Does Disability Matter in Mathematics Educational Research? A Critical Comparison of Research on Students with and without Disabilities

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Abstract

Using a Disability Studies in Education framework, this systematic review analyzed international research published in English (2013-2017) on the teaching and learning of mathematics from the prekindergarten to twelfth-grade level, comparing research on students identified as having disabilities to research on students without disabilities. Coding articles ($N = 2477$) for methodology, participants, mathematical domain, and theoretical orientation, we found that research on students with disabilities was overwhelmingly quantitative (81%) and tended to use behavioral and medical theoretical orientations. Research on students without disabilities was both qualitative (42%) and quantitative (42%) and tended to use constructivist and sociocultural theoretical orientations. In addition, research on mathematical learning that included students with disabilities lacked sustained qualitative inquiry documenting learning processes of students with disabilities and rarely included the teacher as an explicit focus. Following Gervasoni and Lindenskov (2011), we contend that these pronounced differences in research contribute to the segregation of students with disabilities and low-achieving students in lower quality mathematics instruction, and may lead to low expectations of the mathematical competence of students with disabilities. We call for increased attention to research that considers how disability is produced and enacted in the complex context of mathematics classrooms.

Keywords: equity and diversity, research methods, mathematics, special education, disability studies, critical mathematics

Does Disability Matter in Mathematics Educational Research? A Critical Comparison of Research on Students with and without Disabilities

In their 2011 article, Gervasoni and Lindenskov argue that both students with disabilities and low-achieving students deserve “special rights” in mathematics as these students have been systematically excluded from high-quality mathematics curriculum. Gervasoni and Lindenskov describe issues with the quality of the mathematics teaching these students receive, noting that mathematics instruction for these students is overly traditional in its approach, with a limited view of mathematics and a deficit model of student potential. In their paper, drawn from international discussions at ICME 10 and 11, they argue for dramatic change in the mathematics education of students with special rights, including increased collaboration and innovation in research. Internationally, there have been calls for transformation of mathematics education for these students (Scherer, Beswick, DeBlois, Healy, & Opitz, 2016; Kollosche, Marcone, Knigge, Penteado, & Skovsmose, 2019) including rehumanizing mathematics for students with disabilities (Author, 2018).

Some scholars have suggested that students with disabilities may have less access to mathematics instruction that is rigorous and conceptual because of historical differences between special educational research and mathematics education (Boyd & Bargerhuff, 2009; Woodward & Montague 2002). Because these two academic fields are historically rooted in different learning theories (Woodward 2004), research on mathematics teaching and learning may differ in substantial ways. Scherer and colleagues note that " the different fields might follow different paradigms, which in turn might lead to contradictory conclusions with regard to the teaching and learning of students with mathematical learning disabilities" (Scherer et al., 2016, p.633). Research on the mathematical learning of students with disabilities has historically been published in special education and psychology journals, with little focus on disability in mathematics educational journals (Lubienski & Bowen 2000; van Garderen, Scheuermann, Jackson, & Hampton 2009). These differences may complicate inclusion of students with disabilities in standard-based mathematics, as special educators and mathematics educators are asked to collaborate, despite being prepared within different research and pedagogical traditions (Boyd & Bargerhuff 2009).

Scholars in Disability Studies in Education have called for a greater plurality of methodologies and perspectives on disability in special education scholarship (Baglieri, Valle, Connor, & Gallagher 2011; Brantlinger 1997; Connor, Gallagher, & Ferri 2011). Baglieri and colleagues (2011) note "traditional understandings of disability in special education have inadvertently inhibited the development of theory, limited research methods, narrowed pedagogical practice, and determined largely segregated policies for educating students with disabilities" (p. 267). In this paper, we investigate these claims in relationship to mathematics education. To investigate these understandings empirically, we sought to analyze current research on mathematical thinking and learning from the prekindergarten to twelfth-grade levels, using a wide sample of 88 peer-reviewed journals across multiple academic fields to provide a large sample of research (N=2477) in a current time period (between 2013-2017). Our study addresses

the following research question: How does research published on the teaching and learning of mathematics for students with and without disabilities differ in terms of methodology, participants, mathematical domain and theoretical orientation? For this special issue, we additionally considered whether literature published in Australasia differed from the international (English) set.

Conceptual Framework

We situate this research review in a critical perspective on disability, Disability Studies. Disability Studies (DS) emerged as an academic field in the end of the twentieth century, questioning the dominance of the medical model of disability in society, schools and academia. As critiqued in Oliver (2009), the medical model conceptualizes disability as an individual defect to be identified and remediated. The social model of disability "defines disability not as an individual defect but as the product of social injustice, one that requires not the cure or elimination of the defective person but significant changes in the social and built environment" (Siebers 2008, p. 4). The medical and the social model are frequently understood as a binary, yet scholars in DS have urged a more nuanced theoretical approach, proposing that disability is simultaneously both socially constructed and embodied (Kafer 2013; Siebers 2008). A social justice approach to disability includes both individual and social factors in interaction (Gervasoni & Lindenskov, 2011).

Disability Studies does not argue that disability does not exist, quite the contrary. Physical, mental and neurological differences exist, and fundamentally affect the day-to-day experiences of people with disabilities (Wendell 1996). Instead of seeing those differences as inherently a problem, newer approaches to disability understand human diversity as natural and beneficial (Broderick & Ne'eman 2008). Disability is not seen as either entirely biological or entirely cultural; instead, disability resides in the interplay between humans whose biology or physiology differs, and the way that schools and other cultural institutions make sense of those differences (Kafer 2013; Siebers 2008). Language around disability is complex and political (Linton 1998). We use the term disability because it reflects the political goals of the Disability Rights movement, as well as Disability Studies. We also use both person-first and identity-first language to respect the varied preferences (Dunn & Andrews, 2015) and identity complexities (Sommo & Chaskes 2013) of people with disabilities, or disabled people.

Problematizing Special Educational Research

The field of Disability Studies in Education (DSE) applies concepts from Disability Studies to education, including in Australasian contexts with scholars such as Roger Slee in Australia (Slee 2011) and Missy Morton in New Zealand (Connor, Gabel, Gallagher, & Morton, 2008). DSE scholars have critiqued research in special education for its limited methods and theoretical orientations. Brantlinger (1997) juxtaposes special education research with the variety of research methods in other fields, writing that, "In contrast to the deep analysis, theory building, and varied research epistemologies and designs included in many education journals and conferences, most special education publications and organizations seem philosophically and methodologically conservative and monolithic" (p. 429). Indeed, a review of studies published in special education journals on learning disabilities found that quantitative studies (including meta-analyses) comprised 91% of published articles (Connor et al. 2011).

A plurality of methodologies is important because it reflects a plurality of research questions (Connor et al. 2011). Over reliance on quantitative research in education has been critiqued by Eisenhart (2006), who noted that federal agencies have equated science in educational research with a subset of research: science is only that which poses and answers questions about causal effects. Although certain types of quantitative research can answer causal questions, qualitative research is better suited to descriptive and process questions (Eisenhart 2006). At the core of current quantitative science is the idea that experimental research provides answers that will work across contexts. However, educational contexts are complex at multiple levels, and implementation of evidence-based practices is not controllable across settings (e.g. Berliner 2002; Erickson & Gutierrez 2002). Because of this complexity, the assumption of generalizability across such complex contexts should not be automatic (Eisenhart 2006).

It is important to recognize the historical role of research in the lives of people with disabilities. Research universities have long histories of treating those with disabilities as subjects to be studied, rather than as experts (Trent 1995). Many individuals with disabilities have complex and negative relationships with medicine and research in their own lives; research done on people with disabilities has been characterized as ‘‘at best irrelevant, and at worst, oppressive” (Oliver, 1996, p. 129). Thus, what is the ethical responsibility of researchers, as well as universities that conduct research with people with disabilities? As argued by Dolmage (2017), universities have a particular responsibility to respond to the needs of people with disabilities, defining “needs” not as determined by nondisabled professionals, but as determined by people with disabilities. Within the disability rights community, the common saying about research is ‘‘Nothing about us without us’’ (Charlton 1998, p. 3); research should be done in collaboration with disabled people.

Qualitative research has made significant contributions to the field of special education (Greenwood & Abbot 2001, Connor et al, 2011). Mixed methods and qualitative research are increasingly seen as necessary in clinical medical research in the study of special populations, particularly to understand complexity within contexts (Curry, Nembhard, & Bradley 2009). Qualitative research on disability can lead to greater understanding of the lived experiences of people with disabilities, including centering the perspectives of disabled individuals (as subjects and/or researchers) (Brantlinger et al., 2005). Understanding learning in contexts is particularly important with students with disabilities to understand context and culture. Students engage quite differently in different learning contexts, becoming “disabled” in certain contexts and abled in others (McDermott, 1993). Disability is produced interactionally, including in interaction with mathematics teachers (Heyd-Metzuyanim 2015). For example, in a year-long study of an inclusive mathematics classroom, Author (2015) found that the teacher viewed students with learning disabilities as more or less disabled depending on whether her teaching was more focused on creativity or memorization.

Arzubiaga and colleagues (2008) argue that research in special education that ignores culture and context contributes to deficit constructions of students of color. These authors argue for greater reflexivity by researchers, as well as methods that will document the processes through which students of color are disproportionally represented in special education. In this spirit, we reflect on our own identities as researchers. The first author is a white woman, currently nondisabled, who was both a general and a special education teacher for ten years. The

second author is a male of Chinese descent, first-generation immigrant to the U.S., currently nondisabled, a parent of an autistic person, and formerly a teacher of mathematics in public schools for ten years.

Specifically addressing research on mathematics and inclusion in the Australasian context, Faragher, Hill, & Clarke (2016) reviewed research between 2012 and 2015 on mathematics that includes students with disabilities as well as student diversity based on gender, learning difficulties, giftedness, as well as cultural and linguistic diversity. They note the challenges of moving between special education and mathematics educational research, as each field values different methodologies and pedagogies. They note specifically that they did not find research that suggested that certain groups of students should be educated separately from other students or needed a particular pedagogy in mathematics. For example, a study by Clarke and Faragher (2014) found that while students with Down Syndrome may need additional support understanding verbal counts, that appropriate supports (numerical symbols) were commonly used in the general education classroom and broadly helpful to all. The students with Down Syndrome did not need an entirely separate pedagogy, but increased access to the tools available in general education. Faragher, Hill, and Clarke (2016) recommend increased focus on qualitative research, particularly on students learning within the context of inclusive classrooms in order to build knowledge of effective teaching practices for all students.

Literature Review

In an analysis of mathematical educational research published between 1982 and 1998, Lubienski and Bowen (2000) reported how various demographic groups were represented in research in mathematics education, focused on race and gender but including disability. They found that although there was more research on disability than race and class, the research on disability was predominantly found in special education journals and was almost absent from mathematics education journals. They found that 2.3% of all articles published in mathematics education journals included disability, while of the total group of articles, 6.4% included disability. Their analysis did not extend to the articles' methodology or theoretical orientations.

Van Garderen and colleagues (2009) focused on 50 research articles on the mathematics instruction of students with disabilities and/or students defined as "struggling," focusing on a combination of six high-quality special education and five high-quality mathematics education journals published between 1998-2007. They found only one article in a mathematics education journal that included students with disabilities, and six more articles that included students labeled as low-performing or struggling. Van Garderen and colleagues (2009) reported on differences in theoretical orientation of the articles based on journal type. The authors classified studies based on three learning theories: behaviorist, cognitivist, and sociocultural (cognitivist included both information processing and constructivist approaches in individual learning). Approximately 88% of the special education articles utilized cognitivist (47.5%) and behaviorist (40%) theories of learning when examining instructional practices. Only a small number of special education articles based their analyses of instructional practices on a sociocultural (12.5%) theory of learning. Conversely, 80% of the mathematics education articles based their interpretations of mathematics education on a sociocultural theory of learning. None of the

mathematics education articles used a behaviorist theory of learning and only 20% were based on a cognitivist theory of learning. In sum, their work suggests that special education journals publish research with very different theoretical orientations than mathematics education journals.

Similar to the work of van Garderen and colleagues (2009), our research review sought to analyze theoretical orientations to mathematics teaching and learning, but at a larger scale similar to Lubinski and Bowen (2000). We also investigate methodology, as methods are ideological, reflecting the goals and values of an academic field (Brantlinger 1997). We investigate the mathematical domain as well, as research reviews focused on mathematics learning disabilities (Lewis & Fisher, 2016) and intellectual disabilities (Browder, Spooner, Ahlgrim-Delzell, Harris, & Wakeman, 2008) have found studies with students with disability tend to focus on less advanced mathematical content. Our review is unique because of our large sample size (N=2477), and because we utilize a disability studies approach to understanding educational research as inherently ideological (Brantlinger 1997). We compare research including students with disabilities to research that does not, looking for how disability might be employed as a marker of difference in research. This paper presents our complete findings from 2013 – 2017. A previous version of this study investigated research on problem solving between 2013 and 2015 (Author, 2017).

Method

In order to address our research questions on the current state of research on the teaching and learning of mathematics from the prekindergarten to twelfth-grade levels for students identified as having disabilities, compared with research on students without disabilities, we conducted an iterative search and review process of articles published over five years (2013-2017). This time period allowed us to provide a wide sample of journals (88) and articles (N = 2477) and maintaining a focus on current research. Five years was sufficient because we do not analyze trends in this research, rather we provide a large data set within the current landscape of research.

Our sample size is large compared to similar studies. Lubienski and Bowen (2000) conducted a similar research count that spanned the years 1982 – 1998, with a total of 3011 articles, suggesting that we were able to provide a robust sample of research articles considering our smaller time frame (N = 2477). Whereas a previous research review (Van Garderen et al., 2009) focused on a small number of articles (N = 50) across eleven high-quality journals, we sought a broader view of current research.

We included a wide variety of journals, controlling for quality by excluding journals that were not ranked in Quartiles 1-3 in their respective fields (Scimago Journal & Country Rank). Appendix A lists all 88 journals included in this study. Because of our focus on academic research, we excluded work in journals aimed at communicating research to practitioners (e.g., *Teaching Children Mathematics* and *Teaching Exceptional Children*). As our focus was presecondary schooling (prek-12), we excluded journals on undergraduate mathematics.

We searched in three educational databases (ERIC, JSTOR, and PsychINFO) using the general keywords and descriptors of *mathematics*, *math*, and *numeracy* to identify research articles that included mathematics. We also hand searched through all journals mentioned in Lubienski and Bowen's (2000) study, major special education journals, and recently established

mathematics education journals such as *Journal of Urban Mathematics Education.* Research in mathematics education was concentrated in mathematics education and STEM journals, making it fairly easy to locate. We did additional searches in all three databases using each of the descriptors above (*mathematics*, *math*, and *numeracy*) in combination with as many terms as possible that might be used for disabilities. Disability categories included as many specific descriptors as possible for various disability categories. For example, we searched for *specific learning disability, dyslexia, dyscalculia*, *mathematics disability, at risk for mathematics disability, mathematics difficulty,* as well as general terms such as *special educational needs*. We used every combination of these terms to locate as many articles as possible.

Inclusion Criteria

To be included in our study, the article needed to meet the following criteria:

(1) A research report published in peer-reviewed academic journals in English;

(2) Published between 2013-2017;

(3) Focused on mathematics education, defined as a specific mention of words such as *math, mathematics, numeracy,* or terms situated in the field of mathematics (e.g., *fraction*, *geometry*, *multiplication facts*, etc.) in the title or abstract;

(4) Research participants were limited to students (prekindergarten to twelfth grade) and/or teachers of mathematics (including pre-service and in-service).

We determined if an article met our criteria through analysis of the title, abstract and keywords. Because our focus was on prekindergarden to twelfth-grade mathematics education, we excluded articles that focused exclusively on mathematics at the undergraduate level, unless the participants were pre-service teachers. For consistency, we also excluded articles about adult learners of mathematics, whether they were identified as having disabilities or not. This process yielded 2405 articles that met our criteria with approximately 3000 articles excluded.

Review Process

Using a similar methodology to Lubienski and Bowen's (2000) review, we coded articles based on title, abstract, and keywords, seeking breadth over depth. We did so to capture a broad overview of the current state of research. Both authors identified articles and coded data. We conducted a two-level review approach. For the first level, both authors coded the titles, abstracts, and keywords of a subset of 100 randomly-selected articles using our initial coding scheme. To ensure coding consistency between the two authors, we met to discuss discrepancies between our coding of these 100 articles. We refined our criterion for each category and resolved any discrepancies. After establishing a baseline of consistency, we assigned roughly equal responsibility for reviewing the remaining articles. Some articles did not present enough information in the title, abstract or keywords for us to code; hence, these categories were not coded for all articles. In addition, as we coded, we marked difficult coding decisions and consulted on them in additional meetings. All discrepancies were resolved. We conducted an inter-rater reliability assessment from a second sample of 100 randomly-selected articles, which resulted in an agreement rate of 94.6%.

Coding Categories

Journals. We coded journals based on three academic fields: (1) *Science, Technology, Engineering and Mathematics (STEM) education*, (2) *special education and psychology*, and (3) *general education*. See Appendix A for a list of all included journals by field. We originally

began with a separate category for mathematics journals, science journals, and technology journals. As we found a number of journals with a focus on some combination of mathematics, science, and technology, we combined these fields into a single category. Following Lubienski and Bowen (2000), we combined special education and psychology into one field, which was also how the journals were categorized within journal ranking websites such as Scimago Journal & Country Rank. When it was difficult to determine a journal's academic field, we referred to the journal's aims and scope to determine the best fit.

To compare research in the Australasian context to the larger international set, we identified relevant journals that were either explicitly named as Australasian or that were published by Australasian organizations or universities. We found 7 journals represented in our data set that fit this criterion. Three were STEM journals (*Mathematics Education Research Journal*, *Mathematics Teacher Education and Development*, *Australasian Journal of Educational Technology*), two were Psychology and Special Education Journals (*International Journal of Inclusive Education* and *International Journal of Disability, Development & Education*), and two were General Education journals (*Australian Educational Researcher* and *Australian Journal of Teacher Education*). We conducted a separate analysis of disability in this set of articles (the Australasian Set (*n*= 168).

Methodology. Our second area of interest was research methods employed, which we coded in two stages. First, we coded whether an article was *theoretical* or *empirical*. We coded as *empirical* articles that presented original research data on students or teachers, for example by including information about methodology and/or findings. A *theoretical* article either did not include any data or used limited data to situate a theoretical argument. Typically, *theoretical* articles were coded if explicitly so identified in the abstract by authors. Secondly, we coded the *empirical* articles further into four categories based on methodology. We used the following categories: (1) *quantitative*, (2) *qualitative*, (3) *mixed methods*, and (4) *undetermined*. Keywords for *quantitative* methods included: analysis of variance (or covariance), randomized controlled, quasi-experimental, correlation, and hierarchical linear analysis. Keywords for *qualitative* methods included: case study, interviews, ethnography, phenomenology, participant observation, and grounded theory. We coded articles as *mixed methods* if there was evidence of both methods. As some abstracts did not include specific language about their research methods, 8% of empirical articles were coded as *undetermined*.

Participant age. We created age categories based on grade level, as the abstracts are rarely specific as to age. We used the categories of (1) *prekindergarten*, birth until kindergarten, or up until and including age 4; (2) *elementary*, school grades from kindergarten until grade 5, ages 5–11; (3) *middle school*, school grades from 6-8, ages 12–14; (4) *high school,* grades from 9-12, ages 15–18, and (5) *teachers*. If the participants in a study fell into two categories, we coded in both. For example, a study in which students were in grades 4-8 would have been coded as both *elementary* and *middle*. We excluded studies in which the participants were over 18, except for studies of teachers. Because of the international audience of the journals, some grade levels will be slightly different as grade levels vary internationally.

Disability. Some articles in the area of disability were simple to code, as they explicitly mentioned disabilities such as *Cerebral Palsy* or *Deafness*. The most complicated area to code was *specific learning disabilities*. As has been noted by several reviewers of the literature on

mathematical learning disabilities (Lewis & Fisher, 2016; McFarland, Williams, & Miciak, 2013), there is a gray area in diagnostic criteria for learning disabilities in general, particularly so in the still emergent research on mathematical learning disabilities. Because the field currently lacks a precise definition of mathematical learning disabilities, academic articles use a wide variety of terms to refer to students. Under the category of disability, we included articles that used the terms: *dyscalculia, developmental dyscalculia, mathematical disabilities, mathematical learning disabilities*, and *at risk for mathematical disabilities*. Following van Garderen and colleagues (2009), we included articles in the Disability category if they described students as having "mathematical difficulties," "struggling" or having "low achievement," as these terms are frequently used in special educational research in mathematics.

Mathematical domain. We classified studies based on mathematical domain to determine if there was a difference between the content focus in research of students with and without disabilities, as has been found in other reviews of the literature for students with intellectual disabilities (Spooner, Knight, Browder, & Smith 2011) and mathematical learning disabilities (Lewis & Fisher 2016). We utilized categories employed in these previous research reviews. The content areas were: (1) *numbers and computation* (which included number processing, psychometric data, early numeracy, whole numbers and computation, and rational numbers and computation), (2) *algebra*, (3) *geometry*, (4) *measurement*, (5) *data and statistics*, (6) *calculus*, (7) *problem solving* and (8) *proof and argumentation*. Articles could be coded for more than one mathematical domain focus.

Theoretical orientation. Coding the articles for their theoretical orientations was a critical part of our investigation as we were interested in *how* the learning of students with disabilities was understood differently than for those without disabilities. We began with the categories identified by Woodward (2004) that compared the historical development of special education mathematics and mathematics education. These categories are: *behavioral*, *information processing*, *constructivist*, and *sociocultural*. We added *sociopolitical* to capture emerging research in mathematics education that seeks to understand the wider political and social contexts of mathematics teaching and learning (Gutiérrez 2013). After coding our initial set of articles, we refined our coding scheme, adding two categories that repeatedly emerged but were not captured in the initial categories: *medical* and *social psychology*. Coding for theory was complex and required multiple discussions between the researchers to create recognizable boundaries between the theories. We coded for theory by using keywords associated with particular theoretical orientations. Articles were coding in as many categories as we found evidence for. Many articles used keywords associated with multiple orientations.

Medical theoretical orientation. Articles in this category focused on the biological basis of mathematical learning. This classification emerged from articles that were difficult to code using our initial categories. For example, Purpura and Napoli's (2015) article titled "Early Numeracy and Literacy: Untangling the Relation between Specific Components" was one of many articles we found in which researchers sought to describe or identify the biological basis of mathematical learning. In that article, the authors described the "localization" of cognitive "domains," and then traced the "impact in early numeracy development" (p. 197). Another example is an article that tracked rapid eye movement when naming digits (Pan, Yan, Laubrock, Shu, & Kliegl 2013). Articles in this orientation aimed to understand students through

biological/neurological differences as measured by magnetic resonance imaging, or comparison of groups based on cognitive or neurocognitive assessments. Keywords for articles in this category included: cognitive domains, neurology, cognitive sub skills, and approximate number system.

Behavioral theoretical orientation. A study fit this category if it was situated within a tradition of understanding mathematical learning through observed behaviors. Keywords included behaviors, conditions, rewards, feedback, reinforcements, and training. We also included articles that mentioned concepts such as direct/explicit instruction, which developed from behaviorist principles (Woodward 2004). For example, Hall, Hustyi, Hammond, Hirt, and Reiss (2014) used "discrete trial training" in their intervention with students, which included "reinforcements." Davenport and Johnston (2015) described the use of "most-to-least prompting" and "contingent consequences" in their study of numeracy.

Information processing theoretical orientation. Studies fit in this category if the researchers understood cognition from an information processing lens, focusing on strategic thinking and the development of self-regulatory strategies. Examples of keywords for this orientation were self-regulatory strategies, executive functioning, working memory, and metacognitive. We also classified articles that used the word strategies based on whether the strategy was a generalized meta-cognitive strategy, such as think-a-louds. Articles focused on teaching using the CRA sequence (Concrete, Representational, and Abstract) were classified in the information processing category as these understood the development of thinking in generalized strategic terms, not specific to a particular mathematics domain. Sheehey, Wells, and Rowe (2017) studied the "effects of self-monitoring" on the mathematics performance of a student with cerebral palsy. Ok and Bryant (2016) studied the effects of "explicit, strategic intervention with iPad application practice on the multiplication fact performance and strategy use of elementary students with learning disabilities (LD) using a single-case, multiple probe design across participants" (p. 146). This article was coded both as behavioral (because of "explicit instruction"), and as information processing because of the mention of "strategy use", a cognitivist approach.

Constructivist theoretical orientation. These studies were situated in theories of learning that stress the individual learner's active construction of new knowledge through experience and reflection. Studies in this category often included detailed descriptions of individual learner's understandings of mathematical concepts. Keywords for this orientation included some terms from constructivist learning theory such as prior knowledge, learner conceptions, assimilation, cognitive disequilibrium, learning trajectories and misconceptions. Other terms included approaches to pedagogy associated with constructivist theories of learning, such as authentic instruction, project-based and inquiry-based learning. Generalized strategies were coded as information processing, and we coded descriptions of specific mathematical strategies as constructivist, such as using strategies related to ratio to solve fraction problems (Hunt 2015). Ulrich's article is an example of this research, entitled "Stages in Constructing and Coordinating Units Additively and Multiplicatively" (2015; 2016). This research also included articles that used a constructivist lens to understand teacher development, such as the article entitled, "Learning Trajectories in Teacher Education: Supporting Teachers' Understandings of Students' Mathematical Thinking" (Wilson, Mojica, & Confrey 2013).

Sociocultural theoretical orientation. In this category, researchers understood learning as occurring through interactions of students with teachers and peers, often analyzing discourse. We included studies that defined identity as constructed through participation in activity systems. Some keywords come from sociocultural theories such as semiotic mediation and tools. Articles that understood classrooms and other learning spaces as activity systems (or communities of practice or figured worlds) were also included in this category. Selling (2016) studied the mathematical practices in high school classrooms, specifically how students learned to represent their mathematical thinking, collaborate, and justify claims. Langer-Osuna (2017) used a sociocultural framework for her study on "Authority, Identity, and Collaborative Mathematics."

Sociopolitical theoretical orientation. This was a category we added that was not present in Woodward's (2004) classification. We did so in line with a movement in mathematics education that situates math learning in larger sociopolitical contexts (Gutiérrez, 2013). In studies classified under this orientation researchers analyzed issues of power and social positioning at the micro or macro levels. Not all policy articles were sociopolitical. To qualify, the article needed to bring a critical lens to some aspect of mathematics education, such as connecting policy movements to larger political movements (e.g., neoliberal ideology). When researchers analyzed student and/or teacher identity development, we typically coded their articles in this category if such analyses mentioned positioning and power. Articles mentioning social justice and equity in education were also coded as sociopolitical, such as "Learning to Teach Mathematics for Social Justice: Negotiating Social Justice and Mathematical Goals" (Bartell 2013).

Social psychology theoretical orientation. A study fit this category if learning was understood through concepts in social psychology, such as self-efficacy, self-concept, motivation, and mastery versus performance orientations. Mindset was also coded in this category. We added this category for articles such as Luo (2017) which studied how students who were "performance controlling" versus students who were "learning focused" assessed different mathematics teaching practices. Another article in this category, Henschel and Roick (2017), analyzed the relationship between student's mathematical self-concept and their cognitive and affective math anxiety. Keywords included: self-efficacy, self-concept, motivation, mastery and performance orientation, and mindset.

Undetermined. Some articles were difficult to code using these categories. We coded these studies as other. For example, Bouck, Joshi, and Johnson (2013) analyzed student use of calculators, comparing students with and without disabilities. They also compared use within traditional and reform-based curriculum. This article was coded as undetermined because there was not a discernable, explicit theoretical orientation using our coding categories. For example, although the article compared calculator use in traditional and reform-based curriculum, there was no language that indicated a preference for one curriculum or theory of pedagogy. These types of uncoded articles tended to be quantitative. In coding for theoretical orientation, we made the choice to err on the side of caution. We only coded articles if they met the criteria above, including the keywords that we had identified. 24% of all articles were coded as undetermined.

Limitations

Our study has notable limitations. First, we only included articles published in English, which limits our findings. In our initial search, we may have omitted relevant articles that were

not found through our search methods. We did not use mathematics concept terms (e.g., fraction, geometry, multiplication facts) instead opting for broad field terms (i.e., mathematics, math, and numeracy), thus articles could have been omitted that mentioned only specific terms. Another limitation was that we were not always able to determine coding from the title, abstract, or keywords. There were articles that included disability in the text of the article, but not in the title, abstract or keywords, and thus were excluded from the Disability Set of articles. One drawback of coding based on title, abstract and keywords was that certain areas were underreported. We suspect that fewer articles were coded as mixed methods because authors may not describe their methods with sufficient detail within an abstract for that code. Analysis of grade level may have differed based on international differences in grade levels.

Results

In this study, we explore research published between 2013 and 2017 on the teaching and learning of mathematics from the prekindergarten to twelfth-grade levels, identifying commonalities and differences in terms of methodology, participants, mathematical domain, and theoretical orientation for students with and without disabilities. Much of the following data compares the set of articles that included disability (Disability Set) (n = 408) with the set of articles that did not include disability (No-Disability Set) (n = 2069).

Academic field. Of the entire set of articles (N =2477), 408 articles or 16% included disability. However, we found that mathematics research on students with disabilities was overwhelmingly published in special education or psychology journals, with few articles published in mathematics education journals. Specifically, of the set of articles that focused on disability and mathematics (n =408), 76% were published in special education or psychology journals, and only 15% were published in STEM education journals. Examining all articles published in STEM education journals between 2013-2017 (n = 1461), we found that 4% (n =60) included disability as an explicit focus. This suggests that disability may be underrepresented in mathematics and/or STEM educational fields.

In their review of articles between 1982 and 1998, Lubienski and Bowen found that 2.3% of all articles published in mathematics education journals included disability, while of the total group of articles, 6.4% included disability. We found a much higher percentage of articles that included disability in the entire set (16%). However, because our focus was disability, we specifically searched for all articles that included math and disability, no matter the journal. While their analysis found that that 2.3% of all articles published in mathematics education journals between 1982 and 1998 included disability, we found that 4% of STEM education articles included disability.

Research methodology. Research on mathematics teaching and learning that included disability was less likely to be theoretical, and more likely to be empirical. Coding articles as either theoretical or empirical, we classified as theoretical 5% of articles in the Disability Set, compared to 16% in the No-Disability Set. There were 340 non-empirical theoretical articles about mathematics education that did not include disability over these three years, and only 22 non-empirical theoretical articles that focused on disability. Such outcomes suggest that disability may be notably undertheorized in educational research.

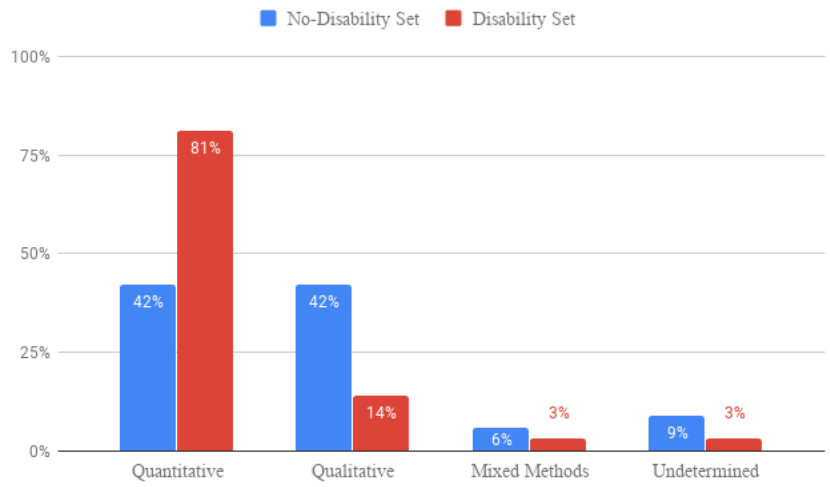

Fig 1. Methodologies for articles that included disability (Disability Set) compared to articles that did not include disability (No-Disability Set) as percentages of all empirical articles in each set.

To better understand the distribution of empirical research methods, we analyzed the set of empirical research papers in the Disability and No-Disability Sets (Figure 1). Empirical research on the mathematical learning of students in the No-Disability Set was fairly evenly distributed between quantitative (42%) and qualitative (42%) studies, with a small proportion of mixed methods (6%) studies. In contrast, research on the mathematical learning of students in the Disability Set was predominately quantitative (81%) with 14% qualitative, and 3% mixed methods. Methods used for students with and without disabilities were different, with qualitative methodologies relatively rare in studies focused on disability.

Participant focus. We found that research in the Disability Set focused more on elementary and middle-school learners, with almost half of the research on elementary-aged students (46%), compared with 22% of the No-Disability Set focused on elementary school (Figure 2). In the No-Disability Set, there was more even distribution across grade levels. The set of articles that included disability was slightly less likely to include students in high school (13% of Disability Set compared to 16% of articles in the No-Disability Set). These percentages reflect the entire data set, not just empirical articles. Overall, research on disability was more focused on elementary-school age learners.

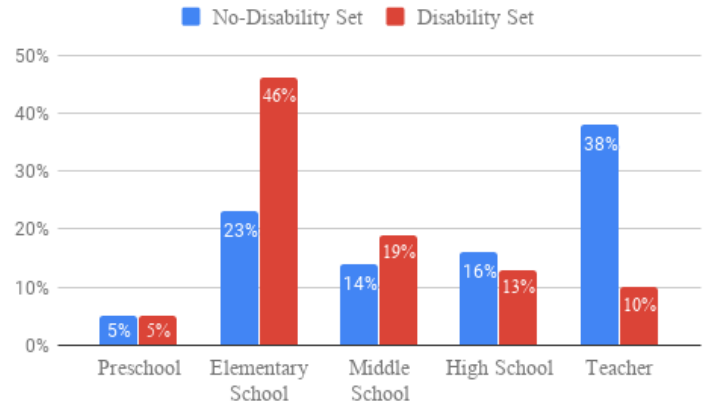

Fig 2. School level of participants in articles that included disability (Disability Set) compared to articles that did not include disability (No-Disability Set) as a percentage of all articles in each set.

There was a notable difference in the percentage of research on teachers in each category. Ten percent of articles in the Disability Set were focused on teachers, compared to 38% in the No-Disability Set. In terms of number of articles, 787 articles focused on teachers in the No-Disability Set, compared to 41 in the Disability Set. Such a difference in focus on teachers suggests that the role of the teacher in mathematics teaching and learning may be understood differently in special educational contexts.

Disability. Research on mathematics teaching and learning did not reflect the diversity within the category of disability, as most articles about disability and mathematics focused on only one category: students with learning disabilities (LD) or, more specifically, mathematical learning disabilities (MD) (Figure 3).

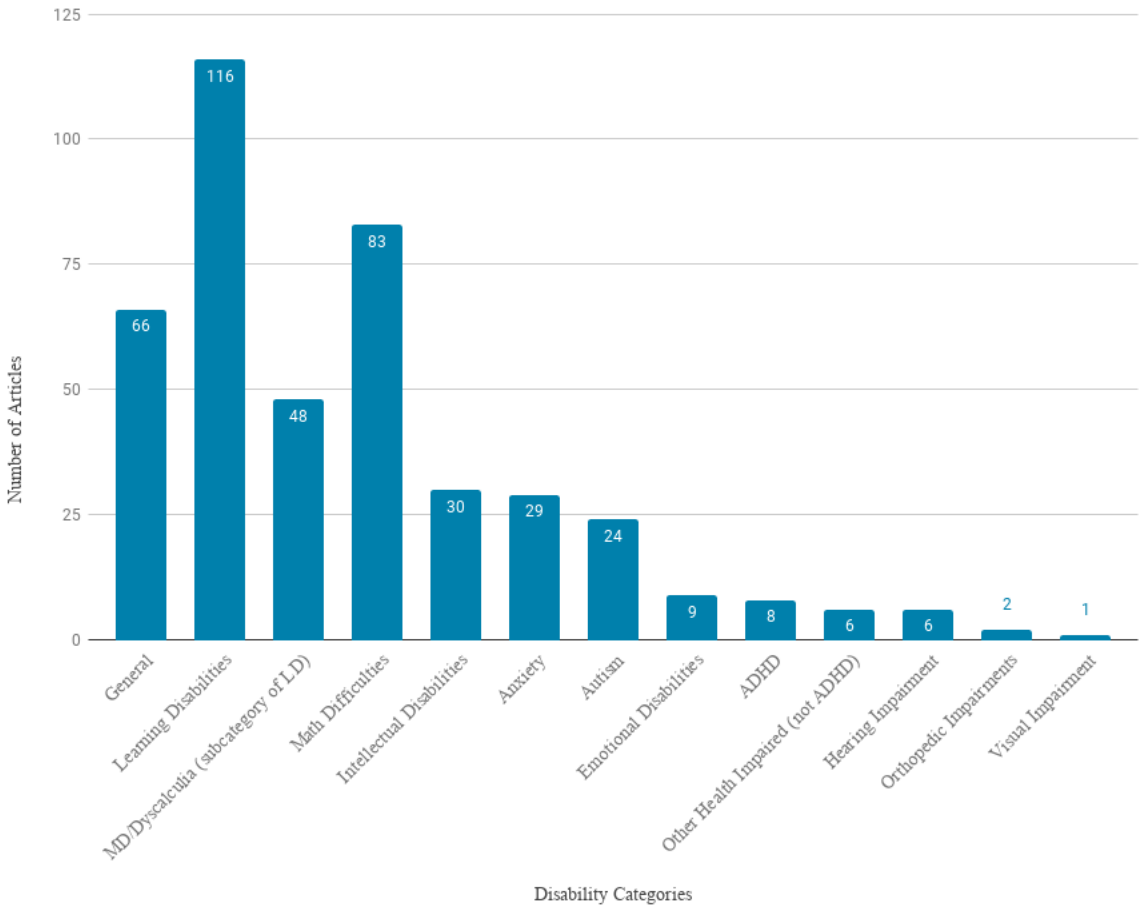

Fig 3. Disability Category included in research on mathematical teaching and learning 2013-2017 as percentages of all articles that included disability (Disability Set).

This group accounted for 116 articles or 27% of the entire Disability Set. Articles that did not specify disability category (i.e., special education students or special educational needs) were the second largest group (n = 66). The next most frequent disability categories were intellectual disability (n = 30), anxiety (n = 29), and autism (n = 24). The remainder of the disability categories were the focus of between 0 to 10 articles between 2013-2017. We also calculated the number of articles (83) that referred to students using terms such as "mathematical difficulties, "at risk of mathematical difficulties," "low-achieving in mathematics," and "struggling in mathematics." This group of students was also included in the category of Learning Disabilities.

Mathematical domain. We found that the two sets of articles had different mathematics foci (Figure 4).

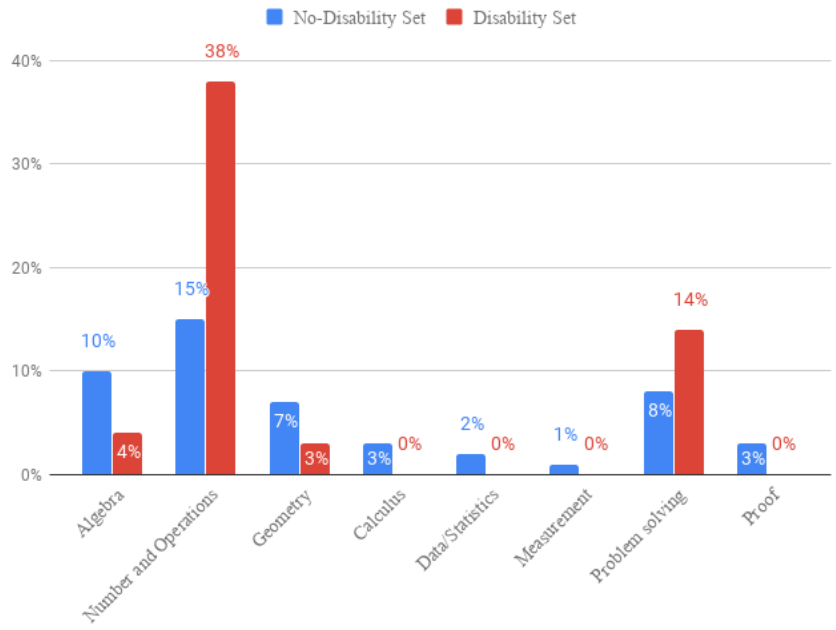

Fig 4. Mathematical domains in articles that included disability (Disability Set) compared to articles that did not include disability (No-Disability Set) as a percentage of all articles in each set. Articles could be coded in more than one category.

Research in the Disability Set was overwhelmingly focused on number and operations (38%). The second most prevalent category was problem solving (13%) compared to 15% of articles in the No-Disability Set focused on number and operations, with 8% on problem solving. Although articles on algebra, geometry, calculus, and statistics were rare in the Disability Set (4%, 3%, 0%, and 0% respectively), 10% of articles in the No-Disability Set focused on algebra and 7% on geometry. In line with the findings from previous research reviews in disability and mathematics (Lewis & Fisher 2016; Browder et al. 2008), we found that articles on students with disabilities tended to focus on less advanced content.

Theoretical orientation. We compared the Disability Set with the No-Disability Set, coding for theoretical orientation (Figure 5). Articles could be coded in more than one category, and we were not able to code 21% of articles in the Disability Set and 25% of articles in the No-Disability Set. The percentages in this section include the non-coded articles.

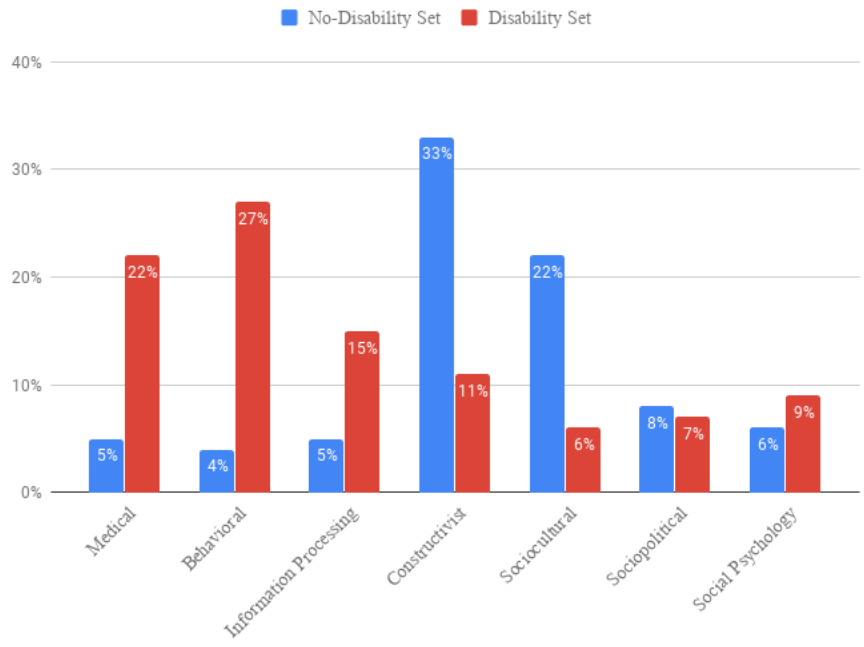

Fig 5. Theoretical orientation of articles that included disability (Disability Set) compared to articles that did not include disability (No-Disability Set) as a percentage of all articles in each set.

Learners in the No-Disability Set were understood most often through constructivist (33%) and sociocultural (22%) orientations. Comparably few articles in this set used medical (5%), behavioral (4%), or information processing (5%) orientations. Sociopolitical orientations represented 8% of the sample. Learners in the Disability Set were understood most often through behavioral (27%) and medical (22%) orientations. Information processing (15%) was the next most prevalent approach to learning. Comparably few articles in this set used constructivist (11%), sociocultural (6%) or sociopolitical (7%) orientations. The most similar finding across the two data sets was the lack of articles from a sociopolitical perspective, which represented 8% of the No-Disability Set and 7% of the Disability Set.

Research in the Australasian Context. For this special issue on inclusion focused on the Australasian context, we conducted a separate analysis of disability in this set of articles (the Australian Set (n= 168). Within this set we identified 14 articles on mathematics teaching and learning with a specific focus on disability or low-achieving students. The Australasian Disability Set has some pronounced differences from the larger Disability Set. First, there was a smaller percentage of total articles about disability in the Australasian Set. While in the larger set, 16% of total articles had a focus on disability, only 6% of articles in the Australasian Set do so. Second, there were fewer articles in Special Education or Psychology journals as we only found two Special Education or Psychology journals in our set. This accounts for the difference in the relative percentage of journal category within the disability sets. While the percentage of General Education journals are comparable across the disability sets, the Australasian Disability

Set is much more weighted towards STEM journals (71% of articles), with a much smaller proportion of articles from Psychology and Special Education journals (21%). Compare this to the larger Disability Set, which was dominated by Psychology and Special Education articles (76%), with only 15% articles from STEM journals. So while there were fewer articles on Disability in the Australasian Set, these articles were much more likely to have been published in a STEM journal.

Methodology in the Australasian Set. Australasian research on disability and mathematics was far more likely to be qualitative or mixed methods than the international Disability Set research on mathematics and disability. In the larger Disability Set, an overwhelming percentage of articles were quantitative (81%), while in the Australasian Disability Set, 4 articles were quantitative (28% of the Set), 6 were qualitative (43% of the set), with 2 articles that were mixed methods (14% of the set). One article was undetermined. This is a much different distribution of methodology that the larger data set on disability and was much closer to the distribution of methodologies in the larger No Disability Set.

Participants in the Australasian Set. In the larger data set, research on teachers was more prevalent in the No Disability Set (38%), with a much smaller percentage in the Disability Set (10%). In the Australasian Disability Set, 8 out of 14 articles had a focus on the teacher.

Theoretical Orientations in the Australasian Disability Set. The distribution of theoretical orientations in research on disability and mathematics was also quite different in the Australasian context. We found that these 14 articles were far less likely to have medical, behavioral, or information processing as a theoretical orientation and more likely to share theoretical orientations with the No Disability Set (dominated by constructivist, sociopolitical and sociocultural theoretical orientations) (Table 1.)

[Insert Table 1 here]

As a reminder, for this category articles could be coded in multiple theoretical orientations. Percentages are out of the total number of articles in the set, including undetermined articles. While the set of articles from the Australasian journals include a smaller proportion of research that includes disability, the research is more likely to have a variety of pedagogical orientations and to include a range of methodologies. Particularly striking is the lack of studies in the Australasian context that use behavioral or information processing as a primary theoretical orientation, since this orientation is quite pronounced at an international level.

These findings support the relevance of this special issue in MERJ on inclusive mathematics, suggesting that disability and other aspects of diversity are underrepresented in mathematics education in general and in the Australasian context as well. At the same time, the Australasian context offers a possible vision of what could be if research on mathematics was more qualitative and understood mathematics teaching and learning through constructivist, sociocultural and sociopolitical contexts. In the discussion, we will discuss exemplars from the Australasian Disability Set.

Discussion

In summary, we found differences between research on mathematical teaching and learning on students with and without disabilities from the prekindergarten to twelfth-grade levels published between 2013 and 2017. Analyzing articles ($N = 2477$) in terms of methodology,

participants, mathematical domain, and theoretical orientation, we found that research on students with disabilities was overwhelmingly quantitative (81%) and tended to use behavioral and medical theoretical orientations. Research on students without disabilities was both qualitative (42%) and quantitative (42%) and tended to use constructivist and sociocultural theoretical orientations. Although teachers were a focus in 38% of articles that did not attend to disability, teachers were a focus of only 10% of articles attending to disability.

In this discussion we will analyze the findings using a Disability Studies in Education perspective. We ground our analysis in Baglieri and colleagues' (2011) critique, which reads, "traditional understandings of disability in special education have inadvertently inhibited the development of theory, limited research methods, narrowed pedagogical practice, and determined largely segregated policies for educating students with disabilities" (p. 267). We will discuss each major finding in turn, specifically relating the finding to these critiques.

Theorizing disability, theorizing mathematics. Our review provides a concrete example of the critique that traditional understandings of disability have "inhibited the development of theory." We found that theoretical articles were far more common in the No-Disability Set than in the Disability Set, with only 5% of articles in the Disability Set coded as theoretical, compared to 17% in the No-Disability Set. As Brantlinger noted in 1997, theoretical innovation is limited in special education, which tends to value replication over innovation. This provides one reason why pedagogical methods in special education tend to be very similar over many years (Woodward 2004).

A plurality of methods versus monolithic methods. Research on students with disabilities was overwhelmingly quantitative (81%) whereas research on students without disabilities was both qualitative (41%) and quantitative (44%). A limited repertoire of methods means a limited repertoire of research questions (Eisenhart 2006). Considering how much we still do not know about students with disabilities learning mathematics, we need attention to both what is happening (descriptive questions) at the individual, classroom and system levels, as well as why such outcomes exist (process questions). Qualitative research is particularly valued in mathematics education research grounded in constructivist learning theories, as this body of research has documented the process through which individuals come to understand complex topics such as place value through sustained, longitudinal qualitative research (e.g. Carpenter, Franke, Jacobs, Fennema, & Empson 1998). Such research often uses qualitative or mixed methods, building evidence through observation and interviews with children. Yet there is little research like this on students with disabilities. In almost all areas of mathematical development, there is no sustained research program that addresses how students with disabilities come to understand concepts such as early number, place value, operations, etc. This means that research on students with disabilities is not grounded in what mathematics education would consider foundational research on mathematical thinking and learning for students.

The only area in which such research is emerging from multiple researchers is in rational number. Jessica Hunt and colleagues (Hunt, 2015; Hunt & Empson 2015; Hunt, Tzur, & Westenskow, 2016; Hunt, MacDonald, & Silva, 2019) and Katherine Lewis (Lewis 2014; 2017) have investigated in detail how students with learning disabilities understand rational number through both constructivist and sociocultural theoretical frames. They have documented both ways in which students with learning disabilities use similar strategies as students without

disabilities, as well as potentially unique strategy development. This body of work is qualitative, offering a deeply detailed analysis of learning trajectories for students with disabilities. We can find no other area in which there has been substantial work from multiple researchers on the developmental mathematical pathways of students with disabilities. Such work will require sustained investigations over time, using a plurality of methods and theoretical orientations.

Based on the overrepresentation of quantitative methods in research on mathematics, we also know little about how students with disabilities engage in classroom contexts. This omits methodologies such as design research, which documents the process through which researchers and teachers design and adapt mathematics instruction for particular groups of students (Prediger, Gravemeijer, & Confrey 2015). Design research has been way of creating and documenting pedagogical innovation in mathematics, with close attention to both teaching and learning in concert. For example, in our work with teachers, we are often asked about including students with disabilities in high school courses such as algebra and calculus. Yet this review suggests that very little to no research has investigated effective accommodations or curriculum for adolescent student with disabilities in high school-level content.

Narrow pedagogical practices for students with disabilities. Learners in the No-Disability Set were understood most often through constructivist (33%) and sociocultural (22%) orientations (Figure 5). Learners in the Disability Set were understood most often through behavioral (27%) and medical (22%) orientations. Information processing (15%) was the next most prevalent approach to learning. Put simply, pedagogy differs for students with disabilities compared to nondisabled peers, quite dramatically. Brantlinger (1997) argues that special education has historically and purposefully differentiated its approach to pedagogy and curriculum, arguing that students in special education needed *different* curriculum than their peers in general education. She reasons that such differentiation allowed special education to develop as a separate field.

We argue that limiting pedagogical approaches for students with disabilities to medical and behavioral orientations takes a deficit approach, and results in deficit constructions of these students. One reason is because a medical approach is designed to document deficit. Much more research on students with disabilities takes a medical perspective on mathematical learning, with 22% of research on students with disabilities classified under this approach, compared to only 5% of research on students without disabilities. Such research is squarely focused on finding and describing student deficits; by their design, this research asks questions about those deficits and how to fix them.

Behavioral approaches to learning are deficit-based approaches because students lack agency to think or invent within these pedagogies. As stated in a report on high leverage practices in special education, in explicit instruction “Teachers make content, skills, and concepts explicit by showing and telling students what to do or think while solving problems” (McLeskey 2017, p. 80). Direct or explicit instructional procedures do not offer students’ choice in how to solve mathematical problems, instead explicitly laying out procedures for solving problems, dictating how students “think.” This pedagogical design assumes that the learner is not capable of thinking or developing strategies, taking a deficit view of the learner.

In the area of sociocultural learning theories, 22% of research that did not include disability was sociocultural, compared to only 6% of research on students with disabilities. This

limited range of pedagogies affects our understanding of social positioning, classroom culture, and other ways in which the specific context of classroom matters for students with disabilities. Students with disabilities are conceptualized as non-raced within special education (Artiles 2011). In order to develop understanding of these complexities, we need qualitative research that investigates how race, genders, class, and sexual orientations might interact with disability, and how these identifications might matter to students learning mathematics (Author 2015).

Finally, we found a pronounced difference in the focus on teachers and teaching in the two data sets. The limited amount of research on teachers and teaching within the Disability Set suggests a limited role for the teacher in pedagogy. Although 36% of articles in the No-Disability Set focused on teachers, only 9% percent of articles in the Disability Set did so. Mathematics educational research has spent decades highly focused on the role of the teacher knowledge and development (Lin & Rowland 2016). Teachers are viewed as creative and complex professionals, whose actions impact learning, and are influenced by their knowledge, beliefs, practice, and its intersections (Charalambous 2015). In contrast, special education research has focused on interventions and viewed teachers as technicians who deliver instructional interventions (Trent, Artiles, & Englert, 1998; Connor et al. 2011, Baglieri et al. 2011). In special education research, teachers are often mentioned only in relationship to fidelity of implementation of the intervention.

The lack of research in this area means that we know little about how teachers of students with disabilities enact or adapt curriculum to meet the often complex needs of students with disabilities. The passive role of the teacher in the research in special education limits both the agency of teachers, and their efficacy. Students with disabilities are complex learners, and present unique situations for their teachers to problem solve. However, the lack of research in this area acts as if only narrow forms of interventions can offer student success. We find this attitude demeaning. Being a successful special educator demands a complex set of skills and a plurality of pedagogical methods (Naraian 2017). Special educators excel at adapting and modifying curriculum, yet little to no research documents these effective practices.

As Boyd and Bargerhuff (2009) noted, those who teach mathematics to students with disabilities must make sense of contrasting approaches to mathematics, documented in this study. Special education as a field is deeply committed to collaboration; serving students with complex educational needs means working across multiple disciplinary boundaries, moving between different discourses. Inclusive research in mathematics depends on this border-crossing that Naraian (2017) found in successful inclusive mathematics teachers. We call for mathematics education and special education researchers to follow the lead of teachers, and to learn to take up multiple methods and theories of learning, all in service of transforming mathematical education for students with disabilities.

Segregation in mathematics teaching and learning. Baglieri and colleagues (2011) wrote, "traditional understandings of disability have . . . determined largely segregated policies for educating students with disabilities" (p. 267). The pronounced differences between research for students with and without disabilities may lead teachers, families, and school administrators to separate students with disabilities from students without disabilities for mathematics instruction. If research identifies that these two groups require different mathematical pedagogies, then they will be separated. If research identifies different roles for teachers of these two groups of

students, they will be separated. Very little of the research we identified explored how teachers can teach in classrooms that include both students with and without disabilities.

Innovation in the Australasian Disability Set.

In the Australasian Disability Set, there was little to no focus on medical, behavioral and information processing as theoretical orientations for understanding mathematical learning for students with disabilities. Instead, the learning of students with disabilities was understood through constructivist, sociocultural and sociopolitical orientations. In a stark contrast to the larger Disability Set, the Australasian Disability Set was predominately qualitative and focused on teachers. In this section, we describe what this literature offers to the field, as it provides an alternative in comparison to research approaches that dominate the study of disability.

One finding that we found across this set of articles was documentation of the low expectations held of students with disabilities. Using longitudinal Australian data, Carmichael (2015) found that teachers significantly underestimated the mathematical abilities of students with special needs. Bailey, Nomanbhoy, and Tubpun (2015) described the negative views about students with disabilities and their families by Malaysian teachers involved in remedial numeracy education, and how these negative perceptions limit inclusion.

Other research in this set documented the links between low expectations and particular pedagogies applied to students with disabilities. Zuber and Anderson (2013), in a study of teacher perceptions of laptop use in mathematics classrooms, found that a sizable portion of the Australian teachers in their sample did not use laptops in classes for lower-achieving students, believing that laptops create classroom management issues for these students in particular.

Tait-McCutcheon and Loveridge (2016) described how two teachers from New Zealand taught the same lesson to their classes labeled as the "lowest ability group." They analyze how the students were positioned as mathematics learners, which impacted student participation. The researchers argue that this differences in positioning had more influence on student learning than the curriculum, which was kept constant. In one classroom, the teacher positioned the students to create an ethos of collaboration and shared responsibility for problem solving. In turn, students in this class shared strategies and discussed multiple explanations. The second teacher positioned students as passive, their role as copying information rather than creating strategies themselves. There was not space for student thinking in this lesson. This study documents how the same lesson can afford very different participation, depending on how the teacher positions low-achieving students as either thinkers or not.

Anther theme was tracing how both disability and ability are constructed in mathematical contexts through interaction. This emerges from the study of Tait-McCutcheon and Loveridge (2016), as they document how the mathematical competence of low-achieving students is constructed differently by different teachers. Lambert (2017) describes how Learning Disabilities are constructed within a mathematics classroom, both in how a child named Elijah with a Learning Disability is positioned as a mathematics learner by his teachers through a complex set of discourses, but also how Elijah makes sense of these discourses, authoring a unique self-understandings as both "fast" and "slow" in mathematics. Focused on the experiences of students with chronic illness who are missing school, Wilkie (2014) studied the perspectives of both

students and teachers of mathematics as they supported students with chronic illness in virtual mathematics environments. The research described the perspective of both groups in detail, and particular characteristics of the teaching/learning interaction that facilitated learning.

These papers offer understanding of learning within contexts, essential to understanding how ability and disability emerge in mathematics classrooms. Also in the Australasian set, Talbot (2016) critiques how students in the Australian context are constructed as "at risk" through the neoliberal agenda of standardized tests which locate deficit within the child. They call for mathematics education research that uses ethnography to understand the standpoint of the student, as well as insights into the complex institutions that surround and shape the child's mathematical learning experiences. This article demonstrates the importance of theoretical critique in the area of disability and mathematics, which can move the field towards additional critical analysis. Taken together, these papers published on disability and mathematics in the Australasian context demonstrate new theoretical and pedagogical directions that could contribute internationally to greater inclusion for students with disabilities.

Implications

Social science has unique obligations to the people that it studies (and serves). Considering the backlash to research using a medical model within the disability rights movement (Oliver 2009; Linton 1998), we call for broad changes in both mathematics education and special education research. Increased participation and inclusion, not separation, is at the center of social justice concerns for people with disabilities (Charlton 1998; Carey, Block, & Scotch 2019). Thus we identify a significant mismatch in the current research on mathematics for students with disabilities. It appears that special education research in the area of mathematics is not responsive to the expressed needs of the disability community (Charlton 1998; Carey, Block, & Scotch 2019), with inadequate attention to participation in general education mathematics, and over differentiation between special educational methods and general education methods. If little research documents the inclusion of students with disabilities in the dominant pedagogical orientations in mathematics education, then not enough is being done by research to facilitate and understand that inclusion. In addition, disability rights advocates press for additional understanding of the role of disability in oppression, including in educational contexts (Carlton 1998). In order to understand the contexts in which students with disabilities are positioned, we call for additional research using a sociopolitical orientation.

We begin with the changes necessary in mathematics education. First, mathematics education needs to consider disability as part of equity. The same care must be directed towards documenting the experiences and understandings of students with disabilities, in all their intersections, as other groups who are underrepresented in mathematics (Author 2015). Definitions of equity used for other populations need to applied to students with disabilities. Students with disabilities are also students of color, also girls, also students from low-income communities, also emergent bilinguals. Definitions of equity used for other populations need to applied to students with disabilities.

Special education needs to broaden its understanding of equity as well. Too often, equity in special education is conceptualized as a scores on an achievement test. But what is lost for these children when equity is defined narrowly as test scores? We have argued elsewhere for

equity in mathematics for students with disabilities to include attention to access to inquiry mathematics, and to identification as mathematical thinkers (Authors 2017; 2018). Future research must document classroom contexts and multiple pedagogies. We need more analysis of students with disabilities learning in and through classroom discourse, as well as close analysis of student thinking. In addition, sociocultural research can help us identify how identity, emotion and dispositions matter in mathematics learning, which may be essential in understanding how students with disabilities develop as mathematics learners over time.

We argue that these shifts would better connect research to practice. Special educators' perceptions of existing research point to skepticism about research claims, noting that quantitative methods are too easy to manipulate in order to sell an educational product (Boardman, Arguelles, Vaughn, Hughes, & Klingner 2005). Connor and colleagues (2011) remind us that special education intervention research is often set in contexts that are impractical to implement for special education teachers: small groups outside classroom settings. Increased attention to the contexts in which students with disabilities learn mathematics could begin to remedy this situation. Future research must begin to document the strengths of special educators as they innovate pedagogically. If research only limits understanding of special educators as those who enact scripted curriculum, we lose sight of the important and innovative work done every day by special educators.

Research on mathematics can present students with disabilities as complex, dynamic learners. We call for additional research in mathematics teaching and learning that assumes competence and allows students with disabilities to engage in rich content, and research that allows agency for teachers to develop new teaching practices that allow access for a wider variety of students. These are critical in order to create more inclusive mathematics classrooms, but they will not be enough. We call for sociopolitical research in inclusive mathematics, that contextualizes disability within political and social spheres. As the inclusion of disability into classrooms can transform those classrooms, so the inclusion of disability in mathematics educational research can transform and invigorate mathematics research.

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Appendix A
Included Journals by Journal Category with Number of Articles Included in ()
88 total journals

STEM Education Journals (17 journals, 1461 articles)
American Journal of Distance Education (2)
Australasian Journal of Educational Technology (5)
Canadian Journal of Science, Mathematics and Technology Education (33)
Educational Studies in Mathematics (183)
EURASIA Journal of Mathematics, Science & Technology Education (131)
For the Learning of Mathematics (56)
International Journal of Mathematical Education in Science and Technology (109)
International Journal of Science and Mathematics Education (156)
Journal for Research in Mathematics Education (76)
Journal of Computers in Mathematics and Science Teaching (37)
Journal of Mathematical Behavior (77)
Journal of Mathematics Teacher Education (112)
Journal of Urban Mathematics Education (37)
Mathematical Thinking and Learning: An International Journal (59)
Mathematics Education Research Journal (108)
Mathematics Teacher Education and Development (72)
ZDM: The International Journal on Mathematics Education (208)

Special Education and Psychology Journals (49 journals, 643 articles)
American Annals of the Deaf (2)
Annals of Dyslexia (2)
Assessment for Effective Intervention (7)
Autism: The International Journal of Research and Practice (4)
Contemporary School Psychology (3)
Developmental Psychology (47)
Developmental Science (18)
Early Education and Development (38)
Education and Training in Autism and Developmental Disabilities (10)
Education and Treatment of Children (3)
Educational and Psychological Measurement (11)
Educational Measurement: Issues and Practice (2)
European Journal of Psychology of Education (15)
European Journal of Special Needs Education (6)
Exceptional Children (17)
Exceptionality (6)
Focus on Autism and Other Developmental Disabilities (4)
Gifted Child Quarterly (7)
Hispanic Journal of Behavioral Sciences (2)

International Journal of Disability, Development and Education (4)
International Journal of Inclusive Education (3)
Journal for the Education of the Gifted (9)
Journal of Applied School Psychology (5)
Journal of Autism and Developmental Disorders (7)
Journal of Deaf Studies and Deaf Education (2)
Journal of Early Adolescence (8)
Journal of Educational Psychology (70)
Journal of Experimental Child Psychology (49)
Journal of Experimental Education (15)
Journal of Intellectual Disability Research (3)
Journal of Learning Disabilities (41)
Journal of Personality and Social Psychology (1)
Journal of Policy and Practice in Intellectual Disabilities (1)
Journal of Research in Special Educational Needs (2)
Journal of School Psychology (4)
Journal of Special Education (6)
Journal of the International Association of Special Education (2)
Learning and Individual Differences (55)
Learning and Instruction (30)
Learning Disabilities Research & Practice (19)
Learning Disabilities: A Contemporary Journal (4)
Learning Disability Quarterly (25)
Preventing School Failure (11)
Remedial and Special Education (17)
Research in Developmental Disabilities (37)
School Psychology Quarterly (4)
Support for Learning (2)
Teacher Education and Special Education (2)
Topics in Early Childhood Special Education (1)

General Education Research Journals (22 journals, 373 articles)
American Educational Research Journal (25)
American Journal of Education (15)
American Secondary Education (3)
Asia Pacific Education Review (11)
Australian Educational Researcher (3)
Australian Journal of Teacher Education (42)
Curriculum Inquiry (4)
Education Policy Analysis Archives (17)
Education Sciences (12)
Educational Evaluation and Policy Analysis (21)
Educational Researcher (17)

Elementary School Journal (29)
Harvard Educational Review (3)
Journal of Curriculum Studies (14)
Journal of Educational Research (43)
Journal of Teacher Education (20)
Journal of the Learning Sciences (19)
Review of Educational Research (6)
Scandinavian Journal of Educational Research (4)
Teacher Development (8)
Teacher Education and Practice (15)
Teachers College Record (42)

Theoretical Orientation	No Disability Set (*n* =2069)	Disability Set (*n* =408)	Australasian No Disability Set (*n* =234)	Australasian Disability Set (*n* =14)
Medical	93 (5% of set)	91 (22% of set)	5 (2% of set)	2 (13% of set)
Behavioral	84 (4% of set)	110 (27% of set)	1 (0% of set)	0 (0% of set)
Information Processing	106 (5% of set)	61 (15% of set)	2 (1% of set)	0 (0% of set)
Constructivist	686 (33% of set)	44 (11% of set)	82 (35% of set)	5 (33% of set)
Sociocultural	446 (22% of set)	25 (6% of set)	68 (29% of set)	2 (13% of set)
Sociopolitical	164 (8% of set)	27 (7% of set)	15 (6% of set)	3 (20% of set)
Social Psychology	118 (6% of set)	36 (9% of set)	14 (6% of set)	0 (0% of set)
Undetermined	497 (25% of set)	87 (21% of set)	48 (21% of set)	2 (20% of set)

Table 1. Comparison of Theoretical Orientations to Mathematics Teaching and Learning