An update to this article is included at the end

Journal of Mathematical Behavior 54 (2019) 100672

Contents lists available at ScienceDirect

Journal of Mathematical Behavior

journal homepage: www.elsevier.com/locate/jmathb

A disability studies in mathematics education review of intellectual disabilities: Directions for future inquiry and practice

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ARTICLE INFO

Keywords:
Disability studies
Mathematics education
Intellectual disability
Equity
Social justice

ABSTRACT

We employ a Disability Studies in Mathematics Education perspective to explore current research involving students with intellectual disabilities. Such perspective affords a critical and social-cultural angle into the construction of disability in mathematics education. Results of our exploration suggest that current research on students with intellectual disabilities largely focused on finding deficits and neglected students' capacity for abstract thought. Moreover, while socio-cultural or socio-political (e.g., equity-based) foci are prevalent in contemporary mathematics education, such foci were largely absent in research involving students with intellectual disabilities. Yet, we identify features of several articles that can inform future socio-political mathematics education research related to individuals with intellectual disabilities. These features are critical for the continual advancement of new knowledge, equitable practices, and global, inclusive education agenda.

1. Introduction

This study uses a critical perspective to take stock of the current state of the research in mathematics education related to students with intellectual disabilities. We interpret the foci and research paradigms in recently published studies, arguing that it is crucial for the field to connect with the work of a growing number of international scholars and the global, inclusive education agenda to advance just knowledge and equitable mathematics practices. Our work in this critical review is congruent with what Shogren and Wehmeyer (2014) call the "third wave of inclusive education," which centers on what students with disabilities learn, exploring ways to find out how they are insured access to "challenging general education curricular content and instructional practices" (p. 238). Moreover, we align with disability studies in mathematics education (DSME) principles and practices in examining ways in which students with intellectual disabilities are honored as mathematics doers and thinkers

Students with an intellectual disability are not all alike (Faragher & Clarke, 2016) as diversity within this disability category is just as common as diversity within any human grouping constructs. For the purposes of this paper, we use the term *intellectual disabilities* broadly to refer to the different ways it has been conceptualized and sub-categorized. In the United States, for example, intellectual disabilities are one of 13 disability categories delineated in the Individuals with Disability Improvement Act (IDEA, 2004). Some genetic differences such as Down Syndrome and Williams Syndrome, as well as learners who score below a particular benchmark on

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https://doi.org/10.1016/j.jmathb.2018.09.001
Received 15 March 2018; Received in revised form 9 July 2018; Accepted 10 September 2018
Available online 22 November 2018

an intelligence quotient (IQ) and adaptive behavior (e.g., social and practical skills) assessments (Tassé et al., 2012) fall under the intellectual disabilities category. This categorical name replaced the term *mental retardation* in part to destigmatize the condition (Schalock et al., 2007). Similarly, a panel of international scholars have recommended replacing the term mental retardation with *intellectual developmental disorders* and define it within a health condition frame as "a group of developmental conditions characterized by significant impairment of cognitive functions, which are associated with limitations of learning, adaptive [behavior] and skills" (Carulla et al., 2011, p. 175). Regardless of the term used,[1] the labels of mental retardation, intellectual disability, and intellectual developmental disorders signal certain expectations about mathematics abilities as these "conceal more than they reveal and that the removal of these verbal screens allows us to see not just more, but also differently" (Ben-Yehuda, Lavy, Linchevski, & Sfard, 2015, p. 135). Paradoxically, as scholars conducting this research synthesis, the naming of this disability category is needed to identify targeted articles.

1.1. Mathematics educators' role in resisting deficit-driven traditions

Mathematics educators' work is preempted by the definitional confines set up by policies and diagnosis. Therefore, it is paramount to distinguish the deficit-oriented dimensions in the paradigm of dominant forms of research and education involving students with disabilities from the ethical and epistemological basis driving the disability studies conceptual scheme that we discuss in the current paper. Given the social and educational stigma associated with intellectual disabilities, this category perhaps more than any other disability label represents an important area in need of radical shifts. Its scholarship is dominated by deficit-centered traditions such as the use of procedural instruction (Hord & Bouck, 2012), a focus on basic mathematics skills (Butler, Miller, Lee, & Pierce, 2001), and narrow approaches to mathematics content (Lemons, Powell, King, & Davidson, 2015). A relatively small number of scholars have focused on examining more rigorous and sophisticated forms of mathematics involving students with disabilities (Baroody, 1999; van den Heuvel-Panhuizen, 1996). We argue that these scholars represent a way to resist dominant discourse around students with intellectual disabilities in mathematics and aim to reconstruct students boxed into this category. Such work may be thought of as counter-narratives that are inherently carried forth against the undercurrent of deficit-oriented research, policy, and practices; in turn, understood within sociopolitical perspectives of mathematics education (Gutiérrez, 2013). These perspectives along with the disability studies in education (DSE) framework (American Educational Research Association [AERA], 2017) ground our work as critical scholars.

1.2. Disability studies in mathematics education

Disability Studies in Mathematics Education (DSME) is a sub-field within the broader DSE movement. A central DSE premise is that disability should be understood in relation to social constructs and responses to differences. These responses often result in social exclusion and oppression in schools (Gabel, 2005). Importantly, DSE scholars acknowledge that biological differences exist. However, they are critical of the unjust responses to those differences (e.g., Lambert & Tan, 2017). In turn, their positioning departs from traditional deficit-oriented approaches and its groundings in positivism depicting disability as deficits located within individuals. Rather, DSE scholars focus on understanding ways to redress traditional practices leading to a disabling view of individuals (Valle & Connor, 2011). de Freitas and Sinclair (2015), for example, describe how efforts to understand *dyscalculia* as a mental disorder located within learners associated with difficulties "processing numerical information, learning arithmetic facts, and performing accurate or fluid calculation" (American Psychiatric Association [APA], 2013, p. 67) often leave the problematic diagnosis procedures unquestioned. In particular, de Freitas and Sinclair point to the narrow and limiting conceptions of number sense used in these procedures that do not reflect the complex, varied, and other humanness dimensions of number sense. Indeed, the DSME perspective elevates and interrogates such taken-for-granted labeling processes.

This current study utilizes DSME as an analytic tool because it affords a critical examination of mathematics education research that centers on issues of disability such as social constructions, stereotyped perceptions, discriminatory practices, and marginalization. Such examination helps guide more productive and liberating forms of mathematics education research and advocacy for and of individuals with disabilities (Tan & Kastberg, 2017). The DSME framework serves as a specific lens that attunes to issues of disability and mathematics education with a social justice stance. Situated within the sociopolitical turn in mathematics education (Gutiérrez, 2013), our utilization of this framework provides critical insights in examining existing knowledge and to guide future inquiries. This is consistent with Ferri's (2009) call: "rather than conducting more clinical types of research in the field of disability education, critical analysis of the current knowledge is needed" (p. 420). For this review, we foreground three interrelated DSME lenses: the nature of disabilities, the nature of mathematics classrooms, and the nature of mathematics learners.

1.2.1. Nature of disabilities

The first lens examines the ways in which disability is framed. In society and schools, disability is typically conceived as a fixed deficit or problem located within an individual. In mathematics education research, moving away from such disability constructions in research and practice involves, for example, "attention to and locating disability within inaccessible and inequitable mathematics curricula" (Tan, 2017, p. 22) and addressing related educational practices, such as professional learning, placement decisions, and

[1] For the purposes of consistency, we mostly refer to the wording *intellectual disabilities* throughout this paper without preference to a specific definition.

teacher discourse. Indeed, European scholars have grappled with these disability construction issues in terms of semantics by reworking the term *students with mathematics learning difficulties* to *students in mathematics learning difficulties*, a move from a deficit within an individual to deficit within the learning environment (A. Beggar, personal communication, June 7, 2018). Thus, examining the ways in which disabilities are reframed and relocated may be useful as it focuses on understanding barriers, both in and out of classrooms, to rich and robust mathematics education for students with disabilities (as opposed to offering rote and low-cognitive demand forms of mathematics curricula as a way to teach to perceived individual deficits). Importantly, this lens recognizes neurological differences between individuals such as the concept of neurodiversity (Baker, 2017). Yet, it critically attunes to the tendency for biological differences to be framed as deficits, which has been given the primacy in educational research and practice at the expense of documenting the social construction of disability in mathematics. In turn, DSME's nature of disabilities lens examines the extent to which disabilities is constructed as "differently abled and differently organized rather than disabled or distracted" (de Freitas & Sinclair, 2015, p. 145).

1.2.2. Nature of mathematics learners

The second lens extends the former by assessing the extent to which all students are regarded as mathematics doers and thinkers and capable of mathematical knowledge construction. In general, students with disabilities are subjected to mathematics content and processes that are of low-cognitive demand and remedial in nature, often several grade-levels below that of their age-group (e.g., Tan, 2014; Lambert & Tan, 2017; Hord & Bouck, 2012; Jackson & Neel, 2006; Kroesbergen & Van Luit, 2003). Even in situations where the content is said to be grade- or standards-aligned for students with disabilities, such content is often modified to a form that resembles low cognitive processes and tasks (Tan, 2016). Thus, this lens examines the extent to which cognitively challenging mathematics content and processes are central to the research.

In line with a sociopolitical perspective, this nature of mathematics learners lens also examines ways in which learning is structured around the wealth of lived experiences, cultural practices, knowledge, and interests (Turner et al., 2012) that individuals with disabilities bring. That is, instead of operating from deficit orientations, mathematics teaching practices and curricula highlights unique assets and skills in ways that underline the student's personhood and contributing capacity as co-learner. This lens also operates under the principle that there are ways of knowing and doing mathematics that are not well understood. What typically counts as knowing and doing mathematics as observable and measurable (e.g., being able to accurately reproduce a number of multiplication facts within a certain time frame) is but one determinate. In turn, this lens examines ways in which research moves beyond biological impairments or any of the socially constructed disability barriers that students with intellectual disabilities face as they engage in learning, which often leads to the determination of "appropriate" forms of mathematics education research, instruction and learning spaces (except for removing such barriers at the classroom and curricular levels of intervention). The examination of these mathematics learning spaces represents our third and final lens.

1.2.3. Nature of mathematics classrooms

This lens considers the extent to which students with disabilities are an integral part of the mathematics learning community alongside their peers, those with and without disabilities. In such learning environments, students construct knowledge alongside a full range of peers and make connections to and sustain their lived experiences (Paris, 2012). Moreover, it embodies the principle that mathematics is not only for all but also *of* all (Tan, 2017). That is, multiple mathematical knowledge bases (Turner et al., 2012) are valued and honored as examples of different ways of thinking and knowing mathematics which can add depth to the conceptual understanding in the community of mathematics learners. In turn, the elevating of students with disability's voices and lived experiences during mathematics interactions is a gateway to expand understandings of different ways of mathematics engagements that have been traditionally marginalized.

The work of inviting and understanding mathematics knowledge is not unidirectional. That is, consistent with a sociopolitical perspective (Martin, 2003), these mathematics learning spaces also strive for equity and social justice involving marginalized groups outside of school (e.g., Gutstein, 2003). Consequently, the nature of mathematics classrooms lens centers the learning of mathematics community in achieving equity in schools and beyond in redressing historical, social, and economical injustices and debt owed to those with disabilities (Thorius & Tan, 2015).

Employing these three interrelated DSME lenses, we address two broad research questions: (1) What are the foci and methods in recently published research in mathematics education concerning students with intellectual disabilities? (2) What kind of knowledge paradigms drives these research endeavors? As a whole, our aim in this study is to identify research and inclusive classroom research unique to the mathematics education field as conceived for all and of all which can translate into humanizing practices relevant for supporting students with intellectual disabilities.

2. Methods

Our search for articles was systematic, but not exhaustive. Thus, it may qualify as a large sample of studies published in the area of interest between 2006–2017. We began with 18 articles that included a focus on issues related to students with intellectual disabilities from a larger study (Lambert & Tan, 2016a, 2016b). That larger study examined mathematics education research reports involving students with disabilities and without disabilities published from 2013–2015. In the process of examining these 18 articles, we noticed that a few of these authors investigated their work related to students with intellectual disabilities in ways that departed from traditional deficit-oriented approaches and toward ways that reflect presuming competence. Thus, we were interested to learn more about the extent to which these articles existed in contemporary research and decided to expand our search to include the years

2007 to 2016. We selected this range to understand research that has been produced since the seminal special issue in the Equity and Excellence in Education journal was published in 2006. The articles in that special issue parallel our work here in moving to understand ways that disability is constructed in education and ways to value individuals with disabilities in and out of schools (Hamre, Oyler, & Bejoian, 2006). Since that special issue's publication, Hord and Bouck's (2012) review of articles involving mathematics education and students with mild intellectual disabilities provided key insights of articles published from 1999 to 2010. However, Hord and Bouck did not explicitly utilize a DSME lens in their analysis. Consequently, the time period for our review, 2007–2016, reflects an examination of contemporary articles through a DSME lens that extends previous key scholarly works from the fields of disability studies and mathematics education.

The search for articles chosen for this review involved using keywords with wildcards[2] across two spheres of terms in the ERIC, Education Research Complete, and PsycINFO databases. The first sphere of keywords attempted to capture articles that centered on mathematics in the study and included the terms *math* and arithmetic*. The second sphere of keywords attempted to capture articles involving students with an intellectual disability label as central to the study: *intellectual disab*, mental retardation, syndrome,*[3] *and developmental.* The search was designed to locate articles that contained at least one term in each of the two spheres (i.e., *sphere 1* AND *sphere 2*) in the abstract field and yielded approximately 1400 articles.

2.1. Criteria for inclusion

We examined the 1400 articles to decide whether they met the following criteria: (a) published in English or translated in English in peer-reviewed journals between the years of 2007 and 2016, (b) focused on mathematics education matters (i.e., curriculum design, instruction, dispositions, performance, assessments, teacher content and pedagogical knowledge, preparation, and development), (c) centered issues of or participants with intellectual disability labels[4] (i.e., intellectual disability, mental retardation, Down Syndrome, Williams Syndrome), and (d) were considered as original empirical studies, excluding dissertations and master's theses, and summaries, evaluations, analysis, or interpretations of original research. After reviewing the title, abstracts, and keywords of the roughly 1400 articles, we identified 40 studies that met all four criteria. The most common reason for which studies did not meet the criteria for this review was that they focused on multiple disciplinary domains beyond mathematics (e.g., English language arts, social studies, science), or studies that used mathematics achievement data as the sole source of connection to mathematics teaching and learning, which for us meant that mathematics education was not a central focus of the study. We also conducted a manual search in major mathematics education journals for articles published from 2007 to 2016, including the Journal of Mathematical Behavior, Journal of Research in Mathematics Education, Journal of Mathematics Teacher Education, For the Learning of Mathematics, and Educational Studies in Mathematics. The manual search yielded one additional study. Lastly, we conducted an ancestral search of articles included in similar reviews conducted by Hord and Bouck (2012), Lemons et al. (2015), and Spooner, Root, Saunders, and Browder (2018), which yielded nine additional studies. Thus, we ended up with a total of 50 articles for this current review.

2.2. Analysis of articles

We examined the 50 articles using the three interrelated lenses, namely the nature of disabilities, mathematics learners, and mathematics classrooms. That is, we analyzed how each study framed disability (i.e., medical or social model leanings), the extent to which students with intellectual disabilities are regarded as mathematics doers and thinkers, and the ways in which students with disabilities are considered an integral part of the mathematics learning community. To do so, we found it useful to interpret each study's positioning and paradigms.

For positioning, we looked at how each study situated students with intellectual disabilities. We derived this from the authors' implicit and explicit signals. Some authors employ reflexivity in their research reports (D'Ambrosio et al., 2011) such as stating their identities, values, and agenda. Indeed, equity-oriented educational researchers have strongly urged the field to practice reflexivity in their research (Artiles, 2017). Other authors may not be as explicit with their positionalities, but the type of research they carry out may be inferred. For example, by labeling their work as a concrete manifestation of collaborative research, Hostins and Jordão (2015) implicitly position themselves as researchers who, by listening critically to the voices emerging from the discursive variation of teacher perspectives in their sample, look for ways to "problematize policy guidelines, curricular practices…" (p. 2) as they pertain to students with intellectual disabilities in the broader Brazilian context of special and regular education schooling dynamics.

For paradigms, we examined each study's methodological and theoretical approaches. We looked for references to major learning theories in mathematics education such as behaviorism (e.g., direct, step-by-step instruction), constructivism (e.g., conceptual understanding of mathematics and relationships), socio-constructivism (e.g., constructivism situated in social classroom interactions), and sociopolitical (e.g., equity-oriented). We sought specific examples of how methods and theory were used in these studies and the extent to which they intersect with DSME concepts. Hence, for example, Göransson, Hellblom-Thibblin, and Axdorph (2016) were

[2] A wildcard is the character * used with search engines to return results that contain at least the prerequisite characters (e.g., the search term "disab*" will return results such as disability, disabilities, and disabled).

[3] We used this keyword with the intent to capture both Down and Williams Syndrome.

[4] Articles that included students with autism or developmental disabilities were not included unless it was clear that a label of or participants with intellectual disability were part of the study.

Table 1
Research in Mathematics Education Involving Students with Intellectual Disabilities (2007–2016) By Categories.

Deficit-oriented (n = 34)			Discursively-aligned (n = 12)	Social-political (n = 4)
Cognitive testing (n = 10)	Behaviorism (n = 24)			
• Abreu-Mendoza and Arias-Trejo (2015) • Dekker et al. (2016) • Djuric-Zdravkovic et al. (2011) • Foster et al. (2015) • Lanfranchi, Aventaggiato et al. (2015) • Lanfanchi, Berteletti et al. (2015) • Libertus et al. (2014) • Robinson and Temple (2013) • Schwenck et al. (2015) • Van der Molen et al. (2014)	• Abdelhameed (2009) • Baker et al. (2015) • Bouck, Bassette, Taber-Doughty, Flanagan, and Szwed (2009) • Bouck, Satsangi, and Bartlett (2016) • Browder, Jimenez, Trela (2012) • Calik and Kargin (2010) • Celik and Vuran (2014) • Cihak and Grim (2008) • Fletcher, Boon, and Cihak (2010) • Flores et al. (2014) • Hansen and Morgan (2008)	• Hord and Xin (2015) • Hsu, Tang, and Hwang (2014) • Hua, Morgan, Kaldenberg, and Goo (2012) • Jansen et al. (2013) • Jimenez and Kemmery (2013) • Kuhl, Sinner, and Ennemoser (2012) • McCallum and Schmitt (2011) • Ozen (2008) • Ozkan, Oncul, and Kaya (2013) • Rao and Kane (2009) • Rao and Mallow (2009) • Sheriff and Boon (2014) • Tzanakaki, Hastings, Grindle, Hughes, and Hoare (2014)	• Agaliotis and Teli (2016) • Belacchi et al. (2014) • Browder, Jimenez, Spooner et al. (2012) • Burton, Anderson, Prater, and Dyches (2013) • Charitaki et al. (2014) • Creech-Galloway et al. (2013) • Gaunt et al. (2012) • Jimenez and Staples (2015) • Monari and Pellegrini (2010) • Rhodes et al. (2015) • Van Luit and Van der Molen (2011) • Yakubova and Bouck (2014)	• Eriksson (2008) • Faragher and Clarke (2016) • Göransson et al. (2016) • Hostins and Jordão (2015)

very explicit about their goal to examine conceptual mathematics principles in curricular interventions specific to students with intellectual disabilities in the Swedish context, which we interpreted as a constructivist theoretical stance. Hostins and Jordão (2015), on the other hand, because of their explicit concerns with policy in action at the classroom level, were more inclined to favor sociopolitical theories and critical discourse analysis methodologies. Nonetheless, Hostins and Jordão supported their focus student's mathematical learning through a constructivists approach by, for example, asking open-ended and inquiry-based questions, thereby allowing the student to reason mathematically without explicit instruction.

2.3. Categorization development

Our article categorization and theme development process occurred over two phases, where initial categories were developed and where we subsequently made refinements during regular meetings and communications. The first phase involved the first author examining each article through the three lenses and correspondently sorting them into categories which were identified a priori and were informed by previous works (Lambert & Tan, 2016a, 2016b, 2017). The second phase involved a series of meetings where the first three authors discussed refinement after engaging in close reading, analysis, and discussion of each article. During this phase, we also had an outside reviewer give feedback based on close examination of the articles and the categories. We discussed this feedback in depth during our meetings. At that point, we mostly agreed on the categorization of the articles (92%). For the areas of disagreements (8% or four articles), we achieved consensus through clarifying and subsequently refining the categories by better defining them and in one case collapsing it, and developing sub-categories as needed.

3. Results

Three categories emerged as a result of our analysis that addresses the two research questions: what are the foci and methods in recently published research in mathematics education concerning students with intellectual disabilities, and what kind of knowledge paradigms drives these research endeavors? The three categories are deficit-oriented, discursively-aligned, and social-political. Table 1 provides a summary of the categories, sub-categories, and their respective articles.

3.1. Deficit-oriented

The majority of the studies in our review (N = 34 or 68%) encompass this category which includes two subcategories of articles within the traditions of understanding mathematical education through (a) cognitive testing (e.g., executive functioning pertaining to "numeracy" and working memory) and (b) behaviorism (e.g., procedures such as direct/explicit instruction, prompting, systematic instruction, and repetitive practice). These studies centered student deficits with participants with an intellectual disability in research foci, methods, and knowledge paradigms. To illustrate this claim, we describe evidence and key features of the articles in each subcategory in the context of two lenses, nature of disabilities and nature of mathematics learners, as none of these studies are overly concerned with the nature of mathematics classrooms.

3.1.1. Cognitive testing

Studies in this subcategory frame disability within students and aim to “bring to light” any mathematical and related skills shortcomings through very limited mathematics scope of content breadth and depth, and through specific disabilities characteristics. For example, in some of these studies, deficit descriptions of students with Down Syndrome (DS) in mathematics include “difficulty solving math problems” and “difficulties understanding the principles of counting” (Abreu-Mendoza & Arias-Trejo, 2015, p. 58), “lower math achievement and slower math growth rates compared with the general population” (Dekker, Ziermans, & Swaab, 2016, p. 1086), “numerosity discrimination is less efficient” (Lanfranchi, Aventaggiato, Jerman, & Vianello, 2015, p. 130), and “difficulties in utilizing arithmetic operations” (Djuric-Zdravkovic, Japundza-Milisavljevic, & Macesic-Petrovic, 2011, p. 214).

The studies in this group focus on assessing students’ mathematical skills and at times in conjunction with other skills that may be “lacking” such as attention (Djuric-Zdravkovic et al., 2011), executive functioning (Dekker et al., 2016), phonological awareness and color naming speed (Foster, Sevcik, Romski, & Morris, 2015), general cognitive ability (Schwenck, Dummert, Endlich, & Schneider, 2015), “impaired language skills” (Abreu-Mendoza & Arias-Trejo, 2015, p. 59), “deficits in [executive function]” (Dekker et al., 2016, p. 1087), working memory (Van der Molen, Henry, & Van Luit, 2014), and “specific deficits even with respect to mental age” (Lanfanchi, Berteletti, Torrisi, Vianello, & Zorzi, 2015, p. 223).

Association to mental age is another feature that drive the selection of mathematics content. For example, participants in the Lanfranchi, Aventaggiato et al. (2015) study had a mean chronological age of 12 but the authors selected mathematics intervention materials that matched their participants’ said mean mental age of five or six. The mathematics skills assessed include numerical and area comparison (Abreu-Mendoza & Arias-Trejo, 2015), estimation (Lanfanchi, Berteletti et al., 2015), early numeracy (Charitaki, Baralis, Polychronopoulou, Lappas, & Soulis, 2014), addition and subtraction (Djuric-Zdravkovic et al., 2011), approximate number system (Libertus, Feigenson, Halberda, & Landau, 2014), and mathematical vocabulary and factual mathematical knowledge (Robinson & Temple, 2013). In sum, the focus, methods, and knowledge paradigms used in these studies signal low confidence in framing students with intellectual disabilities as mathematics doers and thinkers and in engaging them in higher level or more complex mathematics. Likewise, these studies closely reflect a medical model orientation focused on the collective categorization of deficits and whereby student features are identified and categorized as mathematical deficiencies, based on specific disability characteristics.

3.1.2. Behaviorism

Studies in this subcategory made up nearly half (48%) of the overall dataset. Features of studies in this category include interventions that rely on direct, explicit, and systematic instruction (including prompts and decreasing the cognitive demand of mathematics tasks and processes) akin to behaviorist traditions. Individual level behavior is the core unit of analysis even when incidental environmental components may also be present. In these studies, mathematics education is characterized as reproducing or memorization of prescribed facts or procedures. Flores, Hinton, and Strozier (2014), for example, describe their teaching procedures involving direct instruction and prompts as follows:

> Each lesson… began with an advance organizer in which the teacher provided an overview of the lesson. The teacher demonstrated several problems for the students… lessons one to three involved the use of manipulative objects and lessons four to six involved the use of drawings and pictures. Next, the teacher guided the students in solving several problems. Guided practice involved the provision of verbal and/or physical prompts as students completed a set of problems. The third step during instruction was independent practice in which the teacher instructed the students to solve a set of problems without guidance. (p. 550)

Students in these studies are shown a particular sequence of solving mathematics problems, followed by assessing their ability to exactly follow each step in the pre-defined procedure. Such procedure is at the core of systematic instruction that was employed in many of these studies (e.g., Baker, Rivera, Morgan, & Reese, 2015; Browder, Jimenez, & Trela, 2012; Celik & Vuran, 2014; Jimenez & Kemmery, 2013; Rao & Kane, 2009). Similarly, Jansen, De Lange, and Van der Molen’s (2013) research focused on the importance of mathematics fact recall as they connected their work to functional life skills and the importance of mathematics for everyday tasks such as shopping: “using math in everyday life is impossible without automation of basic math facts (i.e., simple addition, subtraction, multiplication, and division)” (p. 1815). Hence, for the studies we describe in this section, success involved not only solving the problems correctly, but also following pre-determined mathematics procedures and rote recall.

Collectively, the features of behaviorists and cognitive testing categories align more with deficit-oriented research traditions than to DSME concepts in that students are essentialized as a collection of their deficits and not positioned as mathematical doers and thinkers. These studies either frame mathematics learning deficits such as cognitive functioning as located within the individual or employ mathematics intervention methods that limit knowledge construction. We find these outcomes problematic as these two categories together represent a large share (68%) of the studies we reviewed.

3.2. Discursively-aligned

The second category, discursively-aligned, encompass articles (12 out of 50 or 24%) that have some degree of DSME orientation. Evident in these articles is a shift to examining or discussing contextual factors and in some cases explicit alignment to equity rhetoric. At the same time, we raise questions about the extent to which these articles presume mathematics competence as they maintain features of traditional deficit-orientations such as the medicalized discourse around students with disabilities and the employment of behaviorist approaches. For us, articles in this category are considered to be discursively-aligned because they signal tensions between deficit-oriented traditions and DSME concepts. In this section we discuss the opposite sides of these tensions.

3.2.1. Shift to contextual factors

Unlike articles in the deficit-oriented categories, articles in this category shift part of the focus to contextual factors that may influence the mathematics experiences of students with intellectual disabilities. For example, one study examined the validity of standardized mathematics tests widely used for students with an intellectual disability (Rhodes, Branum-Martin, Morris, Romski, & Sevcik, 2015). Another study sought to determine whether a more intuitive number naming system (i.e., Korean) helps students' mathematics understanding (Van Luit & Van der Molen, 2011). A third study examined how different types of calculators affected students' performance on word problems (Yakubova & Bouck, 2014). Belacchi et al. (2014) proposed drawing on students' innate visuospatial processing skills to facilitate mathematics learning.

Several studies also explicitly problematize current contextual situations. Monari and Pellegrini (2010) lament in their work situated in an Italian context that "[u]nfortunately, the biggest problem was not the difficulties of the students, who were happy and proud to learn, but the attitude of many teachers and experts who were s[k]eptical about the program and therefore limited the students' right to learn" (p. 14). Educator attitude is also explicitly problematized by Gaunt, Moni, and Jobling (2012) as they challenge the notion that those with intellectual disabilities cannot learn numeracy skills. Such notions may indeed lead to fewer opportunities to learn mathematics which Jimenez and Staples (2015) and Browder, Jimenez, Spooner et al. (2012) raise as the culprit of mathematics skills gaps in students with disabilities.

3.2.2. Presuming mathematical competency?

The shift to inquiry or discourses on contextual factors may be a sign of presuming mathematical competency. Indeed, Monari and Pellegrini (2010) assert that "students with [intellectual disability] can learn mathematics, they might have difficulties with numeracy but may excel in elementary set theory, geometry and algebra" (p. 13). The lack of access to more advanced topics such as geometry and algebra is a major area of concern in the Jimenez and Staples's (2015) work. Citing Baroody's, 1988 work, Browder, Jimenez, Spooner et al. (2012) note that "children whose development is delayed also develop more advanced mathematical concepts in the early years of life than once thought possible" (p. 308) Creech-Galloway, Collins, Knight, and Bausch (2013) also approach concepts of presuming mathematical competency by concluding that "students with disabilities should not be limited by previously low expectations of their capabilities in math" (p. 229).

Although these studies seemingly align to notions of presuming competency and shifting a focus to contextual factors, deficit-orientations are still explicitly signaled. Rhodes et al. (2015), for example, note the presence of language deficits as their study sought to determine the influence of language ability on norm-reference mathematics ability tests. Similarly, Van Luit and Van der Molen's (2011) research question centers participants' deficits as "arithmetically weak children with mild intellectual disabilities" (p. 1942) while Charitaki et al. (2014) in line with the medical model underscores the importance of "overcoming various cognitive barriers" (p. 1432).

The reliance on prescriptive forms of mathematics instruction is another manifestation of the medical model featured in these studies. For example, the use of systematic instruction that include time delay strategies involves step-by-step procedures that includes providing students with the desired response (Browder, Jimenez, Spooner et al., 2012) without allowing time to reason, or breaking the mathematics task into subtasks (Jimenez & Staples, 2015) thereby removing the cognitive demand. Relatedly, Monari and Pellegrini's (2010) instruction to students with intellectual disabilities involved procedures similar to the direct forms of instruction described in the behaviorism section of this paper. In sum, studies in this category are discursively-aligned because they have marginal degrees of DSME elements, but remain anchored in deficit-oriented paradigmatic assumptions that counter notions that students with intellectual disabilities are mathematics doers and thinkers.

3.3. Social-political

The last category encompasses articles centering on socio-political aspects of mathematics education (Gutiérrez, 2013) such as issues of identity, access, and power. These articles have a greater degree of DSME orientation when compared to studies in the previous category. Social-political articles are also distinct from discursively-aligned articles in that deficit-orientations are largely absent. In our review, four of the articles (8%) featured, to a great extent, elements related to lenses of the nature of disabilities, mathematics learners, and mathematics classrooms. Of note, none of these four studies were conducted in the United States. In the section that follows, we describe ways in which the studies in this category addressed the three lenses.

3.3.1. Nature of disabilities

We interpret studies that focused on analyzing issues surrounding the mathematics education of students with intellectual disabilities without necessarily aiming to "fix" them or subjecting them to low-rigor mathematics tasks as, to some extent, reframing and relocating disability from the individual student to other foci areas as needing to be "fixed."

Studies in this category countered the dominant form of mathematics education research involving students with intellectual disabilities by moving away from focusing on the student as the primary unit of analysis (Lambert & Tan, 2017). Faragher and Clarke (2016), Hostins and Jordão (2015), and Göransson et al. (2016) included pedagogy as a primary unit of analysis. In particular, Faragher and Clarke's primary unit of analysis targeted teaching practices, surveying teachers who taught mathematics to students with intellectual disabilities in two Australian general education classrooms. Göransson and colleagues investigated how teachers interpreted and enacted conceptually-based mathematics curriculum for students with an intellectual disability, analyzing curricular content and teaching practices in Swedish special education mathematics classrooms as well as communication within that environment. Hostins and Jordão included mathematical thinking of a student with an intellectual disability in their analysis while examining specific teacher moves during a teaching episode in a Brazilian school. Collectively, these studies sought to reframe and relocate disability as a deficit within the student to a “deficit” in the surrounding mathematics education context as needing “fixing” or attention.

3.3.2. Nature of mathematics classrooms

The authors of the four studies also openly shared their values of and concern with inclusive mathematics education in situating their inquiries. For example, in assessing teachers’ professional learning needs to improve inclusive practices in mathematics classrooms involving students with an intellectual disability, Faragher and Clarke (2016) state: “we have been particularly concerned with the practices of teachers from the academic inclusion perspective” (p. 133). Similarly, in their conclusion, Göransson and colleagues, (2016) refer to their grounding in inclusive mathematics education by emphasizing the importance of “the teaching of mathematics to students with [intellectual disability] from the perspectives of practice and research in relation to the idea of inclusion” (p. 196).

The authors of these studies also relate to the DSME component of reframing and relocating disability in criticizing drawbacks of inclusive mathematics education. Specifically, Faragher and Clarke (2016) noted that knowledge related to specific disabilities could hinder inclusive education: “Diagnosis specific knowledge can be a barrier to inclusive practice” (p. 134). Similarly, Hostins and Jordão (2015) problematized label-specific knowledge as a barrier to inclusive education: “In relation to students with Intellectual Disabilities, for example, the inclusion process has been hindered by ignorance of their learning characteristics and the belief in their lack of capacity for abstract thought” (p. 4). Hostins and Jordão aimed to unearth how special education hindered inclusive practices and drew attention to another core component of DSME, which is assuming mathematical competence.

3.3.3. Nature of mathematics learners

In contrast to the dominant forms of research in mathematics education involving students with intellectual disabilities that focuses on direct forms of instruction and basic mathematics skills development (Kroesbergen & Van Luit, 2003), undermining conceptual construction and understanding of mathematics, the studies in this category presume, to a greater extent, that students with an intellectual disability are mathematics thinkers and doers, capable of a range of mathematics engagement. For example, Eriksson (2008) notes that “the intellectually disabled pupils’ requirements appear to be similar to those of pupils in the compulsory school in the sense that they all have needs to be challenged in relation to their established symbolic worlds” (p. 9).

Further, we interpreted Göransson et al.’s (2016) framing of mathematical competence as related to opportunities to learn: “students learn what they have an opportunity to learn: they can only learn what the curriculum has to offer in terms of mathematical content and the teaching strategies to make that content accessible” (p. 184). Faragher and Clarke (2016) similarly criticize the lack of opportunities to learn based on researchers’ deficit orientations of mathematical competence: “Unfortunately and incorrectly, many authors extrapolate difficulties with number concepts to difficulties with mathematics in general, leading to a very pessimistic view of what might be possible for students with [intellectual disability] to accomplish” (p. 134).

Hostins and Jordão (2015) operated within such mathematical competency orientation in making a case for fostering situations “fundamental for the learning of all students, notably [students with intellectual disability], who can in this way show in different manners and through various strategies their learning capacities” (p. 12). This study is unique, as it is the only study we found that described the individual thinking processes of the student within a sociocultural and a sociopolitical view of disability and mathematics. Next, we briefly summarize their study to illustrate the possibilities of including Disability Studies in Mathematics Education features.

Hostins and Jordão’s (2015) study examined how one teacher and one student, which they refer to as JF, interacted during a Base Three Game. According to the authors, the game involves complex forms of mathematical thinking that foster conceptual understanding. JF was asked to make exchanges between cards of different quantities. Using Vygotsky’s theories of mediation as critical for moving from spontaneous to scientific thinking, Hostins and Jordão describe how the teacher, working in a collaborative group of teachers, was able to develop and guide JF’s conceptual understanding through symbolic mediation. The student took up the new symbols while playing the game, demonstrating conceptual understanding of the mathematics involved. Specifically, JF used symbols to differentiate his results and those of the teacher, worked interchangeably between quantities and game pieces, and differentiated based on form. The authors posited that additional tools could be introduced to continue the advancement of “superior psychological functions…exposing the understanding of the potential possibilities” (p. 14). In sum, Hostins and Jordão’s study described JF’s thinking processes, constructing him as a mathematical doer and thinker while attributing agency to the teacher, who made decisions that best elicited JF’s thinking.

4. Discussion

In this study, we reviewed 50 recently published research articles in mathematics education related to students with an intellectual disability. We identified four studies that featured DSME elements to a great extent while the remaining 46 articles did not feature these elements or featured those elements to a lesser extent. These 46 studies aligned closer to traditional forms of research (i.e., deficit-focused). Next, we discuss the implications of our results for future research, educational policy, and practices.

4.1. Future research

The results of our research point to continuing inquiry into understanding and framing students with an intellectual disability as mathematics doers and thinkers. Such work was exemplified in the late 1980s and 1990s by prominent mathematics education researchers (e.g., Baroody, 1988; van den Heuvel-Panhuizen, 1996) that challenged deficit-oriented research involving students with intellectual disabilities. Recently, the call for a sociopolitical turn in mathematics education (Gutiérrez, 2013) affords researchers an additional layer such as the DSME framework to examine issues related to students with disabilities (Tan & Kastberg, 2017).

Yet, the findings of our review indicate that DSME-oriented research remains marginal. Nevertheless, we remain optimistic that DSME-oriented research will continue to grow in the next decade. A recently formed Psychology of Mathematics Education–North America working group

(Lewis et al., 2017; Sheldon et al., 2016; Candela et al., in press) and an international network of scholars (Tan, Lambert, & Padilla, 2018; A. Bagger, personal communication, June 7, 2018) are proceeding toward this end. From the former group, a special issue in a mathematics education journal on the topic of critical mathematics education involving students with disabilities was recently published (Lambert, Tan, Hunt, & Candela, 2018). A second special issue with a similar theme but in a different journal is scheduled to be published in 2019. From the latter, the foundations of an international collaboration are at the early stages of formation. Indeed these are exciting developments and we are hopeful that such work will continue to reverse the trend of exclusion in mathematics education journals (Lambert & Tan, 2016a, 2016b) and in strengthening the international research community.

The exclusion refers to the finding that major mathematics education-focused journals have published only one article (Eriksson, 2008) related to students with intellectual disabilities during the past ten years. Articles included in this review were mostly published in journals focused on special education[5] (41 out of 50, e.g., *Education and Training in Autism and Developmental Disabilities*), with six articles published in psychology or medical-focused journals (e.g., *Journal of Cognitive Education and Psychology*). One of the four articles in the sociopolitical category appear in the these journals. Moreover, we find it rather alarming that, as reported by Göransson et al. (2016), a 2012 mathematics education review only found seven articles on curricula for students with intellectual disabilities (which of course does not even touch on quality considerations for such curricula from the standpoint of DSME). To us, this is a serious matter of ethics in mathematics education (Boylan, 2016) given the long-standing claims that the field is committed to *all* students (e.g., National Council of Teachers of Mathematics, 2014).

Of note, the results of our review indicate that more inquiry is needed related to the component of mathematics for all and of all (Tan & Kastberg, 2017; Tan, 2017). This component was not prevalent in the studies we reviewed except Hostins and Jordão's (2015) study which alludes that students can "show [mathematics] in different manners and through various strategies their learning capacities" (p. 12). We situate *mathematics of* students as encompassing multiple mathematics knowledge bases (Turner et al., 2012) and engaging in mathematics through various modes of interactions such as swaying, rhythmic movement, gesturing, tapping, feeling, facial expressions, or gaze (Sinclair & Heyd-Metzuyanim, 2014). Given the paucity of this work in recently published research, we recommend mathematics of students with intellectual disabilities and other disability labels as an important area of future inquiry. In particular, we call on mathematics education and equity scholars to lead this crucial work. Indeed, this has not been the case during the past decade.

4.2. Mathematics education practices

The outcomes of this review also suggest that DSME-oriented work need not apply exclusively to research concerns but also to the practices of teacher educators and teachers of mathematics. For teacher educators, the outcomes of this review provide insights into areas of professional learning needed to support effective inclusive mathematics education practices. By using this or similar frameworks, teacher educators can advance effective mathematics education practices that challenge more traditional "evidence-based" practices such as direct instruction and systematic procedures. Indeed, two of the studies we reviewed (Göransson et al., 2016; Hostins & Jordão, 2015) provide teacher educators and the teachers they support with not only what is possible when students with intellectual disabilities are presumed as mathematics doers and thinkers, but also enact tensions that teachers may experience between DSME and other mathematics education models. Surfacing and addressing such tensions are important in advancing inclusive mathematics education (Tan & Thorius, in press; Tan & Thorius, 2018). In turn, professional learning may not only foster classroom teaching practices that focus on structuring opportunities to learn for students with an intellectual disability and to share their mathematical thinking that is congruent with current mathematics education practices for those without disabilities, but more importantly they can help counter ableism in mathematics education (i.e., practices that dehumanize those with disability labels).

4.3. Policy and global initiatives as impetus for research and practice

Lastly, we discuss the implications of this review for policy and the importance of connecting research and practice to international initiatives. In two of the studies that featured DSME concepts to a great extent, national policies requiring schools to enact inclusive practices is clear in their respective countries, namely Brazil and Australia. Of note, the other two studies (Eriksson, 2008; Göransson et al., 2016) were conducted in Sweden which does not have a clear national policy on inclusion practices. Still, at least in Göransson and colleagues case, their impetus for inclusive mathematics research was connected to the international inclusion agenda,

[5] We used the name of the journal as the main determinant of the journal type and focus.

likely tied to the human rights and disability awareness synergy sparked in recent years by the implementation of the United Nations Convention on the Rights of Persons with Disabilities [CRPD] (United Nations, 2006). In countries such as the United States, where national inclusion policies are less clear and connection to international inclusion agendas such as those of CRPD is weak, there is less pressure to pursue inclusive mathematics education inquiries. Hence, to advance inclusive mathematics education, we urge for national- or state-level research collaborations and policies that reflect a commitment to inclusive education and connecting research and practice to global inclusion initiatives. Indeed, such calls from major research associations in the United States have centered international synergistic activities on addressing persistent educational inequities (e.g., Artiles, Carter, Rogers, Ladson-Billings, & Hill, 2017).

4.4. Limitations

A limitation of this study is our use of a uniquely critical perspective to examine the literature. Although we feel that such perspective is useful and has not been employed in this area of study, it does limit the conclusions that we can make. Moreover, this review is not exhaustive as we do not claim it captures every article that fit our selection criteria. We are, however, confident that we did capture a large enough sample to which the outcomes of our analysis adequately address our research questions (i.e., what are the foci, methods, and knowledge paradigms of recently published empirical articles). That is, additional studies that we did not capture in this review would most likely fall under one of the three categories that we developed, namely deficit-oriented, discursively-aligned, and social-political with the majority falling under the first two categories. This assertion is supported by Hord and Bouck's (2012) review of a similar topic which overlaps some with the coverage of our review. They suggested that most studies indeed focus on mathematics facts and computational procedures with students with intellectual disabilities (i.e., not as mathematics doers and thinkers through our lens). Thus, we also call attention to the fact that our sample is the output of a critical systematic review which speaks volumes on the need to cultivate much more DSME-oriented research centering students with intellectual disabilities.

4.5. Conclusion

In the present study, we examined the extent to which critical and sociocultural criteria based on DSME are incorporated into mathematics education research involving individuals with intellectual disabilities. We utilized three DSME lenses in our critical review, namely the nature of disabilities, mathematics classrooms, and mathematics learners to develop three broad categories of 50 articles published during the most recent decade. A majority of these articles fell under the deficit-oriented category with relatively few residing within the discursively-aligned and social-political categories. We described key features of the three categories and provided supporting evidence. Based on these tendencies, we proposed the reframing of research and teaching practices of mathematics education scholars and practitioners (e.g., general and special education teachers) to work with students with intellectual disabilities as knowing participants with a genuine sense of belonging in mathematics.

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Journal of Mathematical Behavior

Volume , Issue , , Page

DOI: https://doi.org/10.1016/j.jmathb.2021.100843

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Journal of Mathematical Behavior xxx (xxxx) xxx

Contents lists available at ScienceDirect

Journal of Mathematical Behavior

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Erratum regarding missing Declaration of Competing Interest statements in previously published articles

Declaration of Competing Interest statements were not included in the published version of the following articles that appeared in previous issues of Journal of Mathematical Behavior.

The appropriate Declaration/Competing Interest statements, provided by the Authors, are included below.

1 "When itâ€™s on zero, the lines become parallel: Preservice elementary teachersâ€™ diagrammatic encounters with division by zero" [Journal of Mathematical Behavior, 2020; 58C: MATBEH_2018_209] 10.1016/j.jmathb.2020.100760 Declaration of competing interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.
2 "Spectral analysis of concept maps of high and low gain undergraduate mathematics students" [Journal of Mathematical Behavior, 2019; 55C): MATBEH_2018_102] 10.1016/j.jmathb.2019.01.002 Declaration of competing interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.
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4 "Defining and demonstrating an equivalence way of thinking in enumerative combinatorics" [Journal of Mathematical Behavior, 2020; 58C): MATBEH_2019_200] 10.1016/j.jmathb.2020.100780 Declaration of competing interest: Defining and demonstrating an equivalence way of thinking in enumerative combinatorics
5 "Computing as a mathematical disciplinary practice" [Journal of Mathematical Behavior, 2019; 54C): MATBEH_2018_28] 10.1016/j.jmathb.2019.01.004 Declaration of competing interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.
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DOIs of original article: https://doi.org/10.1016/j.jmathb.2020.100791, https://doi.org/10.1016/j.jmathb.2019.03.004, https://doi.org/10.1016/j.jmathb.2018.06.004, https://doi.org/10.1016/j.jmathb.2018.06.008, https://doi.org/10.1016/j.jmathb.2018.09.001, https://doi.org/10.1016/j.jmathb.2020.100774, https://doi.org/10.1016/j.jmathb.2019.100739, https://doi.org/10.1016/j.jmathb.2020.100779, https://doi.org/10.1016/j.jmathb.2020.100756, https://doi.org/10.1016/j.jmathb.2018.02.003.

https://doi.org/10.1016/j.jmathb.2021.100843

0732-3123/

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