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Early Childhood Educators' Self-Efficacy in Science, Math, and Literacy Instruction and Science Practice in the Classroom

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ABSTRACT

Research Findings: Quality early science education is important for addressing the low science achievement, compared to international peers, of elementary students in the United States. Teachers' beliefs about their skills in a content area, that is, their content self-efficacy is important because it has implications for teaching practice and child outcomes. However, little is known about how teachers' self-efficacy for literacy, math and science compare and how domain-specific self-efficacy relates to teachers' practice in the area of science. Analysis of survey and observation data from 67 Head Start classrooms across eight programs indicated that domain-specific self-efficacy was highest for literacy, significantly lower for science, and lowest for math. Classrooms varied, but in general, engaged in literacy far more than science, contained a modest amount of science materials, and their instructional support of science was low. Importantly, self-efficacy for science, but not literacy or math, related to teachers frequency of engaging children in science instruction. Teachers' education and experience did not predict self-efficacy for science. **Practice or Policy:** To enhance the science opportunities provided in early childhood classrooms, pre-service and in-service education programs should provide teachers with content and practices for science rather than focusing exclusively on literacy.

Now more than ever, scientific literacy (i.e., systemizing methods, engaging in critical comparison, utilizing research to inform practice) has been recognized as vital for the 21st-century workforce (National Research Council, 2010). Strong science education is critical for developing these skills in the U.S. population. However, U.S. elementary children perform below several of their international peers in science achievement tests (National Center for Education Statistics [NCES], 2012). This is not surprising considering that the foundation for scientific understanding is shaky: Elementary teachers spend just 6% to 13% of their instructional time teaching science (NCES, 2012), and preschool teachers devote even less time (4%–8% of instructional time) to promoting science experiences (Tu, 2006). A primary factor, particularly among early childhood educators, is a lack of preparation for designing and implementing science education, which results in little confidence for teaching science (Greenfield et al., 2009; Hamlin & Wisneski, 2012). Of course, children are unlikely to develop necessary science knowledge and skills without effective science instruction and experiences (Gelman & Brenneman, 2012; Morris, Croker, Masnick, & Zimmerman, 2012). Thus, one critical research aim fulfilled by the present study was to describe early childhood educator self-efficacy for science and identify how self-efficacy is related to the science opportunities provided in early childhood classrooms.

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Young children can develop science knowledge and skills

Early childhood is a time when children begin to develop knowledge and skills for engaging in science (National Research Council, 2005). Young children have the capacity to engage in and learn from scientific thinking (National Research Council, 2005, 2008). They are naturally curious about the world around them (Jirout & Klahr, 2012) and have often been referred to as natural scientists because of their tendency to seek out and integrate information (Gopnik, 2012). Although children pursue information in ways similar to scientists (e.g., Gopnik, 2012), teaching and engagement in scientific reasoning and processes are necessary to further cultivate children's thinking about science (Kuhn, 2010; Zimmerman, 2007).

Preschool science education provides critical opportunities to augment children's curiosity about the world while helping them acquire tools for developing nascent reasoning skills (Morris et al., 2012). Early experience with science may help children avoid misconceptions about the world that inhibit science understanding and reasoning later in their education (Kuhn, 2009). In fact, children who engage in teacher-guided scientific exploration in early childhood have a better understanding of science concepts later in life (Eshach & Fried, 2005). Perhaps most important, early experiences with science are helpful in fostering positive attitudes about science in all areas (Zimmerman, 2007). Clearly early childhood is an opportune time for teachers to engage learners in science.

Young U.S. children perform poorly in the science domain

Unfortunately, U.S. elementary school children perform poorly in science (Casserly, 2003; NCES, 2012) compared to children from other nations (Schmidt, Raizen, Britton, Bianchi, & Wolfe, 1997). Reports of 2012 scores on National Assessment of Educational Progress testing across the United States indicated that just 34% of fourth graders scored at or above proficiency on tests for all areas of science (NCES, 2012). Furthermore, just 54% of fifth graders scored at the level of passing or higher (Florida Department of Education, 2014).

Given these alarming data, researchers and educators have become more interested in ways to develop science knowledge and skills in the early years. Unfortunately, for children living in poverty, like those participating in Head Start, it seems that science education is lacking, even though Head Start has placed an emphasis on science by including it as a domain in the Head Start Early Learning Outcomes Framework for preschool. At entry into Head Start, children's language and literacy development scores on the Galileo Developmental Assessment (Bergan et al., 2003) are similar to their science scores (Greenfield et al., 2009). By the end of the preschool year, children's language and literacy skills are significantly higher than their science scores (Greenfield et al., 2009). Furthermore, at kindergarten entry, children's understanding of science is strikingly lower than their understanding of all other developmental domains, including language, literacy, and math (Greenfield et al., 2009). It seems that Head Start teachers are effective in promoting children's literacy skills during the school year but not as effective in influencing science, which creates a gap between children's literacy development and science skills. Low teacher efficacy in science that inhibits teachers from enacting science activities may be one reason for these poor findings. However, when science is presented in developmentally appropriate ways, young children can benefit a great deal from engagement in science experiences.

The importance of early childhood science education

Quality preschool education can produce lasting positive effects on children's cognitive and social development (Aos, Lieb, Mayfield, Miller, & Pennucci, 2004; Camilli, Vargas, Ryan, & Barnett, 2010). Early childhood science education engages teachers and children in high-quality interactions, which can narrow the achievement gap (Cabell, DeCoster, LoCasale-Crouch, Hamre, & Pianta, 2013) for young children, particularly those at risk for school failure, such as those participating in Head Start.

Teaching and engagement in science education promotes children's understanding of science concepts and skills and provides a meaningful context for developing critical literacy and math skills (Gelman, Brennaman, Macdonald, & Román, 2009; Kuhn, 2010). In fact, compared to other learning contexts (e.g., book reading or literacy/math instruction), teachers tend to engage in the highest quality teacher–child interactions when they engage in science (Cabell et al., 2013); these high-quality interactions include supports for concept development, expansion of child ideas, and use of open-ended questions and advanced language. Scaffolded, responsive interactions such as these significantly enhance children's cognitive development and can reduce the gap between the academic outcomes of children living in poverty and their more economically advantaged peers (La Paro, Pianta, & Stuhlman, 2004; Mashburn et al., 2008). In addition, science instruction can lead to gains in language achievement for English language learners (Gomez-Zwiep & Benken, 2013; O. Lee, Deaktor, Hart, Cuevas, & Enders, 2005).

Despite the powerful opportunities offered from preschool science instruction, quality science instruction and engagement is rare in early childhood classrooms (Cabell et al., 2013; Nayfeld, Brennaman, & Gelman, 2011; Tu, 2006), which likely contributes to the grim child outcomes presented above. In detailed observational work, Tu (2006) identified that only 13% of preschool activities were related to science; 9% of these were informal, in which the teacher provided only incidental support. Only in half of the classrooms did a science area exist for exploration. Note that although 70% of classrooms included plants, no teachers discussed these plants with children at any time during the two full-day observations (Tu, 2006). This suggests that even when science-related materials existed, they were not used spontaneously or in an integrated way to promote science content knowledge or engage in science processes. Although young children are curious about the natural world and inquire about many scientific phenomena (e.g., how magnets work, what it means to be alive, how objects move), they will not develop deliberate scientific reasoning without guided engagement with science content, tools, and processes (e.g., prediction, experimentation, data collection; Gelman & Brennaman, 2012; Klahr, 2002; Morris et al., 2012). This lack of guidance is likely a result of the fact that early childhood educators report feeling unprepared to teach science (Greenfield et al., 2009; Hamlin & Wisneski, 2012), which is largely because of teachers' limited background in science as well as scarce supportive resources and professional development.

Teacher self-efficacy

Teachers' pedagogical self-efficacy is their perceived capacity to effectively educate children (Bandura, 1997, 2001), that is, their belief that they have the skills to promote children's development and learning. Investigating teachers' self-efficacy is important because a teacher's sense of self-efficacy is related to success in children's learning (Gibson & Dembo, 1984; Saklofske, Michayluk, & Randhawa, 1988; Woolfolk & Hoy, 1990). Teachers with high self-efficacy for teaching have more positive expectations for student achievement and better student outcomes (Tournaki & Podell, 2005).

Previous work focusing on teachers of young children has found that high teacher self-efficacy predicts teachers' use of developmentally appropriate practices in preschool and elementary classrooms (McMullen, 1999). In fact, low teaching efficacy can be a barrier to implementing developmentally appropriate practices with children (Kim, 2005) and can result in poorer outcomes (Guo, Piasta, Justice, & Kaderavek, 2010).

It is important to note that teaching content areas such as literacy, math, and science requires domain-specific self-efficacy. That is, teachers need to feel confident in their own ability before they can feel confident in teaching specific content (Vartuli, 1999, 2005). Greater content knowledge is related to more pedagogical self-efficacy for a range of content areas, including mathematics (Newton, Leonard, Evans, Eastburn, & Tatum, 2012), social studies (Holt, 2009), and science (Maier, Greenfield, & Bulotsky-Shearer, 2013). Moreover, professional development focused on improving content knowledge has been shown to improve teachers' pedagogical self-efficacy (Holt, 2009). Because the present study focused on teachers' efficacy within content areas, we defined self-

efficacy as an individual's perceived enjoyment of and ability with respect to a subject or domain (e.g., Van Egeren, Watson, Morris, Farrand, & Lownds, 2007). This is an important distinction and extension of previous work, as Morgan (2012) has shown that including questions about teachers' interest and ability in the content area can make important contributions to efficacy assessments. By assessing teachers' content-specific self-efficacy rather than their teaching efficacy, we learn more about their capacity to share and promote content understanding, thus filling this important gap in the literature on self-efficacy.

Differences in efficacy across domains

Currently, it is unknown whether teachers' self-efficacy for one content area is related to their self-efficacy or practice in another area. One could hypothesize a spillover effect for efficacy such that high self-efficacy in one area could result in high self-efficacy in other areas. This would presume that teachers are skilled in generalizing their knowledge and skills from one area of instruction to another. For example, a teacher who asks open-ended questions during book reading to facilitate conversations with children about book content or literacy concepts may also ask open-ended questions during science experiences to facilitate children's understanding of science concepts or content. The challenge to this assumption is that when a teacher does not understand a concept, he or she will be unlikely to identify meaningful open-ended questions that facilitate children's understanding of the concept. Thus, it is likely that teachers' self-efficacy for different content areas varies substantially.

Teachers' self-efficacy across content areas may vary for several reasons. Given the lack of resources available for supporting teachers to teach science in early childhood classrooms, the teaching of science to young children might be particularly influenced by teachers' own comfort with science. For example, one preservice teacher explained, "I'm not really very good at science. I had to take a few science courses along the way, but I don't really know how to include more science in children's everyday learning," which demonstrates how the teacher's perception of her skill in the content area influenced her pedagogical self-efficacy (Hamlin & Wisneski, 2012, p. 82). Although the Next Generation Science Standards and Head Start Early Learning Outcomes Framework (Office of Head Start, 2010) provide guidance on reform-based practices and goals for young children's development in science, these are newly developed. Most teachers, particularly early childhood teachers, have had minimal exposure to and lack understanding of these practices and how to incorporate them into their classroom. In fact, many teachers report that they will fail if they teach science to young children (Greenfield et al., 2009). The recent emphasis on literacy, stressed by both administrators and families, may contribute to teachers spending less time on science and providing fewer opportunities to engage in science. This may be particularly true if teachers subscribe to a perception that science is separate from other domains or if they struggle to design an integrated curriculum that provides opportunities to engage in literacy, math, and science within the same lessons and activities, as recommended by best practice (e.g., Neuman, Roskos, Wright, & Lenhart, 2007).

Teachers' educational background and experiences may be particularly salient factors influencing teachers' self-efficacy across content domains. Teachers may be burdened with negative feelings toward science from their early schooling experiences that may compromise their teaching (Edwards & Loveridge, 2011). Currently, only 66% of Head Start teachers have a bachelor's degree (U.S. Department of Health and Human Services, 2014), which means that fewer Head Start teachers than elementary-level educators have had exposure to science content. Furthermore, even early childhood educators with bachelor's degrees report feeling unprepared or underprepared to teach science (Greenfield et al., 2009), similar to credentialed elementary teachers, who report very low self-efficacy for science (Morgan, 2012). This is likely because few early childhood teacher preparation programs emphasize science in coursework or practicum experiences (Brenneman, Stevenson-Boyd, & Frede, 2009). However, some research has found that teachers with higher education levels tended to undertake science activities more frequently

and utilize a wider range of methods for engaging children in science lessons (Erden & Sönmez, 2012). More specifically, Dowdy (2005) found that teachers who had taken a greater number of science-related courses during a 2-year college program had more positive beliefs about science in comparison to teachers who had not taken science courses.

Previous work has found that teachers' self-efficacy in general increases with experience from early in one's career to mid-career (Klassen & Chiu, 2010). Other research has indicated that teachers with less than 1 year of experience hold more positive attitudes toward science, especially with regard to the perceived developmental appropriateness of early childhood science education (Erden & Sönmez, 2012). This may be because they received their education more recently, which may have provided more positive views or support for early childhood science education.

The current study

Teachers' self-efficacy, including their beliefs about their skills in a content area (Bandura, 2001; Van Egeren et al., 2007), is important because it is related to their teaching practice and ultimately child outcomes (Tournaki & Podell, 2005). However, we know very little about how teachers' self-efficacy around science, math, and literacy content areas is interrelated and how domain-specific self-efficacy relates to teachers' practice in the area of science. To more fully understand the role of self-efficacy in teachers' practice and child outcomes, we must examine teachers' self-efficacy separately across domains and the relations among domain-specific self-efficacy and teachers' practice.

Research questions

To investigate the nature of teachers' domain-specific self-efficacy we asked five questions:

Research Question 1 (RQ1). How strongly correlated is science self-efficacy to self-efficacy in other domains?

RQ2. How do preschool teachers' mean levels of science self-efficacy compare to their efficacy in other domains?

RQ3. What kinds of science (a) materials and (b) experiences are available in preschool classrooms, and how strongly do measures of these constructs correlate?

RQ4. How strongly are domain-specific measures of preschool teacher self-efficacy in science, literacy, and mathematics correlated with science practice in terms of both (a) materials and (b) experiences provided?

RQ5. How are preschool teachers' educational background and years of experience teaching young children related to their self-efficacy for science?

We expected that domain-specific measures of teacher self-efficacy might not correlate highly because of differences in teacher interest or skill. We expected that teachers' mean level of self-efficacy in literacy would be higher than their efficacy for science or math because of background and programmatic emphasis on literacy. We expected ample variation in the science materials and experiences teachers provide in their classrooms and expected that teachers' self-efficacy for science might predict their provisions and opportunities in the area of science. Finally, we expected that teachers' background characteristics, including level of degree and years of experience, might relate to their self-efficacy for science.

Methods

This study used baseline data from a multisite, cluster-randomized, longitudinal trial evaluating the efficacy of an early childhood science education curriculum and professional development program for Head Start teachers (Head Start on Science; Ritz, 2007; Van Egeren et al., 2014). All research procedures were approved by the university’s institutional review board.

Participants

Each classroom recruited had both a lead teacher and a teaching assistant. This article focuses on lead teachers, who had primary responsibility for instruction and preparation of the classroom environment. We are reporting data from 67 Head Start teachers/classrooms. As Table 1 shows, all teachers were women ($M = 40.6$, $SD = 9.5$ years of age); most primarily identified themselves as White/Caucasian (84%) or Black/African American (12%). They were quite experienced at teaching preschool-age children ($M = 11.7$, $SD = 7.5$ years) and had several years of tenure in their current positions ($M = 6.5$, $SD = 6.2$ years). Most of them had attained a college degree, either an associate’s (19%), bachelor’s (70%), or master’s (9%) degree.

Table 1. Descriptive statistics for teacher characteristics and other study variables.

Variable	n	%	Range
Sex			
Female	67	100	
Male	0	0	
Race			
African American/Black	8	12	
American Indian/Native American	1	1	
White/Caucasian	56	84	
Other	2	3	
Educational attainment			
High school/GED	1	1	
Associate’s degree	13	19	
Bachelor’s degree	47	70	
Master’s degree	6	9	
Science engagement			
Two times/month	3	4	
One time/week	15	22	
Two times/week	21	31	
Three to four times/week	28	42	
Literacy engagement			
Two times/month	0	0	
One time/week	0	0	
Two times/week	1	1	
Three to four times/week	66	99	
Math engagement			
Two times/month	1	1	
One time/week	0	0	
Two times/week	16	24	
Three to four times/week	50	75	
Age (years)	40.59	9.55	25.0–62.0
Tenure in current position (years)	6.49	6.17	0.5–25.0
Teaching experience (years)	11.74	7.48	2.0–31.0
Self-efficacy			
Science	18.79	3.64	12.0–25.0
Literacy	20.87	2.91	15.0–25.0
Math	16.21	4.04	9.0–24.0
Science materials (SMEC)	20.03	10.25	7.0–47.0
Science CLASS-IS	2.84	0.76	1.3–5.0

Note. GED = general equivalency diploma; SMEC = Science Materials/Equipment Checklist; CLASS-IS = Classroom Assessment Scoring System—Instructional Support.

Procedures

We invited eight Head Start programs, grouped into two cohorts of four programs each, to participate in the study. Each cohort followed a 2-year longitudinal research design in which we collected only teacher and classroom data during the first year of intervention and then expanded to include child and parent data as well in the second year. The eight programs included three urban, two suburban, and three rural programs from across one midwestern state.

After obtaining approval from the program director at each Head Start site, we provided an informational session about the study to teachers and solicited their participation. About 96% (74/77) of the teachers consented to participate. Seven consenting teachers were excluded from the sample (one died before baseline data collection; six returned their surveys *after* the intervention had started for their cohort, which raised concerns that their baseline data might be contaminated), which left 67 participants in the sample. We collected baseline data (teacher surveys and classroom observations) in 2011 for Cohort 1 and in 2013 for Cohort 2. The surveys included domain-specific measures of self-efficacy for science, literacy, and math; frequency of instruction for each domain; and demographic characteristics. Trained research assistants observed each classroom for 2.5 hrs (i.e., nearly the entire school day). We scheduled these observations with teachers 1 week in advance to ensure that we could observe a typical school day. During the observation, the researchers documented the science materials in the classroom and video recorded 20-min segments of teachers' practice during a small-group science activity (see "Measures"). Our research assistants watched these video clips to score teachers' science activity (see "Measures").

We randomized classrooms to the control or intervention groups separately for each program after collecting baseline data. Because we used only baseline teacher and classroom data for this article and the analyses reported below do not address intervention effects, we pooled data across both groups and cohorts prior to conducting the analyses.

Measures

Participant characteristics

Our teacher survey collected self-report data on teacher gender, race, educational attainment (highest degree completed, an ordinal variable), tenure in current position at the participating Head Start program (in years), and experience teaching preschool-age (ages 3–5 years) children (in years).

Self-efficacy for literacy, math, and science

The teacher survey included a set of 13 items about each subject domain (literacy, math, and science) from the revised version of the Attitudes Toward Science instrument (Van Egeren et al., 2007; Von Blum, 1998). Five items for each domain were used to measure self-efficacy, defined as teachers' perceptions of their ability and enjoyment of the subject. We used parallel wordings for items across the subject domains, substituting in the subject name. Each item was rated using a 5-point Likert response format (Carifio & Perla, 2007): 1 (strongly disagree), 2 (disagree), 3 (not sure), 4 (agree), or 5 (strongly agree).

We report measurement development for our self-efficacy scales elsewhere (K. Lee, Pierce, & Van Egeren, 2014) but note that composite reliability (Raykov & Marcoulides, 2011) for our final self-efficacy scale scores was high for math and science ($\hat{\rho}_X = .80$, 95% confidence interval [CI] [.70, .87], and 0.79, 95% CI [.70, .86], respectively) and adequate but noticeably lower for literacy ($\hat{\rho}_X = .57$ [.41, .70]) due to ceiling effects on some items. The same work also demonstrated sufficient evidence of partial cross-domain measurement invariance to merit comparing scores across domains. We reverse-scored two items before computing domain-specific scale scores as the unweighted sums of the relevant items. These composite scores can range from 5 to 25, with higher scores indicating greater self-efficacy.

Engagement in literacy, math, and science

The teacher survey included three domain-specific items assessing how often the teacher engaged in instructional activities for each domain. The stem "In this classroom, how often do teachers interact

together with children on . . .” was followed by domain-specific items for literacy and reading, math, and science activities. Teachers selected from four response options: 1 time/month, 2 times/month, 1 time/week, 2 times/week, or 3–4 times/week. We dropped unused categories separately for each item before analyzing these ordinal variables.

Preschool Classroom Science Materials/Equipment Checklist (SMEC)

We expanded Tu’s (2006) instrument by adding two new science materials items (science learning computer games and science magazines) and removing three items with low face validity (puzzles, candles, and latches) to create this 53-item checklist. Trained observers recorded the visible presence of three categories of materials and equipment in the classroom: science materials (20 items), science equipment (24 items), and natural materials (nine items). The SMEC score is a count ranging from 0 to 53 obtained by summing the items, which are scored 0 (not present) or 1 (present). Items can be present at any time during the day and include items available for exploration across the day (e.g., free play) and items available within teacher-led activities (e.g., teacher-led small group). Higher scores indicate richer science environments. Green and Yang’s (2009) reliability coefficient for this measure is $\widehat{\rho_{XX}} = .92$ (95% CI [.89, .94]), and interrater agreement for trained observers was .95.

Science instructional support

The Classroom Assessment Scoring System—Instructional Support (science CLASS-IS; Pianta, La Paro, & Hamre, 2008) was used to examine the instructional quality of teachers’ science opportunities. Researchers trained to the developers’ standards of reliability (i.e., 85% of codes within 1 point of the expert ratings) coded the concept development, quality of feedback, and language modeling dimensions of the CLASS (Pianta et al., 2008) from 15-min video clips ($X = 15$, $SD = 3$ min 40 s) of the teachers engaged in teaching science activities. We computed instructional support (CLASS-IS) composite domain scale scores from those indicators as specified in the CLASS manual (Pianta et al., 2008). These scores can range from 1 to 7, with higher scores indicating better science instructional support. The CLASS manual reports evidence of high internal consistency and predictive validity (Pianta et al., 2008). Krippendorff’s (2013) interrater reliability for this science CLASS-IS is .66 (95% CI [.45, .83]).

Missing data

No data were missing for gender; race; tenure in current position; education; engagement in literacy, math, and science; or SMEC. One teacher did not report her birth year ($n = 1$, 2%), so we computed her age after imputing it. One teacher did not report her teaching experience ($n = 1$, 2%). All literacy and math efficacy items had complete data. Only one science efficacy item had missing values ($n = 1$, 2%); the other science efficacy items had complete data. All three indicators of the CLASS-IS scale were missing for two classrooms ($n = 2$, 3%) because of unusable digital video clips (i.e., the files were corrupted).

Because we had very small amounts of missing data, single imputation was a reasonable solution for the missing data. We used the SPSS (Version 22) multiple imputation procedure to draw a single imputed value via a fully conditional Markov chain Monte Carlo model to replace each missing value prior to conducting the analyses. The imputation model included all domain-specific efficacy items; teacher educational attainment; teaching experience; birth year; race; engagement in literacy, science, and math; plus the SMEC and all three CLASS-IS indicator scores.

Data analysis

Although we report p values for readers who wish to see them, we focus on reporting and interpreting parameter estimates, effect sizes, and corresponding 95% CIs because they are more useful for developing a cumulative body of scientific knowledge (Hubbard & Lindsay, 2008).

As part of our initial descriptive analyses we examined teachers’ engagement in literacy, math, and science. Then we explicitly tested whether teachers engaged in math instruction more often than

they did in science instruction by analyzing the relevant contingency table with log-linear symmetry and quasisymmetry models (Meiser, Von Eye, & Spiel, 1997). The symmetry model assumed that paired off-diagonal cells were balanced (math > science occurred as often as math < science). The quasisymmetry model assumed an upward trend in the paired off-diagonal cells (math > science occurred more often than math < science). To deal with sampling zeros in the contingency table, we added a constant of 0.1 to all cell frequencies prior to estimating the models. We compared the two models via a likelihood ratio test to determine whether adding the upward trend improved the model fit. Literacy engagement had such a skewed distribution that we could not compare it statistically to either math or science engagement (the contingency tables contained too many sampling zeros).

We answered RQ1 by examining Pearson correlations between self-efficacy scores across domains, then used parametric bootstrapping to obtain a 95% CI for the intraclass correlation (ICC; Nakagawa & Schielzeth, 2010) among self-efficacy scores in an unconditional linear mixed model (LMM) with self-efficacy scores (Level 1 units) nested within teachers (Level 2 units). This random intercept model contained only one fixed effect: an intercept term representing the grand mean for self-efficacy across domains. This ICC quantified overall nonindependence of self-efficacy scores.

We then expanded the LMM to answer RQ2 by adding a fixed effect of domain as a within-subjects (Level 1) predictor, which allowed us to compare mean self-efficacy across domains. The categorical domain variable used effect coding (deviation of each level from the grand mean, with math serving as the reference level). We used marginal and conditional R^2_{GLMM} (Johnson, 2014; Nakagawa & Schielzeth, 2013) as indices of model fit, partial eta squared and generalized eta squared (η_p^2 and η_G^2 ; Lakens, 2013) to quantify effect size for the domain effect, and an adjusted ICC with parametric bootstrapped CI to describe residual nonindependence (Nakagawa & Schielzeth, 2010). We used an analysis of deviance Wald F test based on Type III sums of squares and Kenward-Roger degrees of freedom to test the domain effect.

We supplemented this LMM by computing contrasts to estimate the domain-specific means and pairwise differences between them, along with simultaneous 95% CIs adjusted for multiple testing via Westfall's (1997) method. We used Hedges g_{av} with a denominator based on the model mean squared error to measure effect size for the pairwise comparisons (Fritz, Morris, & Richler, 2012; Grissom & Kim, 2005; Lakens, 2013). We graphed the domain-specific means, along with two-tiered CIs (Baguley, 2012); inner tier Cousineau-Morey adjusted CIs graphically illustrate differences between within-subject means (nonoverlapping CIs indicate significant differences), whereas outer tier CIs simply show the 95% simultaneous CIs around the individual domain means.

We used descriptive statistics for the SMEC, science CLASS-IS, and science engagement measures to answer the first part of RQ3. We supplemented those statistics with a dot plot (Cleveland, 1993) of the item-level data from the SMEC scale. We estimated Pearson, polyserial, and polychoric correlations (r , r_{ps} , and r_{pc} , respectively), along with CIs, to answer the second part of RQ3. The r_{ps} statistic is more appropriate than r when one of the variables is ordinal with relatively few categories; r_{pc} is more appropriate when both variables are ordinal. We obtained p values for r_{ps} and r_{pc} via z tests and CIs via Fisher's r -to- z transform (Raykov & Marcoulides, 2011).

Next we answered RQ4 by estimating correlations between the three domain-specific measures of teacher self-efficacy and measures of science practice (the SMEC, science CLASS-IS, and science engagement measures) using either r or r_{ps} , as warranted by the pair of variables involved.

Finally, we answered RQ5 by examining correlations between science self-efficacy and teachers' educational attainment and years of preschool teaching experience using either r or r_{ps} , as warranted by the pair of variables involved.

Software

We used the free, open-source statistical software R 3.3.2 (R Development Core Team, 2016) and several add-on packages to manage the data (Harrell, 2016; Wickham, 2011; Wickham & Miller, 2016), conduct analyses and compute effect sizes and CIs (Aquino, Enzmann, Schwartz, Jain, & Kraft, 2016; Barton,

2016; Bates, Mächler, Bolker, & Walker, 2015, 2016; Fox, 2016; Fox & Weisberg, 2011; Kelley, 2016; Nakagawa & Schielzeth, 2010; Schielzeth & Nakagawa, 2013; Warnes, Bolker, & Lumley, 2015), adjust for multiple testing (Hothorn, Bretz, & Westfall, 2008), and construct graphs (Sarkar, 2008; Sarkar & Andrews, 2016; Tremblay & Ransijn, 2015). We made minor modifications to Nakagawa and Schielzeth's (2010; Schielzeth & Nakagawa, 2013) *rpt.remLMM* and *rpt.remLMM.adj* functions, Baguley's (2012) *cm.ci* function, and Raykov and Marcoulides's (2011) *ci.pc* function before using them.

Results

Table 1 shows descriptive statistics for the measures we used. The primacy of literacy instruction in Head Start classrooms was clear: A total of 99% of the teachers engaged in literacy instruction three to four times per week, with the rest doing so two times per week (see Table 1). In contrast, 75% of teachers engaged in math instruction three to four times per week, and only 42% engaged in science instruction that often. The lack of variability in literacy engagement precluded formal hypothesis testing, but these descriptive data provide compelling evidence that preschool teachers engage in literacy instruction more often than either science or math instruction.

The log-linear model assuming symmetry between science and math engagement did not fit the data, $G^2(6) = 37.14, p < .001$. The quasisymmetry model favoring math over science fit the data quite well, $G^2(5) = 1.36, p = .929$. Adding the trend favoring math improved the model fit, $G^2(1) = 35.78, p < .001$, indicating that teachers engaged in math instruction more often than in science instruction.

We answered RQ1 by examining correlations between teacher self-efficacy measures (see Table 2). Science self-efficacy was weakly positively correlated with both literacy self-efficacy ($r = .07, 95\% \text{ CI } [-.17, .31], p = .548$) and math self-efficacy ($r = .19, 95\% \text{ CI } [-.05, .41], p = .126$). The latter two measures were weakly negatively correlated ($r = -.12, 95\% \text{ CI } [-.35, .12], p = .317$). The asymmetry of these CIs around $r = 0$ suggests the direction of these relationships without firmly establishing them. However, the CIs indicate that large correlations ($|r| \geq .5$) between these measures are unlikely, which suggests that cross-domain correlations are at best small to medium. Further evidence of weak correlation between domain-specific levels of self-efficacy was revealed by the unconditional LMM, where ICC = .00 (95% CI [.00, .15]).

Table 3 shows the analysis of deviance, parameter estimates, and fit indices from the expanded LMM used to answer RQ2. Diagnostic plots (not shown) did not reveal any violations of the normality, homogeneity of variance, or linearity assumptions. The model explained a modest amount of variance in self-efficacy scores (marginal $R^2_{\text{GLMM}} = .22$, conditional $R^2_{\text{GLMM}} = .27$). Adjusting for the domain effect revealed more residual nonindependence (ICC = .06, 95% CI [.00, .21]) than observed in the unconditional model. Figure 1 shows the clear effect of domain on mean self-efficacy, $F(2, 130) = 30.50, p < .001, \eta_p^2 = 0.32, 90\% \text{ CI } [0.20, 0.40], \eta_G^2 = 0.23$. Teachers reported high literacy self-efficacy ($M = 20.87, 95\% \text{ CI } [19.83, 21.90]$) but more modest levels of self-efficacy for science ($M = 18.79, 95\% \text{ CI } [17.75, 19.83]$) and math ($M = 16.21, 95\% \text{ CI } [15.17, 17.25]$).

Contrasts indicated that the domain means formed an ordered set (literacy > science > math). Literacy self-efficacy was 2.07 points higher than science self-efficacy (95% CI [0.68, 3.47], $g_{\text{av}} = 0.60, g_{\text{av}} 95\% \text{ CI } [0.25, 0.94], z = 3.47, p < .001$) and 4.66 points higher than math self-efficacy (95% CI [3.26, 6.06], $g_{\text{av}} = 1.34, g_{\text{av}} 95\% \text{ CI } [0.97, 1.71], z = 7.80, p < .001$). Science self-efficacy was 2.58 points higher than math efficacy (95% CI [1.18, 3.98], $g_{\text{av}} = 0.74, g_{\text{av}} 95\% \text{ CI } [0.39, 1.09], z = 4.32, p < .001$).

With regard to RQ3, the statistics for the SMEC, CLASS-IS, and engagement variables in Table 1 describe the amount of science materials, level of science instructional support, and frequency of science experiences available in the classrooms. The SMEC data show that the classrooms contained a modest number of science materials ($M = 20.0, SD = 10.3$). Figure 2 shows the percentage of classrooms containing each of the 53 SMEC items. The most commonly available materials included science books (91%), magnifying glasses (85%), vinyl animals (85%), and mirrors (84%). The level of science instructional support in these classrooms was low (CLASS-IS $M = 2.8, SD = 0.8$), and only 42% of teachers engaged in science instruction three to four times per week. The amount of science materials

Table 2. Correlations between domain-specific self-efficacy, classroom science practice, teacher experience and education, and domain-specific engagement ($N = 67$).

Variable	1 ^a	2 ^a	3 ^a	4 ^a	5 ^a	6 ^a	7 ^b	8 ^b	9 ^{b,c}	10
1. Science self-efficacy ^a	—									
2. Math self-efficacy ^a	.19 (.00)	—								
	[−.05, .41]									
3. Literacy self-efficacy ^a	.07 (.12)	−.12 (.12)								
	[−.17, .31]	[−.35, .12]								
4. Science materials (SMEC) ^a	.12 (.12)	−.24 [†] (.12)	—							
	[−.12, .35]	[−.45, .00]	.10 (.12)							
5. Science CLASS-IS ^a	−.04 (.12)	−.02 (.12)	−.01 (.12)	.17 (.12)	—					
	[−.28, .20]	[−.26, .22]	[−.25, .23]	[−.08, .39]						
6. Preschool experience (years) ^a	−.13 (.12)	−.22 [†] (.12)	−.13 (.12)	.07 (.12)	−.04 (.12)	—				
	[−.36, .11]	[−.44, .02]	[−.36, .11]	[−.18, .30]	[−.27, .21]					
7. Highest degree ^b	−.06 (.14)	.09 (.14)	.22 [†] (.14)	−.08 (.15)	.37 ^{**} (.13)	.01 (.14)	—			
	[−.33, .22]	[−.19, .36]	[−.05, .47]	[−.35, .21]	[.11, .59]	[−.26, .29]				
8. Science engagement ^b	.38 ^{***} (.11)	−.02 (.13)	−.16 (.13)	.24 [†] (.13)	.07 (.14)	.09 (.14)	−.15 (.15)	—		
	[.15, .58]	[−.28, .24]	[−.40, .11]	[−.03, .47]	[−.20, .33]	[−.18, .35]	[−.43, .15]			
9. Math engagement ^b	.17 (.16)	−.07 (.16)	−.12 (.16)	.44 ^{**} (.15)	.00 (.17)	.11 (.17)	−.36 [*] (.16)	.69 ^{***} (.11)	—	
	[−.14, .45]	[−.37, .24]	[−.41, .19]	[.11, .68]	[−.32, .31]	[−.22, .42]	[−.63, −.02]	[.43, .85]		
10. Literacy engagement ^{b,c}	1.00 ^{***} (.00)	−.53 (.38)	.72 [*] (.33)	.89 ^{***} (.18)	−.68 [*] (.27)	.52 (.53)	— ^d	.09 (.43)	.62 [†] (.36)	—
	[.95, 1.00]	[−.93, .42]	[−.40, .98]	[−.26, 1.00]	[−.95, .16]	[−.70, .96]		[−.64, .74]	[−.41, .96]	

Note. Cells contain correlation coefficient (SE) [95% confidence interval]. We report Pearson correlations when both variables are continuous, polyserial correlations when one variable is ordinal, and polychoric correlations when both variables are ordinal. SMEC = Science Materials/Equipment Checklist; CLASS-IS = Classroom Assessment Scoring System—Instructional Support.

^aContinuous variable. ^bOrdinal variable. ^cInterpret these correlations with caution, as literacy engagement has an extreme distribution (it is nearly a constant; see Table 1). ^dCorrelation not available because of numerical estimation problems caused by the joint distribution.

[†] $p < .10$. ^{*} $p < .05$. ^{**} $p < .01$. ^{***} $p < .001$.

Table 3. Linear mixed model predicting self-efficacy scores.

Source	df	SS	MS	F	η_p^2 [90% CI]	p
Between teachers						
Intercept	1	69,701.74	69,701.74	4,957.61	.99 [.98, .99]	<.001
Error	66	927.93	14.06			
Within teachers						
Domain	2	729.32	364.66	30.50	.32 [.20, .40]	<.001
Error	132	1,578.01	11.95			
Fixed Effects	df	Estimate	SE	t	p	
Intercept	1	18.62	0.26	70.41	<.001	
Domain						
Literacy	1	2.24	0.34	6.51	<.001	
Science	1	0.17	0.34	0.49	.625	
Math (reference)						
Random Effects	df	Variance	SD		ICC [95% CI]	
Intercept	1	0.70	0.84		.06 [.00, .21]	
Residuals	1	11.95	3.46			

Note. The self-efficacy scores had a potential range of 5 to 25. We used restricted maximum likelihood (REML) estimation with effect coding for the categorical domain variable. $N = 67$ teachers, 201 observations. Fit indices: $LL(5\ df) = -539.34$, REML criterion = 1,078.68. If refit via maximum likelihood estimation, then $LL(5\ df) = -538.48$, deviance = 1,076.96, Akaike's information criterion = 1,088.68, and Bayesian information criterion = 1,105.19. CI = confidence interval; ICC = intraclass correlation.

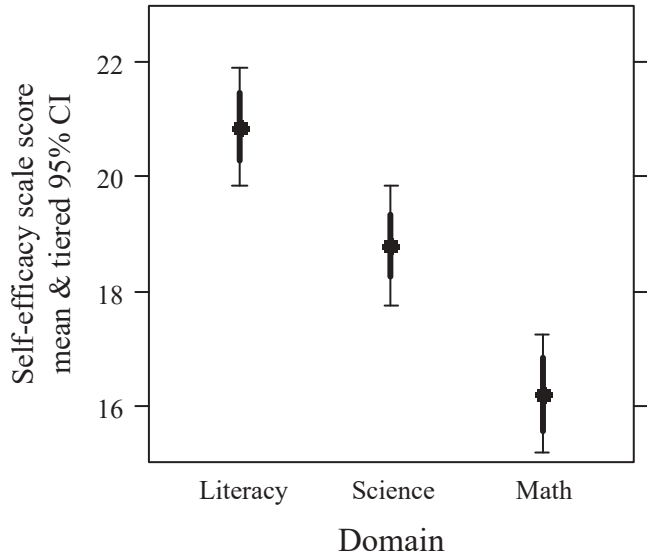


Figure 1. Mean teacher self-efficacy by domain. Two-tiered CIs (Baguley, 2012) are shown. The thick inner tier whiskers are Cousineau-Morey adjusted CIs (nonoverlapping CIs indicate significant differences between within-subject means); the thin outer tier whiskers are 95% simultaneous CIs around the individual domain means. Efficacy scores could range from 5 to 25. CI = confidence interval.

present correlated weakly and positively with the level of science instructional support ($r = .17$, 95% CI $[-.08, .39]$, $p = .176$) but was a bit more strongly correlated with science engagement ($r_{ps} = .24$, 95% CI $[-.03, .47]$, $p = .070$). It is curious that the level of science instructional support was very weakly correlated with science engagement ($r_{ps} = .07$, 95% CI $[-.20, .33]$, $p = .620$).

With regard to RQ4, we found that science self-efficacy was weakly positively correlated with classroom science materials as measured by the SMEC ($r = .12$, 95% CI $[-.12, .35]$, $p = .315$), but it was entirely uncorrelated with science instructional support ($r = -.04$, 95% CI $[-.28, .20]$, $p = .736$). As one might expect, science self-efficacy was moderately positively correlated with engagement in science instruction ($r_{ps} = .38$, 95% CI $[.15, .58]$, $p < .001$). Literacy self-efficacy was weakly but positively related to the SMEC

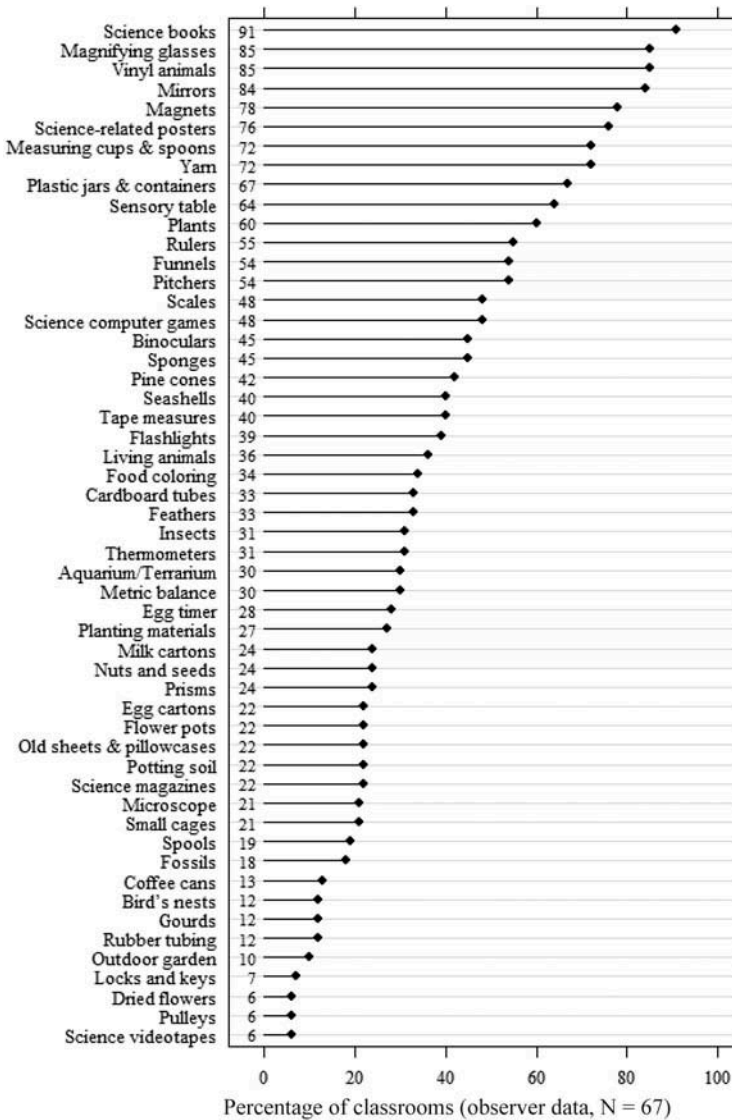


Figure 2. Percentage of classrooms containing each Science Materials/Equipment Checklist item.

($r = .10$, 95% CI $[-.15, .33]$, $p = .434$), unrelated to science instructional support ($r = -.01$, 95% CI $[-.25, .23]$, $p = .964$), and weakly negatively related to science engagement ($r_{ps} = -.16$, 95% CI $[-.40, .11]$, $p = .233$). Finally, math self-efficacy was moderately negatively correlated with the SMEC ($r = -.24$, 95% CI $[-.45, -.00]$, $p = .055$) but entirely uncorrelated with science instructional support ($r = -.02$, 95% CI $[-.26, .22]$, $p = .841$) and science engagement ($r_{ps} = -.02$, 95% CI $[-.28, .24]$, $p = .870$). Some of these CIs suggest the likely direction of relationships, but most indicate that large correlations ($|r| \geq .5$) between these measures are unlikely except between science self-efficacy and science engagement.

Finally, we examined how science self-efficacy was related to teachers' educational attainment and preschool teaching experience to answer RQ5. We found that educational attainment was almost entirely uncorrelated with science self-efficacy ($r_{ps} = -.06$, 95% CI $[-.33, .22]$, $p = .660$). Furthermore, science self-efficacy was weakly negatively correlated with years of preschool teaching experience ($r_{ps} = -.13$, 95% CI $[-.36, .11]$, $p = .284$).

Discussion

The present study provides the first comparison of early childhood teachers' domain-specific self-efficacy across the domains of literacy, science, and mathematics utilizing a sample of Head Start teachers. The results of this comparison illustrate a stark gap between early childhood educators' self-efficacy for literacy and their self-efficacy for science or math. Furthermore, the work identified a positive link between teachers' science self-efficacy and how often they provided science experiences/instruction to young children; this relation to practice did not exist for high literacy self-efficacy and science engagement. However, the level of science instructional support teachers demonstrated while teaching was rather low and unrelated to both science self-efficacy and how often they actually taught science. It is notable that teachers' level of formal education and years of experience did not relate to their self-efficacy for science, but higher educational attainment was associated with higher levels of science instructional support.

According to the findings presented here, teachers have internalized the importance of literacy development for young children. That is, teachers reported high self-efficacy in the area of literacy and reported engaging in literacy experiences multiple times a week. However, teachers were significantly less likely to report feeling efficacious in the domains of science or math. Although teachers engaged in math instruction more often than science instruction, they engaged in both math and science far less frequently than literacy. These findings align with previous work showing that only 5% of teachers preferred science over literacy, aesthetics, or gross motor/outdoor play (Tu & Hsiao, 2008). Although several studies have identified teachers' negative self-perception of their science knowledge and ability as a barrier to science instruction (e.g., Edwards & Loveridge, 2011; Greenfield et al., 2009; Yoon & Onchwari, 2006), this is the first to provide evidence that this low self-efficacy (a) is significantly lower than teachers' efficacy for literacy and (b) is uniquely related to the science provisions teachers provide in the classroom (e.g., materials and frequency of lessons).

Multiple factors may contribute to this lack of efficacy in science education. Teachers' preparation in science may be lacking. This includes the science education they were provided in elementary and secondary school (Ramsey-Gassert, Shroyer, & Staver, 1996). Teachers may have pessimistic feelings or aversions toward science from their past schooling experiences that influence their science teaching (Edwards & Loveridge, 2011). Furthermore, their formal preservice education or professional development in teaching science to young children may be lacking or ineffective. Teacher education programs for early childhood educators require little or no coursework in science or science education and provide limited support in terms of practicum opportunities for teaching science to young children (Brenneman et al., 2009). Similarly, this finding may reflect the imbalance that exists between the availability of in-service early childhood professional development offerings focused on literacy in comparison to those addressing science. In fact, according to a meta-analysis of randomized controlled trial professional development opportunities between 1995 and 2012 (a total of 73 studies), 39 opportunities focused on language and/or literacy and only one focused on enhancements for science (Schachter, 2015). The low levels of science instructional support we observed are consistent with a need for more and better professional development around early childhood science education.

In addition, teachers feel pressure from policymakers and administrators to focus on literacy development (Ramey-Gassert et al., 1996). These policies may be so strong that they have resulted in early childhood educators' focus on literacy to the exclusion of science. Until recently, most states did not have separate learning standards for science but rather integrated science standards into the general knowledge sections of early learning standards (Greenfield et al., 2009). Head Start amended its learning standards in 2010 to include Science Knowledge and Skills, which incorporates developing scientific skills and methods for inquiry as well as conceptual knowledge of science phenomena (Office of Head Start, 2010). Furthermore, kindergarten readiness screeners do not include science content knowledge or skills. Thus, with limited time for preparing children, teachers have to make choices, and these choices may align with what is appreciated by administrators, elementary schools, and families.

According to our findings, teachers' self-efficacy for math was significantly lower than for literacy and science. Like science, teachers may have negative feelings toward math generated from their previous educational experiences (Edwards & Loveridge, 2011). Furthermore, teachers may have limited guidance regarding instruction for early childhood mathematics because the National Research Council (2009) only recently articulated the importance of these skills at the preschool level. Furthermore, given the poorly synthesized research base for early mathematics development (Purpura & Lonigan, 2013), including the lack of uniformity in definitions (Berch, 2005) and the general lack of consensus among experts in early mathematics (Howell & Kemp, 2005), early educators may struggle with this content and thus have few approaches to practice in math. Although teachers report low efficacy with the subject, it seems that they have identified, at a minimum, some regular routines focused on mathematics, as the majority of teachers reported engaging in math activities three to four times each week. This may be because of the nearly universal routine practice of calendar time in preschool, which is often considered a mathematics activity because children count the days of the month.

Efficacy in literacy is not enough

This lack of efficacy in science has dramatic implications for practice that cannot be overcome by improving efficacy in literacy alone. The findings presented here indicate that although efficacy in literacy is important, it does not translate to quality practice in all areas: literacy, science, and math. In fact, results from this study indicate that high self-efficacy in literacy did not relate to a teacher providing more science materials, providing better instructional support, or engaging children in science experiences more often. Instead, teachers who had higher levels of science efficacy specifically provided more opportunities for science learning. In addition, they were a bit more likely to show environmental support for science by having science-related materials visible in the classroom. Therefore, it is particularly necessary to target professional development opportunities and curriculum offerings to teachers that promote early childhood science education rather than just literacy if professional development is to improve teachers' engagement with an integrated set of content areas.

Children's learning and development are enhanced when teachers integrate scientific learning with other curriculum areas, such as math, literature, and creative thinking (Harlan & Rivkin, 2000). For example, experiences that integrate science, literacy, and math include drawing and labeling parts of an insect, recording measurements and writing the results of a science experiment, or creating and summarizing a graph of children's favorite flowers. The results of this study suggest that learning areas are compartmentalized: High self-efficacy for literacy did not translate to providing materials or experiences in science, and more frequent engagement in literacy did not indicate more frequent engagement in science or math. This may mean that teachers do not identify the benefit of integrating science, literacy, and math experiences to create meaningful lessons for young children. Clearly, even when teachers report high self-efficacy in literacy but report lower self-efficacy in science, they continue to struggle to integrate science into their lessons. This has profound implications for teachers' capacity to prepare and provide a truly integrated curriculum for young children.

General lack of science materials and low-quality experiences

Although the present study found that providing more science materials was related to spending more time engaging children in science experiences, in general classrooms were lacking in terms of material support for science. Our examination of classroom materials revealed that in general teachers provided basic science materials, primarily books, vinyl animals, magnets, measuring cups, and magnifying glasses. Less than 40% of teachers provided collections of natural materials such as seashells, feathers, or insects, and less than 25% provided prisms, seeds, fossils, pulleys, or gourds. These results are similar to Tu's (2006) examination of materials in preschool classrooms in that teachers provided a range of materials but just a few science materials were found in the

majority of classrooms. Then as now, more than 50% of classrooms included vinyl animals, sensory tables, science posters/charts, and magnets; however, few natural science materials were available in classrooms. Across both samples few science tools were observed, including prisms, binoculars, food coloring, and flower pots. However, measurement tools such as measuring cups and spoons, rulers, and scales were more common in our more recent sample than in 2006. Although it seems that a few more science materials exist in classrooms today, many meaningful science materials and tools were found in only a very few classrooms. Clearly, classrooms have a long way to go in terms of providing science materials to facilitate children's science exploration. This finding is particularly concerning considering that previous work has shown that even in classrooms that have many science-related materials, many preschool teachers are uncomfortable demonstrating their intended investigational purposes (Fleer, 2009; Greenfield et al., 2009; Nayfield et al., 2011), which results in children ignoring these science tools or using these materials for non-science-related purposes.

In addition, the instructional quality of science activities was low. This finding adds to work identifying the fact that classrooms typically lack opportunities to explore science materials or test ideas and typically do not include teacher guidance for science (Hanley, Tiger, Ingvarsson, & Cammilleri, 2009; Nayfield et al., 2011) by examining the quality of these opportunities when they are provided. In fact, previous work focused on science in preschool identified that on average children were engaged in critical thinking for just 3.35 min a day, and opportunities for critical thinking did not occur at all in one third of classrooms (Piastra, Pelatti, & Miller, 2014). The lack of variation in the quality of science experiences may be why science efficacy was not related to the instructional quality of the science practices. Alternatively, perhaps self-efficacy can only support teachers so far in the area of science. That is, teachers with higher self-efficacy provided more materials and engaged in science more frequently; however, they did not provide higher quality experiences. It is conceivable that enacting higher instructional quality in science takes more than self-efficacy for science—it also takes a specific foundation in science content and pedagogical strategies. In order to enhance the quality of science instructional practice much more must be done to prepare educators for teaching quality early childhood science.

Teachers' educational background and experience

Teachers' educational background or experience teaching young children did not predict their efficacy for science or math. However, education was mildly positively correlated with literacy efficacy and science instructional support. These are important additions to the literature on teachers' educational background, as it is concerning that teachers with higher levels of formal education did not systematically report higher levels of efficacy for science or math. Previous work investigating the relation between educational preparation and general classroom quality has produced largely null results (Early et al., 2007). Only when teachers' actual practices have been observed in detail have background variables such as years of education and specific preparation in early childhood education predicted teachers' behaviors (e.g., Gerde & Powell, 2009). Our finding that teacher education positively related to science instructional quality aligns with this previous work. It may be that higher education, such as a master's degree, requires some experience with research that teachers can draw from when implementing instructional support in science activities.

It is interesting that educational background was related to literacy efficacy. This may be because of the programmatic focus on literacy in preservice education or ample in-service professional development offerings related to literacy (Schacter, 2015). However, teachers reported lower efficacy for science and math, and more formal education was not associated with higher efficacy in either of these domains. As mentioned above, many degree programs, including bachelor's and master's degrees, provide little in terms of science and math preparation through coursework or practicum training (Brenneman et al., 2009), which may be why these programs have little influence on teachers' domain-specific self-efficacy. This finding remains a concern for preservice teacher preparation programs.

Specific supports in science and math are needed for early childhood teacher preparation programs to facilitate teachers' science knowledge and use of practices that promote children's science learning.

Beyond teachers' preservice education, this work highlights the pressing need for the development and evaluation of early childhood in-service professional development focused on science. To date, early educators have had significantly more opportunities to develop their self-efficacy in literacy compared to science or mathematics domains, with a 39:1 ratio in literacy to science professional development programs (Schacter, 2015). Unfortunately, enhanced efficacy in literacy does not translate to enhanced efficacy for science or math, nor does it translate into more frequent science instruction or better science instructional support. Therefore, if professional development research continues to target language, literacy, or social content areas to near exclusivity, it is likely that the results presented here—low teacher self-efficacy for both science and math plus low science engagement and low science instructional support—will persist and perpetuate early childhood classrooms with limited educational opportunities in science or math. We hope that the next decade of intervention research will result in more professional development programs targeting science.

Limitations

Although this study included extensive data from 67 teachers/classrooms, we recognize that these teachers represent eight Head Start programs, and thus the findings may not generalize to other early learning environments. Head Start has invested considerable resources in setting expectations for (and evaluating) environmental arrangements, materials, schedules, and instructional interactions, and this includes establishing specific goals for literacy, math, and science. This may not be the case in other settings. Furthermore, although all data presented in this study were gathered prior to teachers' participation in any intervention, we recognize that these participants volunteered for a science-focused professional development study, which could have impacted participant selection and recruitment of this sample.

The decision to assess teachers' content-based self-efficacy rather than general teaching self-efficacy was critical to the goals of this study. Furthermore, because teachers' content knowledge, even in preschool, seems to matter for children's development (e.g., Wasik & Hindman, 2011), this demonstrates an innovative and necessary way to study preschool teachers' efficacy across domains. However, we appreciate that domain-specific pedagogical self-efficacy is a valuable measure of one's teaching, as one can effectively understand content in an area but lack effective approaches to teach the material to young children. Although we do not suggest our measure to be a superior method, the present study demonstrates the value of including such a measure in future work, as others have suggested (Morgan, 2012), particularly work examining teachers' beliefs or practices across domains.

There may be some benefit here to examining science efficacy more granularly by identifying efficacy for various areas of science (life science, earth/space science, physical/chemical science). It seems plausible that a teacher could have varying levels of efficacy in each content area and thus change his or her practice based on efficacy for one area over another. This might even be more specific to topic areas such as bees, rocks, or waves. When a teacher has more content knowledge in an area, this may lead to higher efficacy and different teaching approaches. As one example, previous work found that elementary teachers reported higher levels of confidence in teaching life science topics than physical/chemical science topics (Harlen, 1997). However, this level of investigation is absent in the preschool literature. Of course, the more nuanced the construct of science self-efficacy examined, the less generalizable and meaningful the results.

Conclusions

Teachers' content-specific self-efficacy differs across the domains of science, math, and literacy such that teachers' self-efficacy is highest for literacy, lower for science, and lowest for math. This variation matters because teachers' science self-efficacy, and not self-efficacy for literacy or math,

was uniquely related to the practices they used and the environments they prepared for promoting science to young children. Therefore, promoting teachers' self-efficacy in the area of literacy alone is insufficient. The development of high self-efficacy and high instructional support in the area of science is vital for supporting quality science environments and practices in early childhood classrooms and thus cannot continue to be ignored as part of preservice and in-service development and education programs for early childhood educators.

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