A Review of Research on Technology-Mediated Language and Literacy Professional Development Models

Emily K. Snell
Annemarie H. Hindman
Barbara A. Wasik

College of Education
Temple University
Philadelphia, PA, USA

Forthcoming, Journal of Early Childhood Teacher Education

Abstract

With the advance of technology, additional opportunities for professional development are available through non-traditional means. In this review, we examine the effectiveness of technology-mediated language and literacy professional development programs (Tech PD) for teachers and students in early childhood settings. We review Tech PD interventions that have been evaluated using random or quasi-random assignment, peer-reviewed studies. Two questions about this corpus of research were examined: 1) how technology is being used in the programs and 2) whether Tech PD is effective for supporting teachers' enhanced language and literacy instruction and children's learning. Examining the past 16 years of published works (2001-2017), 11 studies were identified. We identify five different types of Tech PD: remote coaching over live video, remote coaching via recorded video or email, online courses, group courses over satellite or video, and online curricula, with results suggesting that impacts on teachers' language and literacy practices and student learning can be comparable to in-person equivalents.

Keywords: professional development, technology, language, literacy, review

Considerable effort and financial investment is currently focused on training teachers to implement strategies that promote the development of young children's early language and literacy competence (Markussen-Brown et al., 2017). Specifically, professional development (PD) has been devoted to building the skills of educators serving children in poverty as a mechanism to improve children's fluent and proficient reading by third grade. One challenge to implementing effective PD is that high-quality, on-going, face-to-face training and coaching for teachers is expensive and, therefore, can be cost-prohibitive. In our digital age, a proposed solution to this issue has been to use technology to more efficiently or effectively disseminate PD models. In general, these technologies aim to obviate the need for the teacher and the PD purveyor to be in the same location at the same time and instead facilitate teacher learning over a distance or even on asynchronous timelines (e.g., remote observation via videotape, remote coaching over live video, online courses). Researchers have recognized technology-mediated PD to be in the relatively early stages of development but have celebrated its resource-efficient potential to support teachers' on-going learning and, in turn, advance children's growth and achievement (Borko, Jacobs, Eiteljorg, & Pittman, 2008; Macià & García, 2016).

In this paper, we first provide a systematic review of the nature and effectiveness of evidence-based, technology-mediated language and literacy PD models (Tech PD) for teachers of young (preschool and kindergarten) children; specifically, we ask whether, and under what conditions, Tech PD can improve teachers' practices and/or children's outcomes. Second, we identify gaps in the research on this topic that represent pressing needs for future research. Systematic reviews are a type of literature review that uses structured methods to locate all possible studies, screen potential studies for inclusion using defined criteria, appraise the research, and synthesize findings across studies. They are designed to provide a summary of current evidence relevant to a research question (Petticrew & Roberts, 2006). A systematic review is distinct from meta-analysis

(Hammer et al., 2014) which distils, from a complex literature, the central quantitative trend in results across numerous different studies of a topic. In contrast, systematic reviews summarize and unpack potential "active ingredients" of programs or interventions and often focus on the practical contexts and components of effective studies.

Professional Development in Early Language and Literacy

We focus this systematic review on Tech PD around early language and literacy instruction for several reasons. First, high-quality early language and literacy instruction has important long-term effects on children's later reading skills (Dickinson & Porche, 2011; Hoff, 2013; Zucker, Cabell, Justice, Pentimonti, & Kaderavek, 2013). Children who have well-developed vocabularies are at a greater advantage when learning to read because less effort is needed to understand the meaning of words, leaving more attention for decoding and recognizing words (Kendeou, van den Broek, White, & Lynch 2009). In addition, letter knowledge and sound awareness prepare children to take advantage of formal decoding instruction in kindergarten and first grade (Ortiz et al., 2012; Vadasy & Sanders, 2010). Together, these competencies help children master reading by the end of grade 3, leaving them better able to comprehend texts in other content areas (e.g., reading to learn in mathematics, science, or social studies), which in turn facilitates greater overall achievement in school and beyond (Lonigan & Shanahan, 2009; Snow, Burns, & Griffin, 1998).

Unfortunately, observational data show that the average preschool classroom does not routinely provide high-quality early language and literacy instruction, particularly for children at risk (Dickinson & Porche, 2011; Dickinson & Tabors, 2001; Wright, 2012). For example, studies using the Classroom Assessment Scoring System (Pianta, LaParo, & Hamre, 2006) reveal largely low-quality instruction in American classrooms (Barnett & Friedman-Krauss, 2016). Not only are many teachers ill-prepared to deliver high-quality language and literacy instruction to the classroom as a whole, but they also struggle to modify the general curriculum to suit individual differences (Stayton, 2015; Voss & Bufkin, 2011), making the need for effective PD salient.

Why is the Potential of Tech PD So High for Early Language and Literacy?

There is emerging support for the value of Tech PD, especially in the area of early childhood language and literacy instruction. For example, Pianta and colleagues have reported on MyTeachingPartner (MTP; Pianta et al., 2008), an online coaching professional development program. MTP features web-based coaching in which teachers videotape themselves (rather than being directly observed in the classroom) and coaches provided feedback via phone call. As another example, Powell and colleagues (Powell et al., 2010) also use videotapes to implement long-distance coaching in a study of Classroom Links to Early Learning (CLEL). Other researchers have examined the effectiveness of other types of online PD, such as online video-based learning (Bates, Phalen, & Moran, 2016), live video-based learning (Borko et al., 2008), live video-based coaching (Vernon-Feagans et al., 2015; 2015), and coaching by email (Barton, Fuller, & Schnitz, 2015). In our systematic review, we aim to focus specifically on Tech PD that targets early childhood teachers' language and literacy instruction and children's language and literacy outcomes. In so doing, we aim to summarize how technology is being used by such programs and whether different types of Tech PD are effective for supporting enhanced language and literacy instruction and learning.

Aims of This Paper

The aims of this paper are to review the array of studies reporting on the use of Tech PD to see how technology is being used, and whether it is effective for teacher and/or child outcomes in authentic early childhood (i.e., preschool and kindergarten) contexts. At this time, while technology has permeated our culture, we have limited understanding of the role of technology in teacher PD. Currently, there are no large-scale surveys providing information about the degree to which technology is used for PD in early childhood settings. However, some studies (as discussed above) have focused on specific programs. These initial findings suggest that technology has potential for increasing the efficiency of and access to PD; however, in practice, many questions remain concerning how it might be best utilized for training and supporting teachers, including in early

childhood, and for improving children's educational outcomes, particularly during the foundational first years of schooling (Dede et al., 2009).

Research questions. We conducted a systematic review of published, experimental, empirical studies of language- and literacy-related Tech PD in early childhood (i.e., preschool and kindergarten) located through an extensive search process. We focused on published studies because they have undergone rigorous peer review. Our systematic review is focused on the following questions:

1. How is technology integrated into evidence-based language and literacy PD, and in particular, what aspects of the PD are communicated via technology? For example, is technology being used to provide remote coaching through taped video, remote coaching through live video, online courses, or online curricula or other materials? Further, in what combination is technology used alongside non-technological PD activities?

2. What do we know about the effectiveness of Tech PD, as compared to control conditions (i.e., a no intervention control group), and as compared to non-tech versions of the same PD programs, for teacher and child language and literacy outcomes?

Together, these two research questions elucidate the landscape of Tech PD for early language and literacy, revealing new information about the nature and frequency of its use and the degree of its effectiveness.

Method

The procedures for the literature search that identified papers and models, and the specific selection criteria that distinguished them from other publications that were not included, are described below.

Selection Criteria

To be included in this review, a study had to meet the following criteria:

A. The study had to examine the effects of technology-mediated (in full or part) PD on preschool or kindergarten teachers and if available, students. All settings were included, such as public preschool, Head Start, child care, public kindergarten, or other settings.

B. The study had to target a language and/or literacy outcome (in English), either at the level of the teacher (i.e., some type of language or literacy instruction) and/or at the child level (i.e., some language and literacy skill). Studies were selected if they targeted language and/or literacy as well as other outcomes (e.g., fine motor development); however, only the language and/or literacy findings and indirectly related skills such as child engagement were reported. To be as comprehensive as possible, we included indirectly related skill sets, such as engagement in language and literacy.

C. The study had to appear in a peer-reviewed publication, ensuring the paper had gone through a rigorous review process.

D. The study had to test the Tech PD model(s) using a research design that determined whether the intervention demonstrated effects on either teachers and/or children (i.e., experimental or quasi-experimental design, incorporating one or more of the following: a randomized controlled trial, a pre-test–intervention–post-test comparison with a control group, group comparisons with random assignment or pre-and post-testing, or within-subject designs). We did not include studies that used multiple baseline methods.

This review follows standard key steps (Hammer et al., 2014): locating all possible studies, screening potential studies for inclusion using pre-determined criteria, coding all qualified studies based on their methodological and substantive features, and calculating effect sizes for all qualified studies for further combined analyses.

To obtain the body of studies that met our inclusion criteria, the authors developed a list of comprehensive key search terms. The terms were divided into four primary sets: topics of interest, including technology (i.e., technology/tech, web, video, email, and online (on-line) course) and professional development (i.e., professional development, training, coaching, mentoring, and

curriculum); targeted population (i.e., preschool, kindergarten, early childhood, Head Start, teacher, educator, and professional learning community); outcomes (i.e., literacy, pre-literacy, language, and instruction); and research design (i.e., experiment, quasi-experiment, treatment, control, pre-test, post-test, intervention). We searched all combinations of key terms to ensure that we collected the broadest sample possible. Multiple searches were run across the major academic databases: Elsevier, ERIC, Google Scholar, PsycINFO, PubMed, Scopus, and Web of Science. We also reviewed the reference lists of relevant studies and meta-analyses to ensure that all relevant papers were included. The search was limited to journals published in English that were available through these search engines between 2001-2017.

The searches revealed unique 73 citations. Each citation passed through multiple levels of review. Abstracts were read by the first author and marked for inclusion or exclusion using the team's criteria. Articles that did not meet the criteria were excluded (n=62); for example, we excluded studies that did not use quasi- or random assignment design, studies that did not include a tech-based approach, studies focused on social-emotional learning PD, or studies of older grades. All authors reviewed a randomly selected subsample (1/6) of excluded abstracts to ensure the accuracy of this exclusionary process; inter-rater agreement was 100%.

Selected Research Papers

Following this, 11 peer-reviewed publications remained. Each co-author read the papers, and a final decision was made by consensus to include all 11 publications about PD models that were either exclusively focused on providing Tech PD, or included an arm of the study that was tech-based, which had published evaluations using quantitative methods. Together, this small body of rigorous literature focused on six different PD models: CIRCLE Preschool Early Language and Literacy Training (CIRCLE; Landry, Anthony, Swank, & Monseque-Bailey, 2009); Classroom Links to Early Literacy (CLEL; Powell et al., 2010); HeadsUp! Reading (HUR; Henk, Morrison, Thornburg & Raya-Carlton, 2007; Jackson et al., 2006); My Teaching Partner (MTP; Early et al.,

2017; Mashburn, Downer, Hamre, Justice, & Pianta, 2010; Pianta et al., 2008; Pianta et al., 2017); Read it Again (RIA; Mashburn, Justice, McGinty, & Slocum, 2016); and the Targeted Reading Intervention (TRI; Vernon-Feagans, Kainz, Hedrick, Ginsberg, & Amendum, 2013; Vernon-Feagans, Bratsch-Hines, Varghese, Bean, & Hedrick, 2015).

Data Reduction and Comparison Across Studies

To assist with the critical review and our research questions, information from each article that was highly relevant (as described above) for our research aims was coded and entered into a table by the authors. Information extracted from the articles included: 1) the design of the study and demonstrated impacts of Tech PD; 2) how and what technology was used to support the PD; and 3) the pedagogical approaches to the Tech PD, including what language and literacy outcomes were targeted, the program content (what conceptual and procedural information was conveyed), how it was delivered to teachers (via coursework, coaching, and the like); and 3) the dosage of the program (i.e., frequency, intensity, and intervention duration). Each co-author read the papers and reached 100% agreement for the content that was entered into the table.

Results

Research Question 1. How is Technology Being Used in Evidence-Based Tech PD?

We first examined how technology was used by the six professional development models reviewed in the paper. The six models reviewed in this paper used a total of five distinct combinations of technology-mediated PD, detailed below (and see Table 1).

1) Remote, non-live, asynchronous coaching consists of coaches who work with teachers remotely, including via video sent by teachers to coaches, and phone or email exchanges between coach and teacher about the content. Two programs (CLEL and MTP) studied this approach. CLEL was one semester long, with seven remote coaching sessions, while MTP was a year long, averaging 14 remote sessions over the school year.

2) Remote live coaching consists of coaches observing and providing feedback to teachers live, using web-cams. Only one program (TRI) used this approach. Teachers met with individual students who were struggling for one-on-one reading sessions and coaches provided immediate, targeted feedback to the teachers over web-cam. Coaches helped teachers use the TRI strategies effectively with each struggling reader in real time, guided teachers in deciding when a student was ready to be transferred to a small group, and problem-solved with teachers about students who were not making rapid progress.

3) Online course content allows teachers to access online materials and read about language and literacy, watch videos, and take quizzes. All of the Tech PD models provided teachers with online course materials that teachers could access and study on their own time.

4) Online group courses or satellite courses are similar to standard PD, except that teachers attend a viewing of the PD program offered online or over satellite with other groups of teachers. A model that may be particularly appealing to remote or rural child care centers, the HeadsUp! Program, was delivered as a live broadcast course to preK teachers in large-group settings. Teachers attended the course for 44 hours over 15 weeks. CIRCLE was also delivered as a satellite course, with participating teachers meeting in small groups to viewing 2-hr online classes twice per month throughout the school year.

5) Online downloadable curriculum or **lesson plans** consist of resources available online for teachers to use in the classroom. RIA and MTP both provided teachers with specific curricula and lessons plans to guide their instruction of students. RIA consisted of a 30-week downloadable curriculum for preK teachers. In MTP, all teachers received access to web-based versions of MTP lesson plans in language and literacy and were asked to use these materials during the week for at least 10 min per day.

Comparisons. Overall, across these 11 studies focused on six discrete interventions, satellite courses were more commonly used in the older studies, while more recent work introduced more

current technology such as web cameras. Tech PD models also differed in how they combined technology: several studies layered two forms of Tech PD together (i.e., online course plus downloadable curriculum, as in RIA), while others employed only one strategy (i.e., online coaching only, as in CIRCLE and HUR). In addition, many of the programs were not exclusively tech-based, in that they also used some amount of non-technological, in-person training to introduce teachers to the program prior to the school year (i.e., CLEL, MRP, RIA, and TRI). For example, the CLEL workshops gave an overview of the intervention content, described what teachers would be asked to do over the course of the project, introduced the coach and teacher to one another, and provided training in the use of project equipment. In sum, there was some overlap and intertwining of the five types of Tech PD.

Research Question 2. How Effective is Tech PD?

Our second research question explored findings related to the effectiveness of Tech PD. We examined the impact of Tech PD as compared to a control (i.e. a business-as-usual control, with no Tech PD program), and as compared to non-Tech versions of the same PD program, for teacher and child outcomes. Because there were various types of Tech PD, below we organize our synthesis by type of Tech PD program.

Remote, non-live asynchronous coaching. Two programs tested the effectiveness of remote, non-live, asynchronous coaching (CLEL and MTP) to control conditions (i.e., no intervention control group). The CLEL PD program (Powell et al., 2010), which included 7 sessions of remote, non-live coaching over one school semester, resulted in impacts on general class environment of d = .99 and class supports for early literacy and language development of d = .92 and on child language and literacy skills of d = .17-.29 for pre-literacy skills (letter knowledge, blending skills, writing, concepts about print), but no impacts on letter-word identification or initial sound

matching (Table 1). Importantly, effect sizes for CLEL were similar for students whose teachers were coached live, in-person, using the same content.

The other program that tested asynchronous coaching, MTP, showed smaller impacts. A recent MTP study (Pianta et al., 2017) examined experimental effects on teacher outcomes (relative to a business-as-usual classroom), finding impacts on emotional support but not instructional or behavioral support as measured with the CLASS. Impacts on student learning outcomes are also mixed. Mashburn et al. (2010) found that students whose teachers received MTP remote coaching experienced gains of d =.27 on standardized assessments of receptive language, but experienced no impacts on measures of blending sounds, elision, print awareness, or an emergent literacy composite measure, as compared to control students whose teachers did not receive coaching. Early et al. (2017) also found limited child impacts of MTP, with effects on student inhibitory control (d = .24) but no language or literacy outcomes.

Remote live coaching. We identified only one intervention that has tested the effectiveness of coaching teachers over web-cam to allow for immediate, live coaching (Vernon-Feagans et al., 2013; 2015). Of all the models that we reviewed, the effects on child outcomes were most consistently large for this intervention. Effect sizes for the tested Woodcock Johnson assessments were d = .36 for word attack, d = .54 for Letter Word, d = .48 for passage comprehension, and d = .63 for spelling, for struggling readers, as compared to controls. However, there were no impacts on vocabulary (PPVT). There were no significant differences in impacts for children whose teachers received in-person vs. web-camera PD. The studies (Vernon-Feagans et al., 2013; 2015) did not measure experimental impacts on teacher behaviours, although there is good evidence of strong fidelity to coached teacher behaviours among treatment teachers (Vernon-Feagans et al., 2015).

Online individual course. All of the Tech PD models provided teachers with online course materials that teachers could access and study on their own (as opposed to watching in a group setting, as discussed below). The CIRCLE, CLEL, and TRI studies did not explicitly test the added

value of online course materials, as they were available to all conditions. Critically, though, one MTP study (Pianta et al., 2008) and the RIA design (Mashburn et al., 2016) allowed for the study of the unique benefits of online courses. Specifically, MTP (Pianta et al.) included one intervention group in which teachers were given access to the online course and one intervention group that received the online course and remote asynchronous coaching; researchers found that teachers in the online course group did not improve in teaching quality (nor did their students improve in outcomes), whereas the teachers who also received remote asynchronous coaching did. This suggests just having access to the online course was not enough to improve teaching quality or child outcomes. However, contrasting findings emerged from RIA. The RIA study consisted of one condition receiving a downloadable curriculum and a second receiving an online course and the curriculum. Here, access to the online course and curricular materials was no better than access to curricular materials alone.

Online group courses. Although two different Tech PD programs used online group courses (CIRCLE and HUR), only HUR used a design that explicitly tested the impact of online group courses, in which teachers attended a language and literacy course provided over satellite or online. The results of the two HUR studies show mixed findings. Jackson et al. (2006) found an effect of d = .96 for the online HUR training alone on teacher language and literacy quality outcomes, while Henk et al. (2007) found no impacts of HUR on teacher quality, but did find impacts on teacher language and literacy knowledge (d = .40). For child outcomes, Jackson et al. (2006) found impacts of about d = .50 for a teacher-rated measure of language and d = .90 for an assessment of reading ability, but no significant differences for the two other measures of language and pre-literacy skills. There were no differences in outcomes for children when teachers received additional in-person coaching. Henk et al. (2007) did not measure child outcomes.

Online curricular materials. Child effects for the downloadable curriculum model, RIA (Mashburn et al., 2016), included impacts on children's narrative language (g = 0.15), alphabet knowledge (g = .18), and print concepts (g = .25), but there were no impacts on print knowledge,

vocabulary, and phonological awareness. The study found no added benefits of access to an online self-study program. Teacher impacts were not measured.

In MTP, all teachers received access to web-based versions of MTP lesson plans in language and literacy and a web-based version of the PATHS curriculum in social competence. Teachers were asked to use these materials during the week, implementing a language and literacy activity for at least 10 min per day and a PATHS activity once per week. However, teachers only given access to these curricular materials (and who did not receive the MTP distance coaching) did not experience gains.

"Enhancing" Tech PD with in-person coaching. Two of the studies also examined whether the impact of online PD could be further leveraged by providing live, in-person coaching. The findings from the CIRCLE study (Landry et al., 2009) suggested that providing in-person coaching, when coupled with progress monitoring technology, resulted in greater impacts on overall, and literacy and language-specific, teacher classroom quality measures (d = .75-1.11) and measures of child vocabulary (d = 0.19) and letter knowledge (d = 0.26). Interestingly, children whose teachers received the progress monitoring technology, but no coaching, were the only group that experienced statistically significant impacts on phonological awareness (d =.16), as compared to controls.

In contrast, one study of HUR (Jackson et al., 2006) also examined the impact of adding in-person coaching, finding only mixed effects. Although teachers in the course-plus-coaching group had slightly better outcomes in teaching quality, children in the course-alone classrooms had slightly greater gains on language and literacy outcomes. Note, however, that group differences were not explicitly tested against one another statistically. Overall, the Jackson et al. (2006) findings did not demonstrate benefits of additional in-person coaching to supplement an online group course.

Discussion

The results of this review provide an opportunity to reflect on the development of the role of technology in PD, considering what we have learned and examining which important questions

demand further systematic examination. This review has revealed several important findings about technology and PD in the area of early childhood language and literacy. The first is that there is limited experimental research – just 11 rigorous studies – on this topic. Even though technology permeates our everyday lives, evidence-based Tech PD research in early childhood language and literacy is limited. The available research found that a variety of technologies, as well as varied combinations of technology and classic approaches, are being used in Tech PD. Consequently, while we can draw some key conclusions, many questions about effectiveness remain to be answered.

No program relied entirely on technology to deliver the PD; in all cases there was some in-person contact between the PD intervention and teachers. The CIRCLE and HUR programs provided videos of training to participants in group settings; the other four models all had at least some initial in-person training in a workshop setting. The technology does exist to implement PD fully online; it remains to be seen, however, whether a fully online PD program can result in high fidelity of implementation in the classroom and positive effects on children's learning, or whether hybrid models using both some in-person and some tech-based training are necessary for ensuring positive impacts for teachers and students. Unfortunately, our review is unable to determine the added value of such in-person contact for the effectiveness of PD; however, we can raise the question as critical for future research. We know that for PD to be successful, teachers need continual support in the classroom to implement high-impact, evidence-based strategies. We do not know if teachers need to have in-person contact with trainers, mentors, or coaches to make this possible.

These results also showed that Tech PD programs can be as effective as in-person PD programs, with effect sizes in the moderate to large range for impacts on teaching practices (i.e., Cohen's $d > .5$) and in the small to moderate range for impacts on student learning (i.e., Cohen's $d =$ .2-.5). These studies may also suggest that the PD content was well-developed and tested and that the technology was successfully used as method of dissemination. Indeed, Vernon-Feagans et al. (2015) notably speculated that the TRI model was more efficient (and perhaps more effective) when

implemented using a web-camera because less time was spent on off-topic conversation before, during, or after the coaching session, which allowed for more focused attention on improving instruction for the struggling reader. Put another way, then, the Vernon-Feagans et al. study suggests that technology not only can support dissemination but can also impact the effectiveness of that PD, especially around coaching.

It is important to note that the child outcome effects on the TRI model were significant. As previously stated, child outcomes in language and literacy PD models is difficult to achieve. This model showed the largest effects on child out come than any other PD intervention. Perhaps this is due to the immediate, explicit feedback teachers are provided with in real time.

Although there is reason for optimism for the promise of Tech PD, particularly for those models with strong effects on child learning outcomes, it is important not to over-promise or over-state potential benefits of these or any other technological innovations. In most of the Tech PD studies, not all measured outcomes showed positive results. Sometimes the effects were similar between in-person PD and Tech PD, and sometimes this similarity was reflected in null effects for either condition. With that said, given that many professional development programs show no evidence for effectiveness (Markussen-Brown et al., 2017), we believe these Tech PD programs may be of interest to many early childhood educators and administrators.

Challenges of Tech PD

Teacher professional development using new technologies is at a relatively early stage of development and the number of available published studies are limited. However, our pool of studies is of sufficiently high quality that at least some conclusions can be drawn across studies. As more research is published, results can be updated in further work or with other approaches.

There are several possible shortcomings of Tech PD for improving teacher practice and child outcomes. One key issue is that teachers may struggle with the technology. The teaching workforce

is quite diverse in age and specialization; not all teachers will have equal exposure to and comfort with all of the tools they may be asked to use, although recent work suggest this is not universally the case. For example, LoCasale-Crouch et al. (2016) found high levels of satisfaction and participation rates in a study of an online course for early childhood teachers. Our review did not explicitly examine the role of teacher comfort with technology in the success of Tech PD, and this remains an important topic for future research. Second, technologies like video cameras and storage for videos, even if stored in "the cloud," may be very expensive for schools and districts. Finally, remote Tech PD approaches, in contrast to more face to face approaches, may be limited in their ability to leverage a strong interpersonal relationship with teachers to encourage teacher instructional change.

Limitations of the Current Study

There are several limitations to this systematic review. One is that the nature and number of the studies we reviewed – especially their variation on dimensions including technology used, outcomes examined, and duration of the treatment – impeded our ability to distil clear guidance for practice; more high-quality research is needed on various types of Tech PD in the area of early childhood language and literacy. Second, this paper focused narrowly on language and literacy Tech PD; other areas of early childhood Tech PD are also worthy of attention. Finally, we used a 16-year window of research, but it could be the case that future Tech PD innovations might be different enough that our research findings will not be as applicable.

Conclusions: Research and Practice Implications of Tech PD

As technology and teacher PD is a nascent field, many questions remain. It would be helpful if studies were conducted to systematically answer questions about the added value of technology, exploring where it works well and where it may not be as successful. For example, in TRI (Vernon-Feagans et al., 2013; 2015), the use of remote web-cam allows teachers to get feedback and support in real time, with impressive results. It is important, however, to examine whether teachers are able to transfer the knowledge they learned to other children, including both at-risk and higher-achieving

children. In addition, we need to determine the effectiveness of remote live coaching in other settings, such as full- or small-group instruction, or for other child outcomes such as STEM or social-emotional skills. Similar questions of sustainability and generalizability will be important to answer for the other Tech PD models included in the review, and any future models. Finally, the question of whether effective Tech PD models are also cost-effective needs further research. Future work could provide a cost-benefit analysis of Tech PD models to determine whether there are savings from the use of Tech PD, accounting for the investment in the development and on-going maintenance of the technology used for the PD.

Overall, our review of the small but growing field of technology-mediated language and literacy professional development models for early childhood professionals suggests that such interventions show promise. Administrators and educators who are looking for potential language and literacy PD programs are encouraged to consider those Tech PD programs that have been shown to be effective in improving children's learning outcomes and have the potential to be implemented at scale with high levels of fidelity (Hamre, Partee, & Mulcahy, 2017; LoCasale-Crouch, Hamre, Roberts, & Neesen, 2016). Our findings should signal optimism regarding the learning potential of this type of professional development and may encourage those who have otherwise been wary of using Tech PD with teachers of young children.

References

Barnett, W. S., & Friedman-Krauss, A. H. (2016). *State(s) of Head Start.* The National Institute for Early Education Research.

Barton, E. E., Fuller, E. A., & Schnitz, A. (2015). The use of email to coach preservice early childhood teachers. *Topics in Early Childhood Special Education, 36*(2), 78-90.

Bates, M. S., Phalen, L., & Moran, C. G. (2016). If you build it, will they reflect? Examining teachers' use of an online video-based learning website. *Teaching and Teacher Education, 58,* 17-27.

Borko, H., Jacobs, J., Eiteljorg, E., & Pittman, M. E. (2008). Video as a tool for fostering productive discussions in mathematics professional development. *Teaching and Teacher Education, 24*(2), 417-436.

Center for Improving the Readiness of Children for Learning & Education. (2006). *Preschool early language and literacy training.* Houston: University of Texas.

DeBaryshe, B. D., & Gorecki, D. M. (2007). An experimental validation of a preschool literacy curriculum. *Early Education and Development, 18,* 93–110.

Dede, C., Ketelhut, D. J., Whitehouse, P., Breit, L., & McCloskey, E. M. (2009). A research agenda for online teacher professional development. *Journal of Teacher Education, 60*(1), 8e19.

Diamond, K. E., & Powell, D. R. (2011). An iterative approach to the development of a professional development intervention for head start teachers. *Journal of Early Intervention, 33*(1), 75–93.

Dickinson, D. K., & Porche, M. V. (2011). Relation between language experiences in preschool classrooms and children's kindergarten and fourth-grade language and reading abilities. *Child Development, 82*(3), 870-886.

Dickinson, D. K., & Tabors, P. O. (2001). *Beginning literacy with language: Young children learning at home and school.* Paul H Brookes Publishing.

* Early, D. M., Maxwell, K. L., Ponder, B. D., & Pan, Y. (2017). Improving teacher-child interactions: A randomized controlled trial of Making the Most of Classroom Interactions and My Teaching Partner professional development models. *Early Childhood Research Quarterly, 38,* 57–70.

Hammer, C. S., Hoff, E., Uchikoshi, Y., Gillanders, C., Castro, D. C., & Sandilos, L. E. (2014). The language and literacy development of young dual language learners: A critical review. *Early Childhood Research Quarterly, 29*(4), 715-733.

Hamre, B. K., Partee, A., & Mulcahy, C. (2017). Enhancing the impact of professional development in the context of preschool expansion. *AERA Open, 3*(4), 233285841773368.

*Henk, J. K., Morrison, J. W., Thornburg, K. R., & Raya-Carlton, P. (2007). The efficacy of HeadsUp! Reading in Missouri on teachers' knowledge of emergent literacy: A satellite-based literacy development training course. *NHSA DIALOG*, *10*(1), 20-35.

Hoff, E. (2013). Interpreting the early language trajectories of children from low-SES and language minority homes: Implications for closing achievement gaps. *Developmental Psychology, 49*(1), 4.

*Jackson, B., Larzelere, R., Clair, L. S., Corr, M., Fichter, C., & Egertson, H. (2006). The impact of HeadsUp! Reading on early childhood educators' literacy practices and preschool children's literacy skills. *Early Childhood Research Quarterly*, *21*(2), 213-226.

Kendeou, P., van den Broek, P., White, M., & Lynch, J. (2009). Predicting reading comprehension in early elementary school: The independent contributions of oral language and decoding skills. *Journal of Educational Psychology,* 101, 765–778.

* Landry, S. H., Anthony, J. L., Swank, P. R., & Monseque-Bailey, P. (2009). Effectiveness of comprehensive professional development for teachers of at-risk preschoolers. *Journal of Educational Psychology*, *101*, 448–465.

LoCasale-Crouch, J., Hamre, B., Roberts, A., & Neesen, K. (2016). If you build it, will they come? *The International Review of Research in Open and Distributed Learning, 17*(1).

Lonigan, C. J., & Shanahan, T. (2009). *Developing early literacy: Report of the National Early Literacy Panel. A scientific synthesis of early literacy development and implications for intervention.* National Institute for Literacy.

Macià, M., & García, I. (2016). Informal online communities and networks as a source of teacher professional development: A review. *Teaching and Teacher Education, 55,* 291-307.

Markussen-Brown, J., Julh, C. B., Piasta, S. B., Bleses, Do., Hojen, A., Justice, L. M. (2017). The effects of language-and literacy-focused professional development on early educators and children: A best-evidence meta-analysis. *Early Childhood Research Quarterly, 38,* 97-115.

* Mashburn, A. J., Downer, J. T., Hamre, B. K., Justice, L. M., & Pianta, R. C. (2010). Consultation for teachers and children's language and literacy development during pre-kindergarten. *Applied Developmental Science, 14,* 179–196.

* Mashburn, A., Justice, L. M., McGinty, A., & Slocum, L. (2016). The impacts of a scalable intervention on the language and literacy development of rural pre-kindergartners. *Applied Developmental Science*, 1-18.

Ortiz, M., Folsom, J. S., Al Otaiba, S., Greulich, L., Thomas-Tate, S., & Connor, C. M. (2012). The componential model of reading: Predicting first grade reading performance of culturally diverse students from ecological, psychological, and cognitive factors assessed at kindergarten entry. *Journal of Learning Disabilities, 45*(5), 406-417.

Petticrew, M. & Roberts, H. (2006). *Systematic reviews in the social sciences.* Oxford: Wiley Blackwell.

* Pianta, R. C., Mashburn, A. J., Downer, J. T., Hamre, B. K., & Justice, L. (2008). Effects of web-mediated professional development resources on teacher–child interactions in pre-kindergarten classrooms. *Early Childhood Research Quarterly*, *23*(4), 431-451.

* Pianta, R., Hamre, B., Downer, J., Burchinal, M., Williford, A., LoCasale-Crouch, J., ... & Scott-Little, C. (2017). Early childhood professional development: Coaching and coursework effects on

indicators of children's school readiness. *Early Education and Development,* 1-20.

* Powell, D. R., Diamond, K. E., Burchinal, M. R., & Koehler, M. J. (2010). Effects of an early literacy professional development intervention on Head Start teachers and children. *Journal of Educational Psychology*, *102*(2), 299.

Snow, C.E., Burns, M.S., & Griffin, P. (Eds.). (1998). *Preventing reading difficulties in young children*. Washington, DC: National Academy Press.

Stayton, V. D. (2015). Preparation of early childhood special educators for inclusive and interdisciplinary settings. *Infants & Young Children*, *28*(2), 113-122.

Vadasy, P. F., & Sanders E. A. (2010). Efficacy of supplemental phonics-based instruction for low-skilled kindergarteners in the context of language minority status and classroom phonics instruction. *Journal of Educational Psychology, 102,* 786–803.

* Vernon-Feagans, L., Bratsch-Hines, M., Varghese, C., Bean, A., & Hedrick, A. (2015). The targeted reading intervention: Face-to-face vs. webcam literacy coaching of classroom teachers. *Learning Disabilities Research & Practice, 30*(3), 135-147.

* Vernon-Feagans, L., Kainz, K., Hedrick, A., Ginsberg, M., & Amendum, S. (2013). Live webcam coaching to help early elementary classroom teachers provide effective literacy instruction for struggling readers: The Targeted Reading Intervention. *Journal of Educational Psychology, 105*(4), 1175-1187.

Voss, J. A., & Bufkin, L. J. (2011). Teaching all children: Preparing early childhood preservice teachers in inclusive settings. *Journal of Early Childhood Teacher Education*, *32*(4),338-354.

Wright, T. S. (2012). What classroom observations reveal about oral vocabulary instruction in kindergarten. *Reading Research Quarterly*, *47*(4), 353-355.

Zucker, T. A., Cabell, S. Q., Justice, L. M., Pentimonti, J. M., & Kaderavek, J. N. (2013). The role of frequent, interactive prekindergarten shared reading in the longitudinal development of language and literacy skills. *Developmental Psychology, 49*, 1425.