**FROM TRAJECTORIES, DEFICIT, AND DIFFERENCES TO NEURODIVERSITY: THE CASE OF JIM**

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*Cognitive differences intrinsic to children with learning disabilities (LDs) have historically led to deficit assumptions concerning the mathematical experiences these children “need” or can access. We argue that the problem can be located not within children but instead as a mismatch between instruction and children’s unique abilities. To illustrate this possibility, we present the case of “Jim,” a fifth-grader with perceptual-motor LDs. Our ongoing analysis of Jim’s fractional reasoning in seven equal sharing based tutoring sessions suggests that Jim leveraged his knowledge of number facts and alternative representations to advance his reasoning.*

Keywords: development, learning differences, conceptions, equity

Over their school-age years, many children tend to experience difficulties with fractions. For children with learning disabilities (LD), the difficulties can become persistent and grow into unique learning challenges. As a result, researchers continue to focus on ways these children develop *understandings* of fractions as quantities (Hunt, Westenskow, Silva, & Welch-Ptak, 2016) to provide evidence of and access to the potentially rich mathematics in which these children *can* engage.

Unfortunately, these illustrations stand in sharp contrast to the current literature base and policy recommendations for mathematics instruction for children with LDs. Previous research clearly illustrates instruction for these children have been dominated by basic concepts (Kurz, Elliott, Wehby, & Smithson, 2010). A recent review (Lambert & Tan, 2016) of articles researching the mathematics learning of Kindergarten through 12th grade students found significant differences between the mathematical teaching practices used with children with and without disabilities. Mathematical teaching and learning were informed largely by constructivist and sociocultural perspectives with children *without* disabilities. For children *with* disabilities, mathematical teaching and learning were informed primarily by medical and behavioral perspectives. The distinction is concerning as it suggests two categories of mathematics learners who “need” different kinds of mathematics.

Our work both builds on and critiques work on learning progressions (or learning trajectories). Original discussions of trajectories (Martin, 1995) stressed their hypothetical nature and did not separate actualized trajectories from the teachers and children involved in specific instances of learning. Currently, the term suggests an expected course of development or simplified learning path in a concept area, such as early fractions. When considering children with LDs, who may use different or more informal ways of reasoning than educators might expect, we are concerned that educators might use progressions to direct children to move across the levels or stages of a progression without paying attention to the reasoning that children employ and work to support children to explore, revise, and advance that reasoning

**From Explicit and/or Leveled Instruction to Neurodiversity**

Attempts to remediate, or “fix,” children through procedural training or steering thinking through predetermined pathways or conceptual steps seems problematic if educators wish to provide access to and support reasoning that children with LDs *do* possess and build from it (Hunt et al., 2016). In fact, we contend that these kinds of approaches to remediation may work in part to disable these children more so than their learning differences. Disability Studies (DS) recognizes that although individuals have natural biological variations, it is the social effects of difference that disable rather than the impairments themselves (Siebers, 2008). From the DS perspective, the behavioral/directive tradition apparent in much of the instruction these children experience portray learning differences as deficits *within individuals* that results in viewing difference as something to be fixed as opposed to a natural strength that can be leveraged in instruction. Neurodiversity (Robertson & Ne’eman, 2008) positions cognitive differences as not only natural biological differences, but as potential strengths. For example, individuals with LD demonstrate cognitive strengths in three-dimensional reasoning and creative problem solving (Eide & Eide, 2012). Using this lens, we sought to understand the fractional reasoning of one fifth grade children with perceptual-motor LDs as he worked in fractional tasks meant to support two ways of reasoning fundamental to early fraction knowledge: partitioning and iterating (Steffe & Olive, 2010). We utilized equal sharing (i.e., equally sharing an object or objects among a number of people, where the result is a fractional quantity) because it invites multiple means of reasoning and representation. The research question was, “What ways of partitioning and iterating does a fifth-grade child with LDs display in equal sharing tasks?”

**Method**

**“Jim”**

“Jim” (age = 12 years) attended elementary school in the Northwestern United States. He was identified by his school system as having a learning disability in mathematics. Jim’s performance on the mandated standardized state measure of math performance was at a failing level in 3rd, 4th, and 5th grade, which suggests sustained low achievement in mathematics. His reading scores were at average levels. Jim had received over two years of additional support in fraction concepts and operations that included shading pre-partitioned models and procedures for operations. Finally, Jim evidenced significant difficulties with visual motor integration (i.e., coordination of visual perception and motor skills at 2nd percentile).

**Teaching Experiment**

Data collection was collected in seven sessions of a teaching experiment (Steffe & Thompson, 2000). Sessions took place during school hours and were in addition to the child’s regular math class time. The first and second author attended all tutoring sessions and collaborated throughout the ongoing analysis of teaching episodes. The first author was the researcher-teacher. The second author acted as a witness (e.g., took extensive field notes, observed the interactions to provide an outsider’s perspective during on-going analysis). All authors are engaged in retrospective analysis of the data (described below). Researchers collected three sources of data: transcribed video recordings, written work, and field notes.

**Tasks, teaching moves, and representations.** We prepared problem tasks, representations, and possible teaching moves based on previous evidence of how children with LD might reason in equal sharing tasks (e.g., 3 people share 4 items, Author). Tasks were planned to be dynamic (i.e., adaptable to the child’s current conceptions) and presented to Jim in realistic contexts that we changed according to his preference. In each task, the number of sharers ranged from two to ten and the number of objects shared ranged from three to 13. The problem-solving tasks were designed so that Jim could use a variety of strategies and representations (e.g., drawings, Cuisinaire rods) to reason about the mathematics. Teaching moves were broadly defined as responsive to the child’s thinking (e.g., extending, supporting).

**Data Analysis**

Ongoing analysis of critical events (Powell, Francisco, & Maher, 2003) in the child’s thinking and learning were noted and discussed before and after each session. The focus was on generating (and documenting) initial hypotheses as to what conceptions could underlie the child’s apparent problem solving strategies during these critical events. These hypotheses led to planning the following teaching episode. We are currently using retrospective analysis to delineate Jim’s informal conceptions of fractional quantities, how his reasoning shifts during each tutoring session, and what his conceptions were during the final session. We are also currently working to identify possible indicators of Jim’s conceptual growth using the constant comparison approach (Leech & Onwuegbuzie, 2007). Reported results are tentative.

**Preliminary Results**

**Initial Reasoning: Session One**

Jim had just solved several tasks involving whole number partitive division. Excerpt a begins with an extension of the partitive division situations.

*Excerpt a: Share 7 granola bars between 3 friends*

J: [*gives two whole items to each person*] And of course there would be one left over. [*draws a long bar; carefully marks a small dot at the top middle of the bar and draws a line straight down; then uses the same mechanism to mark each of the two parts into two more parts]. Ok, so they each get a slice of the one that’s left. And there’s another piece left [begins to partition the fourth part into four parts using the same mechanism*[[1]](#footnote-1)].

T: Oh. So [*labels each part*], so if this is my part, and this is yours, and this is Nita’s, you say you have this piece left. And we cut it up again. Any way to do it, so we don’t have to keep cutting?

J: [*attempts to partition two additional times by spinning the paper and draw a line from one of the corners*] I really don’t know of any other way to do it.

T: Ok. Any way to know what to call that parts you made?

J: [*pauses for 5 seconds*] I’m not sure.

In the first session, Jim evidences what we call a *midpoint partitioning strategy*. His partitioning seems to be supported by a careful identification of the midpoint of the length and a unilateral partition. The strategy does not yet seem to be linked with the number of sharers in the situation, a consideration of the magnitude of the parts created, or an iterative consideration of the parts to the whole. In other problems in the session, Jim continues to use the midpoint strategy regardless of the number of sharers. It is unclear whether Jim was conflating partitions with parts (i.e., three lines as opposed three parts), yet Jim’s alternate strategies provide counter evidence of this possibility. It is interesting to us that, throughout the session, Jim seems to view the midpoint as the only valid partition at this point. In later sessions, Jim continued to evidence this strategy in his work in equal sharing tasks, regardless of the number of items or the number of sharers.

**Session Four**

In session four, Jim began to connect his number knowledge to his midpoint partitioning strategy to bring about an early iterative reasoning. Excerpt b shows Jim’s reasoning in a task involving five sandwiches and four sharers.

*Excerpt b: Share 5 sandwiches between 4 people*

J: [draws 5 boxes on the paper; makes a lengthwise and widthwise partition to create four parts in each box. Numbers and names each part].

T: Tell me about your drawing.

J: Well, I made lots of tiny pieces.

T: Oh. How many?

J: [pauses for 5 seconds and looks at his drawing] Well, there are five boxes and four tiny pieces in each. Four times five is 20 and 4 + 4 + 4 + 4 + 4 is 20 [points to each box as he counts].

T: Ok [points to drawing]. How much of a sandwich would I get, do you think?

J: [Looks at drawing] Well, you get five tiny pieces out of all of the 20 pieces of sandwiches.

T: Oh ok. How about for one sandwich?

J: Hmm. Well, [mutters ‘four times one is four’] four of the tiny pieces is a whole sandwich because four times one is 4, and one part and one part and one part and one part is a sandwich [points to one part; taps table four times]. And then one more. So a whole sandwich and a piece.

Jim shows three subtle shifts in his reasoning. First, his way of partitioning seems to have changed to a repeated halving, perhaps due to his self-prompted change of representation from a bar to a square representation. Second, he partitions *each* square into the number of sharers (as opposed only the last item). Partitioning each item also seems to support the final shift which involves a nascent iterative consideration of the parts to the whole[[2]](#footnote-2). This reasoning seems further supported by Jim’s leveraging of his whole number fact recall to support his reasoning of each person’s share as first a share of a subset of the total number of ‘tiny pieces’ he creates and then as a rudimentary coordination or iteration of the part to the whole. We are further examining how Jim’s use of multiple modalities (i.e., changing representations, verbal number facts, gesturing) support his partitioning and iterative reasoning in later sessions, especially in tasks where partitioning proves difficult (e.g., requests to share between 3 or 5 shares).

**Discussion**

Jim’s significant initial misunderstandings about fractions would typically be addressed by behavioral interventions in special education focused on memorizing procedures. In this study, we explore how close analysis of previous understandings based on research in fraction learning can be the framework of an intervention, particularly when the student is understood not as deficient, but as always already having knowledge of the mathematical topic. These two excerpts highlight one of the multiple shifts we document in Jim’s understanding of fractions. We argue further that these shifts in understanding were supported by 1) problem solving in contexts, 2) access to multiple modalities, and 3) instruction that builds from careful attention to previous understandings.

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1. Our presentation will include the child’s work. [↑](#footnote-ref-1)
2. We do not claim that the parts are fractional for Jim at this point, only that he seems to consider their coordination to the whole in a rudimentary way. [↑](#footnote-ref-2)