broader transformative potential that arises from realization that the innovative resource proposed could overcome serious obstacles and offer crucial advantages over current assessment practice. The project's broader impacts include (a) the accumulation of rich data about developmental progress, difficulties in problem solving, and knowledge acquisition in math for students with MLD; (b) the creation of UDL-enabled validated assessments—based on fundamental content so that it is relevant to a variety of curricula—and an interpretive framework for evaluating and promoting classroom learning, thereby allowing the broader participation of underrepresented groups; (c) a ―model" for producing guidelines for developing learning progressions, assessments, and scoring exemplars, including specific considerations for those with MLD; (d) the potential for extension of our methodology to other STEM areas and/or to other special populations to facilitate the efficient development of high-quality measures; and (e) the dissemination of materials developed to all interested school districts.

Appendices
Not included in page count.

Appendix A. References
References are to be in APA version 6 format.

Seeratan, K., Draney, K., Wilson, M., Haertel, G., Murray, E., & Blackorby, J. (April, 2011). *Diagnostic Learning Progressions Framework: Developing a Universally Designed Formative and Summative Classroom Assessment System for Students With Mathematics Learning Disabilities.* Paper presented at the American Educational Research Association Conference (New Orleans, LA).

Rose, D., & Meyer, A. (2002). *Teaching every student in the digital age: Universal Design for Learning*. Arlington, VA: Association for Supervision and Curriculum Development.

Wilson, M. (2005). *Constructing measures: An item response modeling approach*. Mahwah, NJ: Lawrence Erlbaum Associates.

Appendix B. Tables and Figures
Not included in page count.