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A Synthesis of Research on Teacher Education, Mathematics, and Students with Learning Disabilities

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This paper reports the results of a synthesis of research related to teacher education, mathematics, and students with learning disabilities (SWLD) and other struggling learners. The goals of this synthesis were to determine the nature of the current research base (2004-2014) and to determine how it can inform teacher educators about the effective preparation of teachers who teach mathematics for SWLD and other struggling learners. A systematic search process resulted in 16 studies meeting inclusion criteria. Results indicate that the research base is limited with respect to number of studies but quite diverse in terms of research questions and foci, research design, participants, and context. The majority of studies involved some type of professional development (PD) intervention. A limited number of studies included the impact of the PD intervention on PK-12 student outcomes. Studies also focused on evaluating PS and INS teacher perceptions about issues such as competence for teaching mathematics, self-efficacy, mathematical knowledge, and mathematics anxiety while others measured teacher mathematical knowledge utilizing a variety of measures. Implications are discussed including suggestions for future research.

Keywords: Teacher education, teacher preparation, professional development, mathematics, math, learning disabilities, disabilities, at-risk, special education

Introduction

Students with learning disabilities (SWLD) can struggle with mathematics for a variety of reasons. Researchers (e.g., Allsopp, Kyger, & Lovin, 2007; Berch & Mazzoco, 2007; Krasa & Shunkwiler, 2009; Miller & Mercer, 1997) describe a variety of learner related characteristics and curriculum factors that can be significant math learning barriers for SWLD. Learning related characteristics include information processing difficulties (e.g., memory related difficulties such as working memory and long term memory retrieval, attention deficits, visual/spatial, auditory, and motor processing deficits), metacognitive thinking difficulties, language related disabilities, and math anxiety to name a few. Math curriculum factors can also be barriers to learning for SWLD. Curriculum factors such as a lack of utilizing research supported effective instructional practices, the extent to which textbooks afford students with enough opportunities to respond to new math concepts in order to develop proficiency, and failure to emphasize both conceptual and procedural understanding can

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result in knowledge gaps, learned helplessness, and reliance on passive learning approaches for SWLD.

Indeed, SWLD underperform in mathematics compared to their peers without disabilities. The most recent National Assessment of Educational Performance (NAEP) data illustrate the large gap in mathematics performance between students with disabilities, including SWLD, and their peers without disabilities (National Assessment of Educational Performance, 2013). For example, 45% of fourth graders with disabilities who participated in assessments scored below basic compared to 14% of fourth graders without disabilities, 55% of fourth graders with disabilities scored at or above basic compared to 86% of fourth graders without disabilities, and only 18% of fourth graders with disabilities scored at or above proficient compared to 45% of fourth graders without disabilities. Outcomes for eighth graders with and without disabilities were even more disparate with 65% of students with disabilities scoring below basic compared to 21% of students without disabilities, 35% of students with disabilities scoring at basic or above compared to 79% of students without disabilities, and only 9% of students with disabilities scoring at or above proficient compared to 30% of students without disabilities. Data for grade 12 are similar with 25% of students with disabilities scoring at or above basic compared to 69% of students without disabilities and 6% of students with disabilities scoring at or above proficient compared to 28% of students without disabilities.

Although the NAEP data are not disaggregated according to specific disability categories, the difficulties that SWLD specifically have with mathematics are well documented (e.g., Judge & Watson, 2011; Klingner, et al., 1998; Mazzocco & Räsänen, 2013; Miller & Mercer, 1997; Powell, Fuchs & Fuchs, 2013; Watson & Gable, 2013; etc.). The research base on effective mathematics practices for SWLD is limited but has received more attention recently. Recent meta-analyses have helped the field begin to identify mathematics practices that have a substantial enough evidence base to suggest to teachers what they can do to improve mathematics outcomes for SWLD (e.g., Gersten, et al., 2009; Swanson & Deshler, 2003; Xin & Jitendra, 1999; etc.). Well-established organizations have begun to develop an array of mathematics education resources based on this growing research base (e.g., Center on Instruction, 2014; National Center on Intensive Intervention, 2014; RTI ActionNetwork, 2014, National Council of Teachers of Mathematics, 2014, etc.).

The preparation of teachers who can implement effective mathematics practices and interventions for SWLD is also critical to helping SWLD find mathematics success. Examples of such practices include use of explicit systematic instruction, utilization of visuals to represent mathematical ideas, teaching strategies for problem solving, peer tutoring, engaging students in verbalizing their thinking about math ideas, concrete-to-representational-to-abstract (CRA) sequence of instruction, providing students with specific corrective feedback, etc. (Baker, Gersten, & Lee, 2002; Gersten et al., 2009; Newman-Gonchar, Clark, & Gersten, 2009; Kroesbergen & Van Luit, 2003). Without well-prepared teachers who can effectively apply research supported practices, it is unlikely that mathematics outcomes for SWLD will improve. It is unclear how teacher educators are addressing the need to prepare math teachers who can (1) effectively teach SWLD and improve student outcomes, (2) what works and what does not work from a teacher education perspective, and (3) what are factors that affect the preparation of effective math teachers for SWLD. We were unable to find any prior articles in peer reviewed journals that report a synthesis of research on this topic. In order to move forward, the field needs to have an integrated sense of the research related to preparing effective math teachers for SWLD and how the research can inform the practice of teacher education and future research. The purpose of this research synthesis is to begin this process. We report the results of a systematic synthesis of research related to teacher education, mathematics, and SWLD published since several recent math education policy initiatives were advanced in the early 2000s which include the National Council of Teachers of Mathematics (NCTM) Principles and Standards (National Council of Teachers of Mathematics, 2012), National Research Council's (NRC) *Adding it Up* Report (National Research Council, 2001), the report of the National Math Advisory Panel (National Math Advisory Panel, 2008), and Common Core State Standards (Common Core State Standards, 2012). In completing this synthesis, we were interested in obtaining an informed perspective of the current research landscape related to teacher education, mathematics, and SWLD. We wanted to understand the nature of the research base including where and in what types of peer-reviewed venues the research has been published, the focus of research questions, types of research designs, who were the participants (e.g., preservice and/or inservice teachers), and the contexts within which the research was completed (e.g., university classes, peer learning communities in schools, district trainings, field settings for teacher candidates, etc.). We also wanted to understand how the research informs current and future teacher education practice and associated research related to math and SWLD. Two initial questions guided the focus and search method of this paper: (1) What is the nature of research related to the preparation of teachers who teach mathematics for SWLD? (2) How does the research and practice base inform both teacher educators about how to effectively prepare teachers to teach mathematics for SWLD and researchers about designing studies to move the field forward in the future? We begin with a description of our search method and results and then provide a discussion of the results including how the research informs the field about effective teacher education practices related to mathematics and SWLD, and what appear to be barriers and potential facilitators, and implications for future research and practice.

Method

Search Method

The following search terms were utilized for this search: teacher education, professional development (PD), math, STEM, common core, special education, and disability/disabilities. We did not include "learning disability/disabilities" as search terms because the search terms "disability/disabilities" allowed for a wider net of potential papers inclusive of studies that incorporated students with learning disabilities. Papers including the term learning disability/learning disabilities or associated terms such as reading disabilities and math disabilities were captured with the more general terms disability/disabilities. The search terms were entered singularly and in varying combinations in the following data-bases: Education Resources Information Center (ERIC), the University of South Florida database system, which incorporates Omnifile Full Text Mega, Academic Search Premier, Education Full Text, and PsychInfo within a single search portal, and Google Scholar.

The following inclusion criteria were utilized to select studies for this synthesis: (1) research studies published between 2004 and 2014 in order to capture research reflecting the policies of the NCTM Principles and Standards for School Mathematics (2000), the National Research Council's *Adding it Up* (National Research Council, 2001), the Final Report of the National Mathematics Advisory Panel, *Foundations for Success* (National Mathematics Advisory Panel, 2008), and the advent of the Common Core State Standards-Mathematics (we chose 2004 as the beginning year for our search because we believe it allowed an appropriate time-frame for manuscripts to be published that were developed in response to the NCTM Principles and Standards for School Mathematics and National Research Council's *Adding it Up!* which were published in the early 2000s); 2) related to, in whole or in part, preservice (PS) and/or inservice (INS) teacher preparation/PD for SWLD including studies that evaluated the perceptions of PS and INS teachers about the impact of teacher preparation or professional development on their practice; 3) journal articles or dissertations; 4) research designs could be quantitative, mixed methods, or qualitative in nature. Papers which did not meet these inclusion criteria were not included in this synthesis. For example, studies that did not focus on PS or INS teacher outcomes (i.e., studies that measured the effect of teacher implemented mathematics interventions/practices on student outcomes) or studies where minimal teacher outcome data were collected (e.g., social validity data only) were not included. Initially, 50 papers were identified using the search terms and databases described above. Titles and abstracts of each paper were then reviewed to determine which papers met inclusion criteria. When additional information was needed to make this determination, papers were more thoroughly reviewed (i.e., methods section, results/findings section). One author conducted the initial search and review of the papers utilizing the inclusion criteria. Next, the second author reviewed each paper utilizing the inclusion criteria to ensure that all papers meeting inclusion criteria were incorporated in the sample. This two-phase review process resulted in 100% agreement on which articles met inclusion criteria resulting in a total of 16 studies (32%) being integrated within this synthesis.

Coding and Analysis

Each study was individually coded according to seven categories: *type of publication* (i.e., journal article, dissertation, other), *research questions/area of focus* (i.e., focus, scope), *research design* (i.e., quantitative, qualitative, mixed methods), *participants* (i.e., PS, INS, area of certification/teacher preparation program), *focus* (i.e., dependent/independent variables), *context* (i.e., setting, PK-12 student demographics), and *results* (i.e., reported findings by areas of focus). One author initially coded each study according to the identified categories and included data in an initial coding table. For example, for the category "research questions/area of focus," the research questions for each study were coded based on their general focus. Then the other reviewed each study in conjunction with the coding table developed by the first author to confirm or question codes for each category. Additionally, the second author checked the accuracy of any calculations made to quantify the data (e.g., summing the number of instances where studies addressed a particular code). Both authors discussed any discrepancies and reached consensus on final codes and calculations. Table 1 shows the results of this coding process.

In order to make meaning of the coded data across studies, the data were analyzed quantitatively and organized in a way that provided us a structure to visualize patterns and describe the data. Data for each coded category were organized according to subcategories. For example, data related to the category "research questions/area of focus" were organized by question type and area of focus. For question type, coded data were further organized by research questions that addressed INS teachers, PS teachers, and total. For area of focus, coded data were organized by research questions that addressed INS teachers that included a PD intervention, INS teachers that did not include a PD intervention, PS teachers that included a PD intervention and PS teachers that did not include a PD intervention. These data were then quantified by summing the total occurrences for each code among the included studies (e.g., the total number of occurrences for research questions that addressed the impact of PD was 9). Table 2 shows the quantitative analysis of the 16 studies included in this synthesis and organizational structure.

Results

The results of this synthesis are reported according to the research questions that guided this study. Results related to research question one are discussed first and results related to research question two are discussed next.

Research Question #1: What is the nature of research related to the preparation of teachers who teach mathematics for SWLD?

In order to answer this research question the results are discussed by coded categories: publication type, research questions/area of focus, type of research design, participants, and the context within which each study was conducted.

Publication type. Overall, 10 of the studies were published in peer-reviewed journals and six studies were dissertations. Of the 10 journal studies, five were at the PS level only (Dieker et al., 2009; Humphrey & Hourcade, 2010; Johnston & vanderStandt, 2011; Paulsen, 2005; Rosas & Cambell, 2010) and five were at the INS level only (Griffin, League, Griffin, & Bae, 2013; Faulkner & Caine, 2013; Gagnon & Maccini, 2007; Maccini & Gagnon, 2006; Thornton et al., 2008). For dissertation studies, one was at the PS level only (Ray, 2008), four were at the INS level (Beauchaine, 2014; Hellman, 2007; McTigue, 2008; Servilio, 2009), and one was at both the PS and INS levels (Hinton, 2011). None of the dissertation studies were found published in journals at the time of this synthesis.

The 10 journal publications were in seven different journals. Four journals share a focus on special education issues (*Exceptional Children, Learning Disabilities Quarterly, Remedial and Special Education, and Teacher Education and Special Education*), one journal addresses early childhood teacher education issues (*Journal of Early Childhood Teacher Education*), one journal focuses on teaching and administration in middle, junior high, and high schools (*The Clearing House*), and one journal centers on the college level preparation of mathematics teachers (*IUMPST: The Journal*). Four studies were published in one journal, *Teacher Education and Special Education.* The remaining journals had one publication each.

Table 1. ***Summary of Codes.***

Study	Pub. Type	Research Questions/ Area of Focus	Research Design	Participants	Context	Results
McTigue (2008)	Dissertation	How? Collaborative study group PD worked	Qualitative	INS (N=7) - GENED teachers (N=6) - SPED teachers (N=1)	Urban middle school - Grade 6 - Students who are bilingual and students with disabilities	Study Group in AAMSM framework. Had difficulty sustaining work as AAMSM suggests; barriers included unprotected time for meeting, curricular changes, inadequate support materials, district assessment demands and initiatives; uneven participation among members; concerns with barriers tended to divert conversations of AAMSM goals of making math accessible to all students in class.
Beauch-aine (2014)	Dissertation	Impact/effect? Job embedded PD on differentiating instruction with Everyday*Math*	Qualitative	INS ELEMED teachers (N=14)	Primary School - Grades K- 3 - Students with above average performance	Reported increase in differentiated instruction practices; emphasized importance of conceptual understanding over procedural, equally important decreased 4-3; challenges – time, lack of personnel, student frustration with math.
Griffin et al. (2013)	Journal	How? PD discourse practices are used Impact/effect? On K-12 student outcomes?	Mixed Methods	INS (N=2) - Elementary teacher (N=1) - SPED teacher (N=1)	Rural elementary school - Grades 3-4 - Students with SLD and LI	Different patterns and types of discourse practices utilized. Student performance mixed, 4th graders better on unit tests than 3rd graders, both groups consistently low on progress monitoring,

Dieker et al. (2009)	Journal	How? Development of video models of effective math practices? Impact/effect? On teacher knowledge of practices?	Mixed Methods	PS undergraduate SPED teachers (N=22)	Math methods classroom - No K-12 student data reported	Knowledge of effective math practices (MDA); greater overall gains for video group compared to no video group.
Faulkner & Caine (2013)	Journal	Impact/effect? Math content PD on teacher knowledge for teaching mathematics?	Experimental/ Quasi-experimental	INS general and SPED teachers (N=85) - GENED teachers (N=69) -SPED teachers (N=16)	5-day workshop for teachers who support students with disabilities - Grades K-12	Number Sense - no differences between treatment and comparison groups; no differences between SPED and GENED; extended findings using *Content Knowledge for Teaching Mathematics measure* (CKTM).
Paulsen (2005)	Journal	Impact/effect? Implementation of an effective practices intervention on student outcomes and perspective of tutors?	Mixed Methods	PS SPED graduate teachers (N=11)	Tutoring sessions -Students “at-risk” of mathematics failure	Intervention at-risk students showed more gains than comparison group students not at risk; feedback from tutors positive but unclear how data collected.
Johnston & vanderSandt (2011)	Journal	Impact/effect? Mathematics content course on mathematics anxiety of differ education major subgroups?	Experimental/ Quasi-experimental	PS (N=421) - Elementary (N=210) - Early Childhood (N=106) SPED (N=105)	Public liberal arts college math content course for freshman/ Sophomores -No K-12 student data reported	Effect of math content course and math methods course on math anxiety. Elem education students only group with statistically significant decrease after content course; All groups (DHH, Early Childhood Education, and ELEMED) but SPED showed decrease after methods course.

Gagnon & Maccini (2007)	Journal	Perceptions/Beliefs? About mathematics practices and accommodations	Survey	INS SECEDlevel teachers (N=167) - GENED math teachers (N=76) - SPED teachers (N=91)	Database sample - Grades 9-12 - K-12 Students with LD and EBD	SPED and GENED teachers felt more prepared after taking math methods courses but SPED teachers felt more prepared to teach students with LD/EBD. GENED felt more prepared to teach GENED students; no difference between groups to teach students with LD/EBD after SPED teacher prep courses. Predictor variables – number of math methods courses accounted for the greatest amount of variance.
Maccini & Gagnon (2006)	Journal	Factors? Associated with perceived mathematics practices and accommodations used	Survey	INS SECED level teachers (N=176) - GENED teachers (N=78) - SPED teachers (N=98)	Database sample - Grades 9-12 - K-12 Students with LD and EBD	Significant differences between SPED and GENED on both use of practices and accommodations. Predictor variables-teaching experience with LD and EBD, number of methods courses, math knowledge.
Servilio (2009)	Disser-tation	Perceptions/ Beliefs? PD needs among and between GENED and SPED teachers?	Survey	INS elementary and SECED teachers (N=457) - GENED N=(383) - SPED (N=69) -Unknown (N=5)	Mid-Atlantic school systems - K-12 student data not reported	SECED teachers statistically more confident in math content knowledge and ability to teach math. Overall, GENED teachers more confident in math content knowledge and teaching and felt they only needed some to a little PD for math content knowledge. SPED teachers felt average in their math content knowledge and ability to teach math. Overall they felt more PD in math content knowledge and PD for teaching math. SECEDSPED teachers wanted more knowledge in geometry, while elementary SPED teachers wanted more knowledge in process.

Hinton (2011)	Dissertation	Impact/effect? On ELEMED and SPED teachers math content knowledge in number sense?	Survey	PS & INS (N=113) - Undergraduate GENED (N=80) - Undergraduate SPED (N=20) - Graduate GENED (N=2) - Graduate SPED (N=11)	University/ College mathematics classroom for undergraduate and graduate level elementary teachers - K-12 student data not reported	No significant differences between SPED and GENED PST on perceived competence or outcome expectancies for teaching mathematics.
Humphrey & Hourcade (2010)	Journal	Perceptions/Beliefs? PS SPED teachers' math experiences and phobias?	Qualitative	PS SPED teachers (N=2)	Mathematics methods course for graduate SPED teachers -No K-12 student data reported	Math experiences unpleasant No math courses voluntarily beyond high school. Afraid of failing graduate math course they were taking. Both teachers indicated their students were performing poorly on classroom and standardized assessments. Neither linked teacher math competence as a means to improve math instruction. Refused to complete math knowledge measure.
Thornton et al. (2008)	Journal	Perceptions/Beliefs? Practices related to mathematics concepts Impact/effect? PD intervention on teacher content knowledge of instruction	Survey	INS Early Childhood teachers (N=97)	Large school districts, majority of economically disadvantaged - K-12 Students who are bilingual and students with disabilities	Focus on Geometry, Measurement, Graphing – significant positive changes in teacher predictions on time to teach developmentally appropriate practices.

Rosas & Campbell (2010)	Journal	Perceptions/Beliefs? Regarding previous mathematics experiences; math knowledge; beliefs	Survey	PS graduate SPED teachers (N=26)	Graduate SPED access course _ No K-12 student data reported	Range of 39% - 68.2% believe have competence in range of math areas; belief in teaching math according to grade ranges – 78% K-3, 60% 4-8, 25.4% 9-12; range of 21.7% - 52.2% believe they have competence in range of math process skills; 67% indicated they liked math.
Hellman (2007)	Dissertation	Impact/effect? Factors? Of facilitated support group PD and implementation of differentiated instruction on student outcomes	Mixed Methods	INS (N=55)	Two Title 1 urban middle schools - Grades 6-8 - Students identified as "at-risk" of math failure	Significant differences between treatment and comparison groups in use of DI practices; implementation fidelity associated with K-12 student outcomes; teachers believed FSG PD was positive and improved their practice and student outcomes.
Ray (2008)	Dissertation	Impact/effect? Intervention training/coaching PD on self-efficacy, attitudes, math knowledge/practices	Mixed Methods	PS SPED teachers (N=19)	Research 1 University classroom and Urban Title 1 elementary school - Students "at-risk" of mathematics failure	Scores on all measures rose between pre and mid-point of intervention then declined from mid-point to post. Qualitative analysis of PS teachers' reflections showed greatest intensity on thinking about their instructional practice.

Table 2. ***Quantitative Analysis of Coded Categories.***

Pub Type	**Dissertation (n=6)** PS (n=2) INS (n=4)	**Journal (n=10)** PS (n=5) INS (n=5)					
	Question Type			**Area of Focus**			
Research Questions/ Area of Focus	INS (n=11) How? (n=2) Impact/effect? (n=6) Perceptions/ beliefs? (n=2) Factors? (n=1)	PS (n=9) How? (n=1) Impact/effect? (n=5) Perceptions/ beliefs? (n=3) Factors? (n=0)	Total (n=20) How? (n=3) Impact/effect? (n=11) Perceptions/ beliefs? (n=5) Factors? (n=1)	INS-PD Intervention Diff. Instr. (n=2) Discourse practice (n=1) Math content Know. (n=2) Effective Practices (n=1)	INS-No PD Intervention Math Know (n=1) Math Practices/ Accomm. (n=1) Perceived needs (n=1)	PS-PD Intervention Video modes/effective practices (n=1) Intervention/effective pract.(n=3) Math Knowledge (n=1) Self-Efficacy (n=1) Attitudes (n=1)	PS-No PD Intervention Math Anxiety (n=2) Math Knowledge (n=1) Math Pedagogy (n=1) Math Experiences (n=1) Math Beliefs (n=1)
Research Design	**Overall (n=16)** Qualitative (n=3) Mixed Methods (n=5) Survey (n=5) Exper/Quasi Exper (n=3)	**INS (n=10)** Qualitative – 2 Mixed Methods (n=2) Survey (n=4) Exper/Quasi (n=2)	**PS (n=7)** Qualitative (n=1) Mixed Methods (n=3) Survey (n=2) Exper/Quasi Exper (n=1)				

Participants	**INS-Grade Range** Pre-K (n=1) K-3 (n=1) 3-4 (n=1) 6 -8 (n=2) 9-12 (n=2) K-12 (n=1) Not specified (n=2)	**INS-Teaching Area** ELL (n=1) GENED (elem) (n=2) GENED (middle (n=1) GENED (HS) (n=2) GENED (not specified (n=2) SPED (n=7) ECE (n=1)	**PS Degree Level** Undergrad (n=4) Grad (n=2) Both (n=1)	**PS Teacher Prep Area** Elem (n=1) ECE (n=1) SPED (n=8) GENED-not specified (n=1)	**PK-12 Student Populations** Disabilities unknown (n=10) SLD/LI (n=1) ECE/Sped/DHH (n=1) LD/EBD-(n=2) ECE (n=1) At Risk (n=3)	**Range of Participants by Research Design** Qualitative (n=2-14) Exper/Quasi Exper (n=85-421) Mixed Methods (n=2-55) Survey (n=26-457)
Context	**INS** Urban Middle School (n=2) Primary School-above average performing (n=1) Elementary-Rural (n=1) K-12-Sped & GENED (n=1) Data Base-Secondary GENED & SPED (n=1) Data Base-General GENED & SPED (n=1) Mid Atlantic School System-2 schools (n=1) Large School District-Low SES (n=1) University Graduate Class (n=1)	**PS** Math Methods Class (n=3) Fresh/Soph Math Content Course (n=1) SPED Math Methods (n=1) Graduate SPED Assessment Course (n=1) Sped general methods course (n=1) Urban Elementary School (n=1) Unclear (n=1)				

	PD Intervention-impact/effect (n=9)		PD Intervention-process (n=1)	Non-PD Related (n=6)	
Results	Nature of PD/ Outcome Facilit. Support Groups (n=1) + Job Imbedded PD (n=1) + Teacher Prep Program (n=1) - Video Models (n=1) +/- Tutoring Intervention (n=2) (+/-) Multi-day Workshop (n=1) (+/-) Ongoing PD program (n=1) (+) Math Content & Math Methods Courses (n=1) (+/-)	Independent Variable/Outcome Differentiated Instruction (n=2) + Discourse Practices (n=1) - Knowledge of Practice (n=1) +/- Knowledge of Content (n=2) +/- Fidelity Implementation-Interv. (n=2) +/- Math Anxiety (n=1) +/- Self-Efficacy (n=1) +/- K-12 student outcomes (n=3)	Study Group PD (multiple barriers noted)	Perceptions/ Self-Report Constructs Practices (n=2) PD Needs (n=1) Math Learning Experiences (n=2) Math Competence/ Expectations Teaching Math (n=2)	Math Knowledge/ Proficiency Measures 8^{th} grade math (n=1) – INS performed low Calculation/Number Sense (n=1) – no diff. between SPED and GENED on calculation; participants scored better on number sense; difficulties with estimation

Note. INS = inservice; PS = preservice; PD = professional development; ELL = English language learner; GENED = general education; SPED = special education; ECE = early childhood education; How? = How a particular PD process worked, how particular math practices were used, etc.; Impact/effect? = Effect of a particular PD intervention on PS and INS teacher & PK-12 student outcomes (e.g., math practices, math knowledge, etc.); Perceptions/beliefs? = Perceptions of PS and/or INS teachers about math knowledge, experiences, beliefs, anxiety, PD needs, teaching math in the future, etc.; Factors? = Relationship among particular factors and reported math practices used; Hinton (2011) included both PS and INS participants which affected the n for "Overall" for research design; under results "+" indicates positive impact/effect, "-" indicates negative impact/effect, and "+/-" indicates mixed impact/effect

Dissertations were published at five different universities (*Auburn University, Boston College, University of South Florida, University of West Virginia, and University of Wisconsin-Milwaukee*). Two dissertation studies were published at one university (*University of South Florida*). Four of the major professors for the dissertation studies were professors of special education. Information about the discipline areas of the major professors for two of the studies was not found.

Research questions/Area of focus. This coded category describes the focus of the research questions of studies included in this synthesis. Research questions represented four different areas of focus based on the coding process: (1) *how* questions (n=3) which were research questions related to how a particular PS and/or INS teacher PD intervention/program worked, how a particular PS and/or INS PD addressed specific math content and practice, and how a particular PS and/or INS PD was developed; (2) *impact/effect* questions (n=11) which were research questions that related to the effect of a particular PD intervention on PS and INS teacher outcomes or PS and INS teacher outcomes *and* PK-12 student outcomes (e.g., math practices, math knowledge, etc.); (3) *perceptions/beliefs* questions (n=5) which were research questions that related to the perceptions of PS and/or INS teachers about math knowledge, experiences, beliefs, anxiety, PD needs, teaching math in the future, etc., based on a PD intervention/program/course; (4) *factor* questions (n=1) which were research questions that related to the relationship among particular factors and reported math practices used based on a PD intervention/program/course. Three studies (Dieker et al., 2009; Griffin et al., 2013; Thornton et al., 2008) included research questions with different areas of focus so these studies had two different codes. One study, Hinton (2011), included both PS and INS participants and so the research question (impact/effect) was coded twice meaning the total *n* for impact/effect research questions (i.e., eleven) was greater than the actual number of studies that included impact/effect questions (i.e., ten). Given these research question categories, more studies included research questions that related to the impact/effect of a PD intervention than other areas (n=10). The next greatest number of studies included research questions relating to the perceptions/beliefs of PS and INS teachers (n=5). Studies that included how questions (n=3) and factor questions (n=1) were fewer in number. No appreciable differences were found with respect to the focus of research questions between studies including PS teacher participants and those including INS teacher participants.

Given these research questions, the overall focus of the studies in this synthesis represent a myriad of interests. Studies were initially coded based on whether a PD intervention was included. Ten of the 16 studies included a PD intervention. Nine of these studies evaluated the impact of a PD intervention on PS or INS teacher outcomes. Only two studies, Griffin et al. (2013) and Paulsen (2005), also evaluated PK-12 student outcomes. A variety of PD areas were targeted by these studies including effective instructional practices for ELLs with and without disabilities (McTigue, 2008), differentiated instruction in mathematics (Beauchaine, 2009; Hellman, 2008) mathematics discourse practices (Griffin et al., 2013), mathematics content knowledge (Faulkner & Caine, 2013; Ray, 2008; Thornton, Crim, & Hawkins, 2009), effective mathematics instructional practices for students with disabilities and other struggling learners (Paulsen, 2005; Ray, 2008), self-efficacy in teaching mathematics for students with disabilities (Ray, 2008), attitudes about teaching mathematics (Ray, 2008), fidelity of practice (Paulsen, 2005; Ray, 2008), and social validity on an intervention PS teachers were trained to implement (Paulsen, 2005; Ray, 2008).

Six of the 16 studies did not include a PD intervention. These studies focused on perceptions and measuring the mathematical knowledge of PS and INS teachers. Studies which focused on teacher perceptions centered on the perceived use of effective instructional practices by INS teachers and abilities to teach mathematics for SWLD and EBD (Gagnon & Maccini, 2007; Maccini & Gagnon, 2006), perceived PD needs of INS teachers (Servilio, 2009), previous mathematics experiences and phobias, perceived knowledge of/competence in mathematics content (Hinton, 2011; Gagnon & Maccini, 2007; Maccini & Gagnon, 2006; Rosas & Campbell, 2010). Two studies focused on measuring PS and INS teachers' mathematics knowledge/skills (Hinton, 2011; Rosas & Campbell, 2010).

Research design. Studies included in this synthesis represented a variety of research designs including survey designs (n=5), mixed-methods designs (n=5), qualitative designs (n=3), and experimental/quasi-experimental designs (n=3). A study was coded as "survey design" when a self-report survey was the primary measure and the focus was not on evaluating the impact of a PD intervention (Hinton, 2011; Gagnon & Maccini, 2007; Maccini & Gagnon, 2006; Rosas & Campbell, 2010; Servilio, 2009). These studies evaluated the perceptions of PS or INS teachers on a variety of issues such as PD needs, competence in mathematics, self-efficacy in teaching mathematics, mathematics anxiety, experiences learning mathematics, etc. Studies were coded as mixed methods when both quantitative and qualitative methods were utilized (Dieker et al., 2009; Griffin et al., 2013; Hellman, 2007; Paulsen, 2005; Ray, 2008). All five mixed methods courses focused on evaluating the impact of a PD intervention. Mixed methods studies incorporated a quasi-experimental research method (i.e., comparison groups or time series) and one or more qualitative methods (i.e., interviews, observations, focus groups, and artifact analysis). Qualitative studies were coded when the sole methods utilized were qualitative in nature (Beauchaine, 2009; Humphrey & Hourcade, 2010; McTigue, 2008). All three qualitative studies incorporated case study methodology. A variety of methods were utilized in these qualitative studies including interviews, surveys, interviews, observations, participant reflection journals, and student work samples. Studies were coded as experimental/quasi-experimental designs when comparison groups or time series methods were utilized and when all measures were quantitative in nature (Faulkner & Caine, 2013; Johnston & vanderSandt, 2011; Thornton et al., 2009). All three of the coded experimental/quasi-experimental design studies (comparison groups or time series) measured the impact of a PD intervention on outcomes of PS and/or INS teachers. Teacher outcomes measured in these studies included knowledge of mathematics and instructional practices (Faulkner & Caine, 2013; Thornton et al, 2009) and mathematics anxiety (Johnston & vanderSandt, 2011). Only six studies reported effect sizes (Faulkner & Caine, 2013; Gagnon & Maccini, 2007; Hellman, 2007; Maccini & Gagnon, 2006; Paulsen, 2005; Ray, 2008). No appreciable differences in terms of the types of designs employed were noted between studies that focused on PS teachers versus studies that focused on INS teachers.

Participants. Because teacher education was the focus of these studies, PS and INS teachers were the primary participants in the studies included in this synthesis. Of these studies INS teachers were in 10 studies and PS teachers were included in seven studies. As mentioned previously, one study, Hinton (2011), included both PS and INS teachers. PS and INS teachers represented a broad range of educational levels, certification areas, and grade levels. For the seven studies that included PS teachers, three studies included undergraduate students only (Dieker et al., 2009; Johnston & vanderSandt, 2011; Ray, 2008), three studies included graduate students only (Humphrey & Hourcade, 2010; Paulsen, 2005; Rosas & Cambell, 2010), and one study included both undergraduate and graduate level PS teachers (Hinton, 2011). For the ten studies that included INS, nine studies included INS teachers only (Beauchaine, 2014; Faulkner & Caine, 2013; Gagnon & Maccini, 2007; Griffin et al., 2013; Hellman, 2007; Maccini & Gagnon, 2006; McTigue, 2008; Servilio, 2009; Thornton et al., 2008) and one study included both INS and PS teachers (Hinton, 2011). Multiple studies included participants that represented more than one certification area, grade level, and school context. With respect to studies that included PS teachers as participants five of seven studies included special education PS teachers only (Dieker et al., 2009; Humphrey & Hourcade, 2010; Paulsen, 2005; Ray, 2008; Rosas & Cambell, 2010), one study included special education and elementary education PS teachers only (Hinton, 2011), and one study included special education, elementary education, and early childhood education PS teachers (Johnston & vanderSandt, 2011). Regarding studies that included INS teachers, all but one study (Thornton et al., 2008) included INS teachers representing a variety of certification areas. Seven studies included special education INS teachers (Faulkner & Cain, 2013; Gagnon & Maccini, 2007; Griffin et al., 2013; Hellman, 2007; Maccini & Gagnon, 2006; McTigue, 2008; Sevilio, 2009), two studies included general education high school teachers (Gagnon & Maccini, 2007; Maccini & Gagnon, 2006), two studies included general education teachers whose grade range was not specified (Faulkner & Caine, 2013; Servilio, 2009), two studies included general education middle school teachers (Hellman, 2007; McTigue, 2008), two studies included general education elementary level teachers (Beauchaine, 2014; Griffin et al., 2013), and one study included early childhood education teachers (Thornton et al., 2008). One of the middle school teacher studies included teachers of English language learners (McTigue, 2008).

Overall, studies in this synthesis included both PS and INS teachers with slightly more studies including INS teachers. PS teacher participants represented undergraduate and graduate teacher preparation levels as well as different teacher preparation program areas. INS teacher participants taught a wide range of grade levels and represented a wide range of certification areas. The number of participants in each study also varied greatly. For example, the fewest number of participants participated in qualitative studies (range from 2 to 14) and the greatest number of students participated in survey studies (range from 26 to 457).

Context. These studies were conducted in a variety of contexts. Seven of the 16 studies were conducted primarily in PK-12 schools, two studies in urban middle schools (Hellman, 2007; McTigue, 2008), one study in a high performing primary school (K-3) (Beauchaine, 2009), one study in a rural elementary school (Griffin et al., 2013), one study in an urban elementary school (Ray, 2008), one study in a multiple elementary schools (Paulsen, 2005), and one study in a variety of early childhood/pre-kindergarten educational settings (Thornton et al., 2008). Five of the 16 studies were conducted in university courses/classrooms including a graduate special education assessment course (Rosas & Campbell, 2010), two undergraduate mathematics methods course (Dieker et al., 2009; Humphrey & Hourcade, 2010), both an undergraduate mathematics methods course and an undergraduate mathematics content course (Johnston & vanderSandt, 2011), and a combination of undergraduate and graduate general education and special education methods courses (Hinton, 2011). Two of the 16 studies were conducted utilizing a large existing database (Gagnon & Maccini, 2007; Maccini & Gagnon, 2006). One of the 16 studies was conducted via an online survey (Servilio, 2009). Finally, one of the 16 studies was conducted within statewide and district-wide professional development (PD) workshops (Faulkner & Caine, 2013).

When comparing studies that involved INS versus PS teachers there are noticeable differences in the contexts. The overwhelming majority of studies involving INS teachers were conducted in school settings while the overwhelming majority of studies involving PS teachers were conducted in university courses/classrooms. All of the studies in this synthesis included participants who were INS or PS teachers (special education and general education) teaching or being prepared to teach mathematics for students with disabilities. Specific information regarding the particular disabilities or learning difficulties participants taught or were being prepared to teach was reported in only six of the 16 studies. Several studies referenced more than one disability area/learning difficulty. These disabilities/learning difficulties included specific learning disabilities (3 studies), emotional/behavior disorders (2 studies), language impairments (1 study), "special education" (1 study), deafness/hearing impairments (1 study), English language learners (1 study), and "at-risk" (3 studies).

Summary. The majority of the studies included in this synthesis were journal publications. The majority of journal publications were special education related journals with seven of the 10 journal publications published in special education related journals. Six of the publications were in teacher education related journals. Four studies were published in a single teacher education journal in special education (*Teacher Education and Special Education*). One study was published in a mathematics education related journal (*The Clearinghouse*); another study was published in a journal devoted to early childhood teacher education (*Journal of Early Childhood Teacher Education*). Dissertation studies represented a minority of the studies included in this synthesis (n=6). All dissertations were completed at a major research institution. Two of the six dissertations were completed at one institution. A search for information about major professors resulted in identifying the area of expertise of major professors for four of the dissertation studies. All four were professors in special education at the time of publication. Information on the expertise of major professors for two of the dissertation studies was not found.

The majority of studies in this synthesis focused on some type of PD intervention with research questions about how a PD intervention worked, the impact/effect of a PD intervention including associated factors contributing to an effect, and the perceptions of PS and INS teachers about a PD intervention. The nature of the interventions range in type and included job imbedded, facilitated support groups, coaching, collaborative planning groups, training on the implementation of intensive interventions with coaching, mathematics education methods courses, mathematics content courses, district-wide and statewide district workshops, video models of effective practices, and a teacher preparation program. Teacher outcomes measured by studies evaluating the impact/effect of a PD intervention included fidelity of utilizing mathematics instructional practices, mathematics knowledge, self-efficacy, attitudes about teaching mathematics, perceptions of the PD intervention, knowledge of effective instructional practices, and mathematics anxiety. Other non-PD related studies focused on the perceptions of PS and INS teachers on a variety of issues including efficacy/perceived competence for teaching mathematics, previous mathematics experiences, attitudes and beliefs about teaching mathematics, perceived PD needs, and use of instructional practices and accommodations. Two non-PD related studies focused on the mathematics knowledge of PS teachers.

With respect to research designs, the most common designs were survey and mixed methods designs. Other designs included qualitative or quasi-experimental methodologies. Designs did not differ in any appreciable way by participant type (PS or INS teachers) or by study type (journal publication or dissertation). All studies except one included PS teacher participants only or INS teacher participants only. One study included both PS and INS teacher participants. At the PS level both undergraduate and graduate students were included as participants with the vast majority being undergraduates. Moreover, both special education and/or general education PS teachers were represented in the samples of these studies. At the INS level, participants represented special education, early childhood education, elementary, middle school, and high school teachers.

The contexts of studies in this synthesis were varied. At the PS level, contexts included math education courses, mathematics content courses, special education methods or assessment courses, and elementary schools. At the INS level, contexts included early childhood education settings, elementary schools, middle schools, and multi-day district and statewide workshops. Two studies utilized of a large database comprised of K-12 teachers and one study included an online survey. For studies that focused on PD interventions, the demographics of the K-12 students with whom participants taught were not always described in detail, in particular disability status. For studies that did describe these data, the students were identified as having the following disabilities – specific learning disabilities, emotional/behavioral disorders, language impairments, deafness/hearing impairments, and "special education." Several studies reported including students who were English language learners, who are in early childhood education, and who were "at risk."

Evaluation of the quality of each study's design is beyond the scope of this study. However, in general terms, studies with similar designs differed with respect to the depth of description of procedures and analyses. Effect sizes were reported by only six studies and ranged from small to large effects.

Research Question #2: How does the research and practice base inform teacher educators about how to effectively prepare teachers to teach mathematics for SWLD?

Data coded from the results sections of studies were analyzed to answer this question. Ten of the 16 studies included a PD intervention. Of these 10 studies, nine studies evaluated the impact/effect of a PD intervention and one study focused on the how a PD intervention (i.e., study group) functioned. The remaining six studies evaluated the perceptions of PS and/or INS teachers on a variety of issues related to teaching mathematics (e.g., PD needs, mathematics anxiety/phobia, mathematics learning experiences, etc.) or evaluated their knowledge of mathematics content.

PD and teacher outcomes. Two studies (Beauchaine, 2009; Hellman, 2007) evaluated the effect of two different PD interventions on INS teachers' abilities to implement *differentiated instruction* in mathematics classrooms. Beauchaine (2009) utilized pre-post surveys and interviews to ascertain the effect of a *job embedded PD* related to differentiating instruction with Everyday*Math* with 14 K-3 INS special education and general education teachers at a high performing primary school. The authors reported an increase in DI practices among participants. Participant comments emphasized the importance of conceptual understanding over procedural understanding. However, teachers who believed teaching both conceptual and procedural understanding was equally important decreased from four teachers to three teachers. Participants also reported challenges to implementing differentiated instruction including time, lack of personnel, and student frustration with mathematics. Hellman (2007) evaluated a *Facilitated Support Group* PD intervention with 55 sixth-eighth grade INS teachers at two urban middle schools. Significant differences were found between treatment and comparison groups in use of DI practices. Participating teachers believed that *Facilitated Support Group* PD was positive and improved their practice and student outcomes.

Several studies evaluated the impact of PD that was focused on particular mathematics instructional practices. Griffin et al. (2013) evaluated the utilization of mathematics discourse practices by two 3rd and 4th grade teachers who recently graduated from the same teacher preparation program. Results indicated that the teachers utilized different patterns and types of discourse practices. Student performance was mixed with the three 4th graders performing better on unit tests than the three 3rd graders. Both 3rd graders and 4th graders performed consistently low on progress monitoring measures. Dieker et al. (2009) evaluated the impact of web-based video models on the knowledge of 22 PS teachers in a mathematics methods course about effective mathematics informal assessment practices (i.e., CRA assessment, error pattern analysis, and flexible interviews) for students with disabilities and other struggling learners. PS teachers who were provided access to the video models demonstrated greater knowledge gains pre to post compared to those who were not provided access to the videos. Gains were mostly found with responses to recall type questions on the measure whereas little or no gains were found on application type questions. Three studies included measuring participants' knowledge of mathematics content (Faulkner & Cain, 2013; Thornton et al., 2009; Ray, 2008). Faulkner and Cain (2013) measured changes in INS teachers' knowledge of number sense based on participating in a 5-day content focused PD intervention that included lecture, discussion and exploration activities, and readings. No pre-post differences were found between treatment and comparison groups and no differences were found between special education and general education teachers. Thornton et al. (2009) evaluated the impact of a coaching PD intervention (*C^3 Coaching*) on the mathematical knowledge of 97 pre-kindergarten INS teachers. Statistically significant pre-posttest gains were found by participants in the areas of geometry, measurement, and graphing. Statistically significant gains were not found for counting, understanding numbers and patterns. Ray (2008) evaluated changes in the knowledge of K-3 algebraic thinking concepts and skills of 19 PS teachers as they implemented a mathematics intervention process (*Developing Algebraic Literacy*) for which they received training on during a connected course and practicum experience at an urban elementary school. The PS teachers were assessed at three points (pre-mid-post) as they implemented the intervention with two elementary age students who were low performers in mathematics. Participants demonstrated gains in knowledge of algebraic thinking concepts and skills from pre to midpoint but showed a decline in performance from midpoint to post. The accuracy rate of participants overall was low across all three test administrations (pre - 35%, mid – 40%, post – 30%). Ray (2008) also evaluated changes in self-efficacy, fidelity of implementation, and attitudes about teaching mathematics. Increases in self-efficacy, positive attitudes, and fidelity with the implementation of effective practices occurred pre to mid with decreases from mid to post. Post assessment of PS teachers' knowledge of effective practices showed their ability to identify effective practices and knowledge of learning characteristics that can impact mathematics but they had difficulty in articulating how to apply effective practices. Paulsen (2005) evaluated the impact of explicitly teaching PS teachers how to utilize effective mathematics teaching practices through a tutoring intervention with first graders considered at risk of math failure. Students considered at risk made statistically significant gains on computation and concepts/application subtests compared to similar students who did not receive the tutoring intervention. Moreover, growth of the at-risk students who received the intervention was greater compared to students not considered to be at risk. PS teachers reported that the structure of the intervention provided them with a good model for teaching and that the experience would be helpful to them in the future. The author concluded that the PS teachers benefited from explicit teaching of effective instructional practices and feedback.

Johnston and vanderSandt (2011) investigated the effect that completing a mathematics methods course or a mathematics content course had on mathematics anxiety of 421 general education and special education PS teachers. Pre-post course results utilizing the *Revised-Mathematics Anxiety Survey* revealed that only elementary-general education students showed a decrease in anxiety after completing the mathematics content course. PS teachers representing elementary education, early childhood education, and the area of deafness/hearing impairments all showed decreases in mathematics anxiety after completing the mathematics methods course. Special education PS teachers did not show a decrease in their mathematics anxiety.

Perceptions and mathematics knowledge of PS and INS teacher with no PD. Two studies, Maccini and Gagnon (2006) and Gagnon and Maccini (2007) evaluated the perceptions of INS teachers about their knowledge of mathematics, utilization of instructional practices, use of accommodations when teaching mathematics, familiarity of mathematics content, and confidence in teaching students with learning disabilities and emotional/behavioral disorders. For both studies, the researchers utilized a database developed by Quality Education Data (2000-2001) to obtain their samples. Maccini and Gagnon (2006) evaluated the perceptions of 176 general education and special education secondary INS teachers who taught students with LD and EBD with respect to their mathematics instructional practices and utilization of accommodations. Significant differences were found between special education and general education teachers. Special education teachers reported utilizing greater amounts of explicit instruction practices with basic mathematics facts (e.g., cue cards illustrating strategy steps, graphic organizers, etc.) and instructional accommodations (e.g., extended time on assignments, problems read to students, reduced number of problems to solve for classwork, etc.). Special education secondary teachers also reported utilizing a statistically greater number of assessment accommodations compared to general education secondary teachers (e.g., reduced number of problems on tests, problems read to students, use of manipulatives, etc.). An analysis of predictor variables revealed that several factors correlated with the number of instructional practices and assessment accommodations reportedly utilized by general education and special education teachers for students with LD and EBD including the number of years teaching students with LD and EBD, the number of methods courses completed, and knowledge of mathematics topics. Gagnon and Maccini (2007) evaluated the perceptions of 167 general education and special education teachers who teach mathematics for students with LD and EBD on a variety of topics related to their instructional practice. Significant differences were found between special education and general education teachers on their familiarity of particular mathematics topical areas with general education teachers reporting more familiarity with middle and high school topics including pre-algebra, algebra 1 and 2, geometry, trigonometry, and statistics/probability. Special education and general education teachers both felt more prepared after taking mathematics methods courses. Special education teachers felt more prepared to teach students with LD/EBD while general education teachers felt more prepared to teach general education students. No differences were found between general education and special education teachers regarding how they felt about teaching mathematics for students with LD/EBD after taking special education teacher preparation courses. Number of mathematics methods courses taken by teachers accounted for the greatest amount of variance for the sample with respect to reporting the use of practices consistent with the National Council of Teachers of Mathematics (NCTM) practices.

Four additional studies evaluated the perceptions of PS and/or INS teachers focusing on issues such as perceived PD needs, previous mathematics experiences, perceived mathematical competence, and expectations about teaching mathematics. Servilio (2009) utilized a survey to understand the perceived PD needs of 457 INS general education and special education teachers from two school districts in the Mid-Atlantic region related to teaching mathematics. Secondary teachers reported being statistically more confident in their mathematics content knowledge and ability to teach mathematics. Overall, general education teachers reported being more confident than special education teachers in their mathematics content knowledge and ability to teach mathematics. General education teachers reported that they needed less PD in mathematics content knowledge compared to special education teachers. Humphrey and Hourcade (2010) conducted a case study of two graduate PS teachers in special education and their previous experiences with mathematics. Both participants reported that their mathematics experiences were difficult and unpleasant. Both worried about their skills in relation to teaching SWDs, but felt math had value to students. Both teachers indicated their students were performing poorly on classroom and standardized assessments. Neither linked teacher math competence as a means to improve math instruction. Both reported that they preferred not to engage in math outside of work and avoided adult math tasks such as balancing a checkbook. Rosas and Campbell (2010) investigated the perceptions of 26 graduate level PS special education teachers both about their previous experiences with learning mathematics and their confidence in teaching mathematics. Participants completed a 19-question survey with 56.5% reporting positive experiences in math in grades K-12 and 38.4% reporting that they believed their undergraduate degree provided them a solid foundation in mathematics. Hinton (2011) surveyed 113 elementary general education and education special education PS teachers regarding their personal efficacy and outcome expectations about teaching mathematics. No significant differences were found between special education and general education PS teachers on either their perceived competence or outcome expectancies about teaching mathematics.

Finally, two studies evaluated the mathematics knowledge of PS and INS teachers without a PD intervention. Rosas and Campbell (2010) evaluated the mathematics knowledge level of PS special education teachers utilizing the *Ohio Achievement Test-Practice Eighth Grade Mathematics*. Results showed that overall, 76% of participants answered 15/26 questions correctly (58% accuracy level) and 24% of participants answered 16-20/26 correctly (62% - 77% accuracy). Geometry was a relative strength for participants with three-quarters scoring at a 75% accuracy level or greater, while measurement, data and probability, patterns/algebra, and number sense were areas of weakness with 61%-69% of participants correctly answering 50% or fewer questions in each area. Hinton (2011) utilized the calculation subtest of the *Woodcock Johnson III* and an open-ended interview protocol to evaluate the computational knowledge of 113 PS teachers. No statistically significant differences were found between special education and general education teachers on calculation knowledge via the *Woodcock Johnson III*. Overall, participants performed better on number sense components (i.e., understanding meaning of numbers, operations and relationships, and recognizing relative number size). Results of the interview revealed that a majority of participants struggled with developing benchmarks appropriately and judging the reasonableness of a computational result by using strategies of estimation.

Summary. The results of PD interventions evaluated by studies in this synthesis were mixed in nature. Several studies reported positive results related to instructional practices including differentiated mathematics instruction, recall knowledge of effective mathematics practices for students with disabilities and other struggling learners, mathematics anxiety, and K-12 student mathematics outcomes. Only a few studies reported effect sizes regarding the impact of PD interventions (Hellman, 2007; Paulsen, 2005; Ray, 2008). Hellman (2007) reported positive effect sizes (low, moderate, and high) for a variety of INS general education and special education teachers and middle school student outcomes related to facilitated support group PD and differentiated instruction. Paulsen (2005) reported positive effect sizes (low) for K-12 student outcome related to PS special education teachers who implemented a mathematics tutoring process for which they received explicit training and coaching. Ray (2008) reported intensity effect sizes (through qualitatively coded PS written post reflections) related to PS teachers perceived self-efficacy, attitudes, content knowledge, and knowledge of instructional practices after receiving explicit instruction, coaching, and implementation of an intensive mathematics intervention process. Ray found that 57% of total coded themes related to instructional practice knowledge and application. In other cases, PD interventions did not result in positive effects or had mixed results (i.e., mathematics discourse practices, application knowledge of effective mathematics practices for students with disabilities and other struggling learners, fidelity of implementation of effective practices, self-efficacy in teaching mathematics for students with disabilities and other struggling learners, and mathematics content knowledge). One case study evaluated how 6th grade INS teachers experienced a collaborative planning group PD intervention. Results primarily identified barriers to fully implementing the PD intervention. Barriers included available time, lack of support materials, district demands and initiatives, and uneven participation among participants.

Studies that investigated PS and INS teacher perceptions (non-PD related) reported results on a variety of issues related to teaching mathematics for students with disabilities and other struggling learners. Special education and general education INS secondary teachers reported utilizing different mathematics instructional practices for students with LD/EBD with special education teachers reporting to utilize more explicit teaching practices and accommodations (Maccini & Gagnon, 2006). Predictor variables for utilization of instructional practices and accommodations for students with LD/EBD by secondary INS teachers included the number of methods courses completed, and knowledge of mathematics topics. Secondary special education teachers reported feeling more prepared to teach students with LD/EBD compared to secondary general education teachers while general education teachers felt more prepared to teach general education students (Gagnon & Maccini, 2007). Number of mathematics methods course taken by special education and general education teachers accounted for the greatest variance for instructional practices consistent with NCTM practices. With respect to knowledge of content knowledge, general education teachers reported feeling more prepared to teach mathematics and believed they needed less PD in mathematics content than did special education teachers. PS special education teachers in two studies reported low levels of confidence in teaching mathematics, poor experiences with learning mathematics, and a low level of belief that their undergraduate programs provided them with a solid foundation for teaching mathematics (Humphrey & Hourcade, 2010; Rosas & Campbell, 2010). In another study no differences were found between PS special education and general education teachers in their perceived confidence about teaching mathematics (Hinton, 2011).

Two studies directly evaluated PS teacher mathematical content knowledge. Rosas and Campbell (2010) found that PS special education teachers scored low on an assessment related to eighth grade mathematics content. Hinton (2011) found no differences between special education and general education PS teachers on computation knowledge. Participants demonstrated difficulty with judging the reasonableness of a computational result using estimation skills.

Discussion

Mathematics outcomes for SWLD have been historically low and continue to significantly lag behind their peers without disabilities. In an effort to better understand what teacher educators and researchers can do to improve the knowledge and skill of teachers who teach SWLD this synthesis was designed to 1) better understand the nature of the research base related to teacher preparation, mathematics, and SWLD, and 2) understand how this research base can inform teacher educators about how to better prepare PS and INS teachers to effectively teach mathematics for SWLD and to provide researchers with a frame for building a more robust research base to inform the field.

With respect to the nature of the research base in this area, two overarching characteristics are apparent. One, the research base is limited in the number of studies conducted and even more limited in terms of journal publications. Two, these studies are quite varied in scope and the nature of research designs utilized, participant demographics, and context. Of the 16 studies located in our search, only 10 studies were published in peer-reviewed journals and the remaining six were dissertations, none of which we could find published elsewhere (e.g., journals). This is of concern as it demonstrates the lack of emphasis researchers have placed on the preparation of teachers to teach mathematics for SWLD. The lack of evidence with respect to what constitutes effective teacher preparation practices in this area makes it difficult for teacher educators to determine how they can best design their preservice teacher education programs and inservice professional development activities to address this critical need.

The fact that the focus of the studies in this synthesis were varied in scope and nature points to the complexities the preparation of teachers in this area. Three primary topical areas were evident across the 16 studies: 1) PD interventions, 2) perceptions, 3) and mathematical knowledge. Within each of these three topical areas studies varied with respect to sphere of interest. The topical area receiving the most interest in this synthesis was PD interventions. A variety of PD interventions were studied for both preservice and inservice teachers. An encouraging finding was that at least half of the PD interventions included a substantial amount of embedded school-based PD (e.g., coaching, school based study groups, facilitated support groups). This characteristic is congruent with what researchers and policy makers have called for in recent years (e.g., Darling-Hammond & Baratz-Snowden, 2007; Levine, 2010). Only three studies PD intervention studies measured K-12 outcomes in addition to PS or INS teacher outcomes so it is difficult to ascertain the extent to which the PD interventions included in this synthesis have potential for affecting student outcomes. This is a weakness of the current research base. Measuring student outcomes as part of any future study related to PD interventions should be strongly considered by researchers. A variety of research designs were utilized by researchers and the research questions ranged widely in type/focus. The fact that researchers are addressing multiple questions from multiple research perspectives can be considered a positive attribute of the current research base. However, due to the limited number of studies, this attribute is also a liability in that it is difficult to cull together how findings from individual studies relate to one another. Researchers in the future should consider how their studies might connect to, build upon, and inform findings from pre-existing studies.

We were encouraged to find that both PS and INS teachers were prominently included as participants in these studies. Too often, teacher education has bifurcated professional development between PS and INS levels when, in fact, teachers learn and develop across time, within and across critical incidents and as they move from one position or context to another (e.g., from PS to induction to INS; and from novice to skilled to advanced to teacher leader). Although there is plenty to learn from studies related to preservice and inservice teacher preparation separately, future research should also emphasize how to effectively move teachers throughout their careers. We suggest that teacher educators and researchers attend to this bigger picture, to acknowledge that teacher PD occurs across connected continua and to situate what we do purposefully within such a frame.

We were pleasantly surprised to find that these studies were conducted in diverse contexts (e.g., urban, rural, elementary schools, middle schools, general education, special education, mathematics content and mathematics methods courses, special education methods courses, etc.). Given that SWLD and other struggling learners receive their mathematics instruction in an array of contexts and teachers who provide instruction are prepared to teach mathematics in a variety of contexts, we encourage researchers to continue this trend. For many studies, it was difficult to determine the disability related PK-12 student populations that PS were being prepared to teach or that INS teachers were teaching at the time the studies were conducted. There were only three studies in which SWLD were specifically mentioned. In fact only six studies out of the 16 total studies reported PK-12 student demographics. With respect to studies involving PS teachers, one reason for this could be the nature of most state certification requirements that are non-disability specific. This means that most initial licensure special education teacher preparation programs are considered general special education programs and therefore it would be assumed that the PS teachers are being prepared to teach students with a variety of disabilities including SWLD. One reason for why some of the INS teacher focused studies did not include PK-12 demographics may be the context of the study (e.g., district/statewide workshops with large numbers of participants; use of databases where specific student data like this were not available). This issue is a definite weakness in the current research base as it relates to teacher preparation, mathematics, and SWLD and researchers should consider reporting these data even when the focus of the study is not on PK-12 student outcomes.

With respect to how the studies in this synthesis can inform teacher educators about the effective preparation of teachers to teach mathematics for SWLD, the overwhelming characteristic is that there are no straightforward answers. Combined, the small number and varied nature of the studies make it difficult to reach any definitive conclusions. Few studies incorporated research designs that allow for determining effect. Maccini and Gagnon (2006) reported promising effect sizes related to mathematics instructional practice and differences between INS level general education and special education teachers, yet because the data collected were self-report data it is difficult to interpret whether the data can be generalized to actual practice. However, their findings provide insights into the possible types of instructional practices that each group of teachers might be more likely to implement which can provide teacher educators a reference point for considering what types of instructional practices they believe they should emphasize in their PD. Gagnon and Maccini (2007) also report promising effect sizes related to INS general education on special education teachers' perceptions about their preparedness to teach mathematics for SWLD and students with EBD. Their findings can inform teacher educators about areas (e.g., content knowledge, teaching SWLD) where teachers believe they are more prepared compared to where they believe they are less prepared, providing teacher educators a framework for addressing areas of perceived strengths and weaknesses, and considering why certain types of courses seem to have greater levels of impact on teachers' feelings of preparedness compared to others. For example, in their study, Gagnon and Maccini (2007) reported that both general education and special education INS teachers believed they were more prepared by mathematics methods courses than special education methods courses. Hellman (2007) also reported promising effect sizes related to characteristics of facilitated support groups that positively affected teachers' utilization of differentiated instruction practices in mathematics. These data can inform teacher educators about the nature of one PD intervention that might have potential for enhancing INS teachers' understandings of and abilities to implement targeted instructional practices related to mathematics and SWLD.

Several studies provide insights into interesting teacher specific (personal) constructs that may have importance with respect to preparing teachers to teach mathematics for SWLD and other struggling learners. These constructs include self-efficacy for teaching mathematics, prior mathematics learning experiences, and mathematics anxiety. Findings from this synthesis suggest that many PS and INS teachers, general education and special education alike, report having low self-efficacy, poor experiences with learning mathematics, and high levels of mathematics anxiety. Intuitively, it makes sense that these constructs could affect the effectiveness of teachers and would be factors which teachers educators should be cognizant of so that they can affect them in positive ways. Unfortunately, the scope of these studies did not include evaluating how these constructs actually impact PS or INS teachers' teaching practice or outcomes of the students they teach. Several studies in this synthesis demonstrated that the mathematical knowledge among elementary and special education teachers is low. Unfortunately, as was true with studies that focused on self-efficacy, prior mathematics learning experiences, and mathematics anxiety, the studies that addressed mathematical knowledge did not also evaluate the effect that level of mathematical knowledge had on PS and INS teachers' practice or student outcomes. One study, Ray (2008), attempted to connect how PS teachers' self-efficacy, attitudes about teaching mathematics, and mathematical knowledge changed as PS teachers implemented a semester long intensive mathematics intervention process that incorporated a set of research supported mathematics practices for struggling learners. Interestingly, PS teachers' sense of self-efficacy, attitudes towards teaching mathematics, and performance on a mathematics knowledge test increased at midpoint of implementing the intervention but decreased at post intervention.

Future Research

Based on the results of this synthesis, we offer several suggestions for future research. To begin, teacher education researchers in mathematics education and special education must increase the number and breadth of studies in this area. Several studies measured a variety of PS or INS specific constructs such as self-efficacy, mathematics anxiety, mathematical knowledge, previous mathematics learning experiences, etc. However, few studies attempted to connect participant scores to their actual practice or PK-12 student outcomes. Only six studies included data related to teaching practice (e.g., use of particular types of practices; planning, etc.) as an outcome of a PD intervention and only three studies included data related to PK-12 student outcomes. A characteristic of the studies in this synthesis is that most focused on a particular aspect of the teacher development continuum. Researchers should consider investigating how PD related to mathematics and SWLD and other struggling learners affects PS and INS teachers' implementation of practice longitudinally in order to better understand how to best structure ongoing PD in ways that lead to improved outcomes (e.g., PS-induction-INS/novice-advanced-skilled-teacher leader). Studies in the synthesis were conducted in diverse contexts. We encourage researchers to continue this trend of conducting research within the types of diverse contexts that reflect the reality of where SWLD learn mathematics.

Limitations

Several limitations should be considered when interpreting the findings presented. First, the studies in this synthesis should be considered to be only a sample of all studies conducted on this topic. We limited our search to the last decade because we wanted to analyze research that occurred during a time period when the NCTM Principles and Standards (2000) were operating, when reports such as the National Research Council's *Adding it Up* (National Research Council, 2001), and the Final Report of the National Mathematics Advisory Panel, *Foundations for Success* (National Mathematics Advisory Panel, 2008) had been published, and during the advent of the Common Core State Standards-Mathematics. Studies published prior to this time may differ because of the policies and events that were operating then. Second, the results should be interpreted within the context of the search process as outlined. Third, it is possible that although we utilized a systematic review process that allowed for establishing inter-rater reliability during coding, analysis, and writing, we may have made a mistake in one or a very few instances (e.g., calculating number or participants, types of contexts, etc.).

Conclusion

There is much to learn about how to best prepare PS and INS teachers to teach mathematics for students with SWLD and other struggling learners. The results of this synthesis suggest that the research base in the last 10 years is limited in number and research in this area needs much greater attention than it has received to date. The studies included in this synthesis reflect a wide range of topics with a wide range of PS and INS teacher participants. The fact that the majority of studies concentrated on evaluating different types of PD interventions is also important to note. Several well-conducted studies demonstrated that PD interventions that are embedded in practice, whether at the PS or INS level, led to positive teacher and K-12 student outcomes. These findings are consistent with recent suggestions about the importance of PD that integrates rich field experiences with systematic supports. Several suggestions for future research were identified and we encourage interested researchers to use these suggestions as a beginning framework for improving the research base. We end with the notation that it is likely that many robust PD initiatives are occurring at both the PS and INS levels with respect to mathematics and SWLD and other struggling learners. It is incumbent upon teacher educators and researchers to systematically study such initiatives, including the investigation of malleable and mitigating factors that are associated with success in order to improve the knowledge base.

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