Teacher-Student Interactions within Mathematics Instructional Contexts in Classrooms Serving Students with Autism

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Background & Significance

Mathematical Practices. Achievement in mathematics is one of the strongest predictors of lifelong success (Gamse et al., 2009). However, despite considerable efforts ineffective instruction in math remains a critical educational problem across the U.S. This problem is intensified for learners with disabilities, with only 13% performing at or above a proficient level of mathematics by the 4th grade (NAEP, 2017). Studies have shown that students with disabilities typically engage in low rigor mathematics despite evidence suggesting they can engage in more rigorous and grade-level mathematics (Browder et al., 2008, Lambert et al., 2018). Currently, there is little research that sheds light on "best mathematics practices" for students with autism, of which this study aims to do.

Teacher Language. An increasingly robust body of literature identifies interactions between teachers and their students as an important intervention target for student development and academic learning (e.g., Howes et al., 2008; Pianta, 2016). High quality interactions, in which teachers are responsive to their students and ask open-ended questions to encourage students' generativity, has been associated with student engagement, accelerated academic development, communication and language development, and fewer problem behaviors (e.g., Burchinal et al., 2008; Connor et al., 2020). Little is known regarding the role that interactions play in classrooms serving students with autism.

Study Purpose and Objectives. This study used classroom video observations to examine how teachers (with a range of knowledge, skills, and practices) teach mathematics lessons and how learners with autism (with a range of skills and abilities) engage in these learning opportunities. Specifically, we investigated varying mathematical tasks presented to students with autism during mathematics lessons, the amount and types of talk teachers used within the mathematics tasks, and the degree to which students participated.

Methods

Participants. Participants included 86 preschool–3rd grade students with autism (M = 6.91, SD = 2.01) and their 49 educators within general and special education classrooms across 17 districts in CA who were recruited for a longitudinal project evaluating the efficacy of a classroom-based intervention.

Procedures. As part of the longitudinal project, students participated in a diagnostic battery at the beginning of the school year to assess the presence and severity of autism symptoms and cognitive functioning. Teachers completed a questionnaire to measure students' adaptive functioning and the presence of problem behavior.

Standardized Measures Teacher Questionnaire	M	SD
Cognitive Abilities (DAS-II)	85.26	18.40
Autism Symptoms (ADOS-2)	7.73	1.60
Teacher-Rated Adaptive Behavior (VABS-II)	70.17	11.08
Teacher-Rated Problem Behavior (PDDBI)	52.43	11.51

Observational Procedures and Measures. Teachers and students were also video-recorded in their classrooms while participating in a variety of activities. Data for this study included video observations collected from the beginning of the school year. We systematically selected videos that included mathematical lessons (activities incorporating numbers, patterns, and measurement), and then coded mathematics tasks, teacher language, and student engagement within each lesson using Noldus Observer XT 14, 2017).

We identified the duration of time teachers provided instruction across **4 types of mathematics tasks** based on a framework of cognitive demand outlined within the general education literature: Recall & Reproduction, Procedural, Conceptual, and Problem Solving (Stein et al., 2000; Van de Walle et al., 2019).

Math Tasks	Description	Example Activities
Recall & Reproduction	Directly recalling or reproducing information, repetitive exercises	• Rote counting • Repeating numbers or patterns • Matching numbers
Procedural	Learning a math procedure; following step-by-step instructions for math computation	• Practicing steps of a numerical operation (e.g., multi-digit division or regrouping) • Using touch math strategy to find the answer to an addition equation
Conceptual	Building student understanding around a concept; understanding how and why a procedure works	• Understanding why and how to "regroup" from the tens place • Using manipulatives to represent an equation
Problem-Solving	Promote student reasoning and analytical thinking	• Solving word problems • Thinking logically about the relationships among concepts and situations solving word problems • Providing explanation or justification

We drew from the extant literature for guidance in examining teacher language and coded each instance that teachers used 5 categories of language:

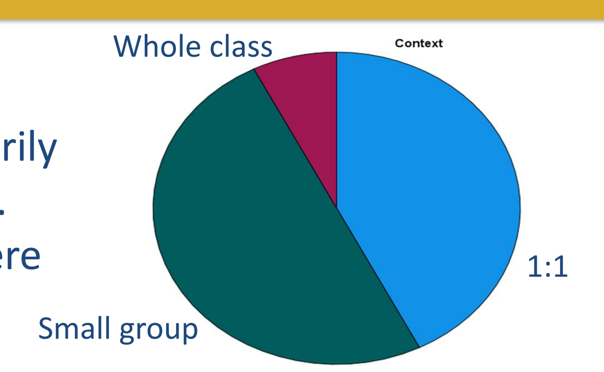
- **Responsive Language** – *"Yes, you are correct. We need to add 4 more."*
- **Open-Ended Questions** -- *"How we can solve this problem?"*
- **Close-Ended questions** -- *"What two numbers do you need to include in your problem?"*
- **Task-Related Directives** – *"show me 4 counters on your number strip"*
- **Non-Task Related Directives** -- *"sit down," "get your pencil," "stop," "quiet hands"*

We adapted the *Classroom Measure of Active Engagement* (CMAE; Sparapani et al., 2016) to evaluate student active engagement across 3 dimensions:

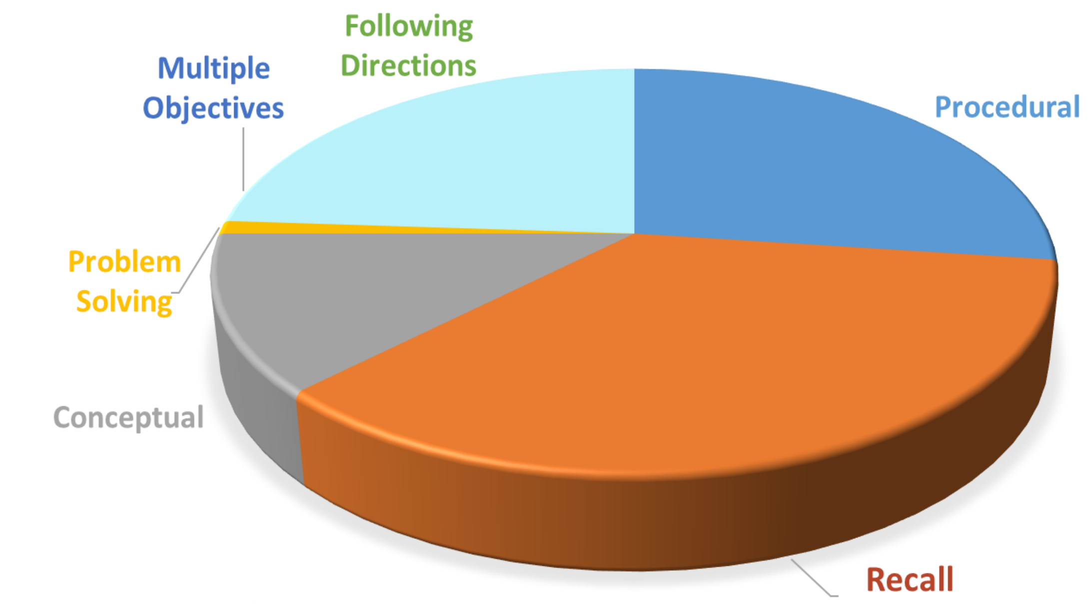
- **Emotion Regulation**: The amount of time that students spent well-regulated
- **Productivity:** The amount of time students had access to and used materials productively
- **Initiating Communication**: Each instance students directed communication toward a partner

Findings

Instructional Context. We observed **134 tasks in total**. Tasks were 12.22 minutes in length on average. We found that teachers primarily delivered tasks within 1:1 (43%) and small group instruction (50%). Very few tasks were delivered via whole class instruction (7%). There were no tasks that were delivered via peer-mediated instruction.



Mathematics Tasks. We observed 134 tasks in total (M = 12.22). We found that teachers delivered recall and procedural tasks most often--tasks that require low/medium cognitive demand. They also delivered 2 types of tasks outside our framework. Teachers' decisions were influenced, in part, by students' cognitive abilities F (29) = 1.11; $p < 0.05$. and problem behavior F (29) = 2.29; $p < 0.05$.



Teacher Language. Teachers used more non-task related directives ("sit down") than all other language categories (M = 17.32; 24.26). Some teachers were very responsive (39), while others did not use any responsive language. We observed few task-related directives [M = 5.8; 9.7), and only 3 tasks included open-ended questions.

Student Engagement. Recall Tasks were characterized by a low frequency of teacher language and low student productivity (M = 1:38; SD = 3:11). Teachers used significantly more **responsive language** during conceptual tasks ($p < 0.05$). Students spent significantly more time **well-regulated** (M = 7:12, SD = 5:00) and **productive** (M = 4:29, SD = 5:18) during **conceptual tasks** than recall and procedural tasks ($p < 0.05$).

Conclusions

Our findings suggest that some students with autism may be receiving less than substantive learning opportunities in mathematics, which may have important educational consequences. Specifically, different mathematical tasks appear to be associated with differences in student active engagement and skill development. Rather than simplifying or "watering down" the richness of the mathematics tasks for specific learners, it seems important to maintain the rigor of the learning opportunity and instead include scaffolds, modifications, and/or adaptations to help students access the mathematics content. We also argue that this might have equitable implications for learners with autism, highlighting the need to view students with autism as capable learners that bring strengths into the learning opportunity. However, future research is needed to further understand the impact of varying mathematics tasks on learning outcomes.

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