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An empirical investigation of the dimensionality of the physical literacy environment in early childhood classrooms

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Abstract

This study investigated the dimensionality of the physical literacy environment of early childhood education classrooms. Data on the classroom physical literacy environment were collected from 245 classrooms using the Classroom Literacy Observation Profile. A combination of confirmatory and exploratory factor analysis was used to identify five separate dimensions of the physical literacy environment; including (a) variety and use of books, (b) variety and use of writing center materials, (c) variety and use of technology, (d) variety of environmental print and (e) variety and use of other literacy-related materials. Overall, these five dimensions demonstrated reasonable reliability and validity. Implications for investigating the physical literacy environment and future directions for research are discussed.

Keywords: Early literacy, classroom practice, early childhood education, early childhood literacy, classroom interaction

The early childhood education (ECE) classroom is one context for bolstering young children's language and literacy skills through children's engagement in literacy activities (e.g. Dickinson and Neuman, 2006; Dickinson and Tabors, 2001; Morrow, 1990; National Early Literacy Panel, 2008; Neuman and Roskos, 1992; Snow et al., 1998; Wasik et al., 2006). The ECE classroom environment is frequently conceptualized via two specific domains that include the process (e.g. adult–child interactions) and the structural environments (e.g. number of books) (Guo et al., 2012; Mashburn et al., 2008), the latter of which encompasses the physical literacy environment. The focus of the present study is to investigate the dimensionality of the physical literacy environment in ECE classroom settings. The physical literacy environment has been characterized in multiple ways (e.g. Neuman and Roskos, 1992; Smith et al., 2002). As discussed further below, over time, understandings of and research about what constitutes the physical literacy environment and its association with children's language and literacy growth have developed.

Possible dimensions of high-quality physical literacy environments

There are several key aspects of the physical literacy environment that are associated with children's learning (see **Table 1** for a review) (Celano and Neuman, 2001; Wolfersberger et al., 2004). Specifically, research supports the importance of providing access to a variety of literacy materials in the classroom (Neuman and Celano, 2001; Neuman and Roskos, 1997). For example, when children were provided with a variety of *books* and *literacy-related materials*, they tended to engage in emergent reading activities more (Neuman and Roskos, 1992) and participated in play surrounding literacy (Morrow, 1990). Additionally, in studies in which literacy-related materials, such as puzzles and props, were intentionally placed throughout the classroom, children's use of these items increased (Morrow and Weinstein, 1986; Neuman, 1999). Thus, it may be that both the presence of books as well as other literacy materials within the physical environment can facilitate children's language and literacy development.

The inclusion of *writing-specific materials* in preschool classrooms has also been linked to children's literacy development (Clark and Kragler, 2005; Morrow, 1990). For instance, Zhang et al. (2014) found that the quantity of writing materials in a classroom was positively connected to child growth in name-writing ability. Similarly, Guo et al. (2012) reported that within the context of high-quality classrooms children's growth in alphabet knowledge and name-writing ability was associated with the

Table 1. Support for the aspects of the physical literacy environment.

Aspect of the physical literacy environment	Definition	Citations
Books and literacy-related materials	Books available in the classroom library and materials such as puzzles and props (e.g. menus)	Morrow and Weinstein, 1986; Morrow, 1990; Neuman and Celano, 2001; Neuman and Roskos, 1992; Neuman and Roskos, 1997; Neuman, 1999
Writing materials	Writing tools (pens, markers, pencils) and writing media (lined paper, construction paper)	Clark and Kragler, 2005; Guo et al., 2012; Morrow, 1990; Zhang et al., 2014
Print environment	Environmental print including labels, charts, names and displays	Dowhower and Beagle, 1998; Graves et al., 1996; Loughlin and Martin, 1987; Neumann et al., 2013; Vukelich, 1994
Technology	Computer and literacy-related computer games; audio center	Brown and Harmon, 2013; Couse and Chen, 2010; Kelley et al., 2015; Plowman et al., 2010; Schmidt and Vandewater, 2008
Use of materials	How many children spend time using literacy and writing materials	Baroody and Diamond, 2014; Bracken and Fischel, 2008; Deckner et al., 2006; Lyytinen et al., 1998; Wolfersberger et al., 2004

presence of writing materials. Therefore, both the quantity and the variety of the types of writing materials in the classroom appear to be important considerations when assessing the quality of a physical literacy environment.

The *print environment* is another component of the physical literacy environment that research has shown to be related to child outcomes. For instance, Vukelich (1994) found that the introduction of relevant environmental print (e.g. signs in the dramatic play area) and strategic placement of that print within the classroom was connected to children's ability to read words. This association may be attributable to the adult–child interactions provided by the presence of environmental print. In a study of mother–child interactions, the frequency of adult and child referencing to environmental print was related to children's knowledge of

print concepts as well as name and letter writing (Neumann et al., 2013). This adult-mediated learning may be similar in educator–child interactions around environmental print within the classroom's physical literacy environment. Furthermore, the presence of environmental print within the classroom may be particularly important as other researchers have suggested that children's ability to display their own work as part of the physical literacy environment is central in order for children to understand the purposes of print (Dowhower and Beagle, 1998; Graves et al., 1996; Loughlin and Martin, 1987). Although environmental print is sometimes conceptualized as part of the writing environment, the connection with children's outcomes has been studied separately from writing. Therefore, it may be that the environmental print in a classroom is a separate dimension.

As inclusion of *technology* in the classroom has increased in recent years, research has begun to show that the use of technology can be a powerful intervention tool for increasing children's language and literacy skills (Brown and Harmon, 2013; Kelley et al., 2015). However, research also suggests that how educators include technology in their curriculum is related to children's use of it (Couse and Chen, 2010; Schmidt and Vandewater, 2008) and that technology may be limited in preschool classrooms (Plowman et al., 2010).

Additionally, children's engagement and *use of materials* is an oft-overlooked aspect of the physical literacy environment. Simply having materials in the classroom may not be enough to improve outcomes. In fact, evidence suggests that children ought to be provided with opportunities to purposefully interact with literacy materials (Baroody and Diamond, 2014; Wolfersberger et al., 2004). Although this emerging evidence is from studies of children in family settings, literacy interest and engagement during reading has also been found to be associated with children's alphabet knowledge, phonological awareness and sometimes oral language (Bracken and Fischel, 2008; Deckner et al., 2006; Lyytinen et al., 1998). Thus, it seems plausible that these types of relations or associations may also be present in preschool classrooms, and engagement may be particularly important for improving outcomes for children.

Within the extant research, many dimensions of the physical literacy environment have been noted as contributing to children's language and literacy outcomes. Specifically, the availability of literacy-related materials, including access to a variety of books and other literacy materials; the inclusion of writing-specific materials; a strategically designed print environment; and children's engagement with literacy materials may all contribute in some way to the development of children's language and literacy

skills. Despite the evidence linking individual dimensions of the environment with specific child outcomes, little is known about the physical literacy environment as a construct. Specifically, it is unclear if the physical literacy environment is best conceptualized as a singular construct or a multi-dimensional construct comprised of these different dimensions.

Measures of the physical literacy environment

Although the physical literacy environment may be comprised of many dimensions, most psychometrically validated assessment tools conceptualize the physical literacy environment as a singular construct consisting of two subscales. For example, the Early Language and Literacy Classroom Observation Literacy Environment Checklist (ELLCO; Smith et al., 2002), a widely utilized observational instrument that measures the physical literacy environment of a classroom, examines classroom materials and their organization within the environment. This measure consists of items used to rate classrooms for the presence or absence of literacy-related spaces and materials. An evaluator's responses to individual items are then summed to form a *books* subscale and a *writing* subscale that can then be totaled into an overall score. Researchers have used the total score (e.g. Dickinson and Caswell, 2007), just one subscale (e.g. Zhang et al., 2014) or both subscales and the total score (e.g. Neuman and Cunningham, 2009) in their studies. Thus, the ELLCO and those using the measure have conceptualized the physical literacy environment as either one- or two-dimensional.

The Classroom Literacy Environmental Profile (CLEP), created by Wolfersberger et al. (2004), is another measurement tool developed to assess the 'print richness' of the physical literacy environment. Like the ELLCO, this measure also comprises two subscales; however, these subscales capture different dimensions of the physical literacy environment than the ELLCO. The first subscale focuses on the provision of literacy-related tools and the second incorporates the classroom arrangement as well as gaining and sustaining children's interest in literacy materials. Thus, the second subscale contains items related to multiple features: the physical literacy environment as well as educators' efforts to engage children with it. Similar to the ELLCO, the CLEP conceptualizes the physical literacy environment as a two-dimensional construct.

The Early Childhood Environment Rating Scale (ECERS; Harms et al., 2014) is another measure that is designed to measure the process quality of the environment but has a curriculum extension that includes items that assess physical literacy environment. The literacy items in

the curriculum extension include similar subscales to the ELLCO (books, writing), and this measure also includes environmental print items (Sylva et al., 2003).

Another more recent measure of the physical literacy environment, the Classroom Literacy Observation Profile (CLOP; McGinty and Sofka, 2009), was developed to broaden aspects encompassed in the physical literacy environment. The CLOP is comprised of a series of items related to specific literacy materials in the classroom and extends the content addressed in previous measures to include additional features of the physical literacy environment. This observation checklist evaluates the availability of literacy materials, including the quantity and variety of books and other literacy-related materials (e.g. literacy props, puzzles), writing materials (e.g. pens, markers, variety of paper), environmental print (e.g. labels, nametags), literacy displays (e.g. print materials, child-dictated writing) and the extent to which children engage with these materials. Each item is rated according to its prevalence in the classroom. Currently, the CLOP does not have identifiable subscales nor does it identify specific dimensions within the classroom physical literacy environment.

The current study

Although the physical literacy environment is acknowledged as important for young children's literacy development and, correspondingly, several measures of the physical literacy environment are available to assess the physical literacy environment in classrooms, there has been limited empirical investigation of this environment. Moreover, it is important to understand the extent to which these individual components of the environment hold together and validate whether they are one, two or more constructs. This is important because much of the research describing the relation or association between dimensions of the physical literacy environment and children's outcomes is specific to one aspect of the environment. In contrast, many of the measures that assess the entire physical literacy environment do not include all of the dimensions identified within the research base (e.g. children's engagement with materials) or do not separate different dimensions of the environment within the measures. Understanding the individual dimensions within the environment and their relations or associations with the overall physical literacy environment may be important for accurately describing classrooms and improving instruction, particularly as these environmental measures are frequently used to evaluate instruction, evaluate the quality of ECE

programs and inform professional development efforts (e.g. Dickinson and Caswell, 2007; Neuman and Cunningham, 2009).

The present study represents an initial exploration of the physical literacy environment of ECE classrooms as afforded by a more-encompassing measure, the CLOP. Given the range of the items assessing the physical literacy environment and the lack of definition of dimensions within the physical literacy environment, the CLOP is ideal for examining the dimensionality of the physical literacy environment. Therefore, the present study includes two research aims:

1. To examine the dimensionality of the physical literacy environment of ECE classrooms, and
2. To conduct a preliminary examination of the reliability and validity of each dimension of the physical literacy environment.

We hypothesized that the physical literacy environment, as measured by the CLOP, would be a multi-dimensional construct. Specifically, we tested the one- and two-dimensional models employed by other researchers, evidenced in measures such as the ELLCO and the CLEP, and then used the extant research to test several multi-dimensional models. Regarding the reliability and validity of the CLOP, we examined the test–retest reliability of CLOP scores from autumn to spring observations. We also used two measures to examine the concurrent validity of the CLOP. A measure of educators' beliefs related to developmentally appropriate language and literacy practice was used as educators' beliefs have been found to be linked with language and literacy instruction (Hamre et al., 2012; McMullen et al., 2006). The second measure was the instructional support domain from the Classroom Assessment Scoring System (Pianta et al., 2008), which assesses the quality of the process environment and thus we hypothesized would be associated with the quality of the structural environment (Mashburn et al., 2008).

Method

Participants

We examined the physical literacy environment in the classrooms of 245 early childhood educators participating in a larger study investigating professional development offered to educators across one Midwestern state. The Midwest (one of four geographic regions) is in the northern central

part of the United States. Eligible educators from the first two cohorts of the larger study constituted the sample for the present one. Educators were asked to voluntarily enroll in the larger study if they met the following criteria: (a) were lead, co-lead or assistant classroom educators, early childhood special educators or home care providers; (b) had a minimum of one child who was at least four years old in their classroom; and (c) agreed to participate in all of the project's data-collection procedures.

These educators were primarily female (98%) with an average of 11.35 years of teaching experience (*SD* = 7.38 years; range = 0 to 36 years). The majority of educators were White/Caucasian (78%), 18% were Black/African American and 1% were Asian (3% unreported). Less than 1% of educators described themselves as Hispanic or Latino. With respect to the highest degree earned, 13% had a high-school diploma, 23% had an Associate's degree, 30% had a Bachelor's degree and 32% had a Master's or advanced degree (2% unreported). Based on educators' reports, classrooms were located in urban (25%), suburban (26%) and rural (32%) locations (17% unreported) and were half-day (52%), full-day (30%) or mixed (11%) programs (7% unreported).

Although the children in these classrooms were not the focus of the present study, some demographic data are reported to provide a snapshot of the general classroom makeup. Data were collected for up to five randomly selected preschool-aged children per classroom (n = 974). Forty-five per cent of children were female. The average age was 56 months (*SD* = 6.99 months; range = 25 to 126 months). Most of the children were White/Caucasian (76%), 21% were Black/African American and 3% identified as 'Other'. Five per cent were described by their caregivers as Hispanic or Latino. For most children, the highest degree earned by children's mothers was a high-school diploma (56%); 8% of mothers did not have a high-school diploma, 12% held an Associate's degree, 12% held a Bachelor's degree and 12% held a Master's or advanced degree.

Data collection and procedures

For the larger project, data about children, educators and classrooms were collected at four time points. For the present study, we included classroom-level measures and educators' responses to questions regarding their beliefs about language and literacy instruction. These data were gathered at the first data-collection point, in the autumn or beginning of the academic year, prior to the professional development; additional CLOP data collected in the spring or end of the academic year, the third data collection point, were used for reliability analyses.

CLOP. Classroom observations were used to collect a variety of data, including measurement of the physical literacy environment via the CLOP. The CLOP is a 21-item observation checklist evaluating key dimensions of the physical literacy environment as described in the literature review. This includes the availability of literacy materials, the availability of writing materials, the features of environmental print, the availability of technology resources and the extent to which children engage with these materials. All items were categorical and received a score according to frequency, with a total possible score of 65 on the measure. Of the 21 items, 5 were scored dichotomously and 15 were scored using a scale. An example of a dichotomous item was the question, 'Are there writing portfolios in the classroom?' This was scored as either a 0 for no portfolios or a 1 for the presence of portfolios. The scaled items accounted for the range in the number of materials. For example, the question, 'How many books are in the classroom library?' was scored from 0 to 4 with a score of 0 indicating fewer than five books present in the classroom library and a score of 4 indicating the presence of at least 26 books. Trained assessors completed the CLOP during a classroom visit. Prior to data collection, an experienced observer trained all assessors. In order to be able to score the CLOP while observing the classroom, the assessors had to demonstrate at least 90 per cent agreement with the experienced observer on three separate CLOP in-classroom observations. Thus far, no reliability or validity data exist for this measure.

Educators' beliefs about literacy. The Preschool Teacher Literacy Beliefs Questionnaire (TBQ; Hindman and Wasik, 2008; Seefeldt, 2004) was used to examine the concurrent validity of the CLOP. The TBQ questionnaire measures educators' reported beliefs about early literacy development and instruction using 30 items on a 4-point Likert scale with higher scores indicating more developmentally appropriate beliefs. Although we used a total score, these items address four subscales regarding beliefs about code-related skills, oral language/vocabulary, book reading and writing. Participants completed this measure along with a battery of assessments in the autumn at the beginning of the study. Overall, internal consistency for this measure was high ($\alpha = .96$). We anticipated that this measure would provide evidence of concurrent validity as it measures educators' beliefs about practice in dimensions aligning with components of the environment measured on the CLOP. Thus, we expected that more developmentally appropriate beliefs would be positively related to the increased incorporation of CLOP components in the classroom (Hamre et al., 2012; McMullen et al., 2006).

CLASS instructional support. The Classroom Assessment Scoring System (CLASS; Pianta et al., 2008), specifically the instructional support domain, was also used to assess the concurrent validity of the CLOP. The CLASS instructional support domain measures the degree of high-quality educator–child interactions, including educators' concept development, feedback and language modelling, and this measure is a way of assessing the process domain of the literacy environment (Mashburn et al., 2008; Neuman and Roskos, 1993). The CLASS is measured on a 1 to 7 scale, with higher scores indicating higher quality. As the CLASS instructional support domain measures the process quality and the CLOP measures the structural quality of the environment, we anticipated that this CLASS domain could be used to assess the concurrent validity of the CLOP. Trained observers coded videotaped observations of classroom instruction for educators' use of instructional support-related strategies. Twenty per cent of all cycles were double-coded for within-one-point agreement, which was .8 across both cohorts.

Results

Preliminary analyses

Although there were no missing data for our variable of interest, autumn CLOP scores, there were missing data for spring CLOP (13% missing), TBQ (2.86%) and CLASS instructional support (1.63%). Results from the Little's MCAR test provided evidence the data were missing completely at random (χ^2 = 40.00, df = 29, p = .085). Given the low percentages of missingness and that the data were missing completely at random, a single imputation was used to impute missing data for these variables (Tabachnick and Fidell, 2013).

To ensure that the data were appropriate for the subsequent analyses, frequencies for the item-level data were calculated and examined for variability and multicollinearity. Items assessing the quantity of narrative books and the quantity of electronic books were removed due to lack of variability in responses: 95 per cent of classrooms included 4+ narrative books and 0–1 electronic books. Inter-item correlations were also examined. Although items were often correlated, most correlations were small to moderate, with a few exceptions. The item assessing the presence of a writing center was removed because it was accounted for in questions that addressed the quantity of writing tools and writing media within the writing center (i.e. if there was no writing center, the

responses for the questions on tools and media in the writing center had to be 0). The quantity of writing tools and media were also strongly correlated with the presence of the writing center (r = .69, p<.001 r = .70, p<.001, respectively).

The dimensionality of the physical literacy environment

The primary research aim involved investigating the dimensionality of the physical literacy environment. To examine dimensionality, we used a combination of confirmatory factor analysis CFA and exploratory factor analysis (EFA) models in Mplus (Muthén and Muthén, 2006). Mplus was selected because of its ability to model categorical outcome variables via robust weighted least squares (WLSMV) estimation.

First, to empirically examine whether the physical literacy environment constituted a single construct, a one-factor model (including all CLOP items remaining after preliminary analyses) of the physical literacy environment was tested. Model fit was examined using the Comparative Fit Index (CFI), the Tucker–Lewis Index (TLI), the Root Mean Square Error of Approximation (RMSEA) and the Weighted Root Mean Square Residual (WRMR). Based on the results, this model was not a good fit for the data (see **Table 2** for model comparisons), thus suggesting that the physical literacy environment may not be best conceptualized as a single construct.

Second, we examined a three-factor model. This was based on the two factors suggested by the ELLCO, literacy materials and writing, and a third factor, the use of materials. The latter is not included in the ELLCO; thus, we hypothesized it might constitute a separate dimension. Items relating to literacy materials and writing were grouped in a similar way to the grouping used in the ELLCO, with the items capturing

Table 2. Model comparisons for the dimensionality of the physical literacy environment.

Model	*CFI*	*TLI*	*RMSEA*	*WRMR*
1-factor	0.62	0.58	0.10	1.75
3-factor	0.71	0.68	0.08	1.57
4-factor	0.76	0.73	0.08	1.44
5-factor	0.97	0.95	0.06	1.04

The CFI and TLI statistics should be greater than .90; and for categorical data, the RMSEA should be less than .06 and the WRMR less than .90 (Yu, 2002). The 1- to 4-factor models were theoretically driven and the 5- factor model was based on results from the EFA.

CFI: Comparative Fit Index; TLI: Tucker–Lewis Index; RMSEA: Root Mean Square Error of Approximation; WRMR: Weighted Root Mean Square Residual.

use-of-materials loading as a separate factor. Results indicated that the three-factor model also did not provide a good fit for the data.

Next, a four-factor model was investigated. The factors were created based on the theoretical literature and the ELLCO. The factors included literacy materials, use of materials, writing and environmental print (these items were separated from the writing factor used in previous models). Similar to the three-factor model, results indicated that the four-factor model did not provide a good fit for the data.

Finally, given the range of materials included in the literacy-materials factor (literacy puzzles, audio books, literacy-related computer games), we hypothesized that books and other literacy-related materials might represent different dimensions of the environment. Thus, we examined a five-factor model: books, other literacy-related materials, writing, environmental print and use of materials. However, this model appeared to be misspecified and would not converge.

Given that the theoretically based models were not a good fit when using CFA models, we conducted an EFA to empirically generate the factor structure for this measure. The EFA would not converge when more than five factors were allowed. Model-fit indices for the one- to three-factor models were not within the suggested ranges. Although the four-factor model had reasonable model fit, the five-factor model provided the best fit for the data (see Table 2 for model fit). We selected this as our final model.

Thus, the final model indicated that there were five dimensions to the physical literacy environment. These were variety and use of books, variety and use of writing center materials, variety and use of technology, variety of environmental print and variety and use of other literacy-related materials. The individual components of each dimension are listed in **Figure 1.** Importantly, when we used geomin rotation to examine the major differences between CFA (theoretical) and EFA (empirical) models, the geomin-rotated loadings indicated that the primary difference between the models was that items measuring the use of materials did not constitute a separate factor. Instead, these items were absorbed into factors with related materials (e.g. engagement with books in the classroom library was part of the books factor). Additionally, the technology items (presence of computer and audio center, use of computer/audio center) were a separate factor. Using the empirically-driven EFA model allowed us to observe that use of materials was nested within each dimension and that technology constituted its own dimension.

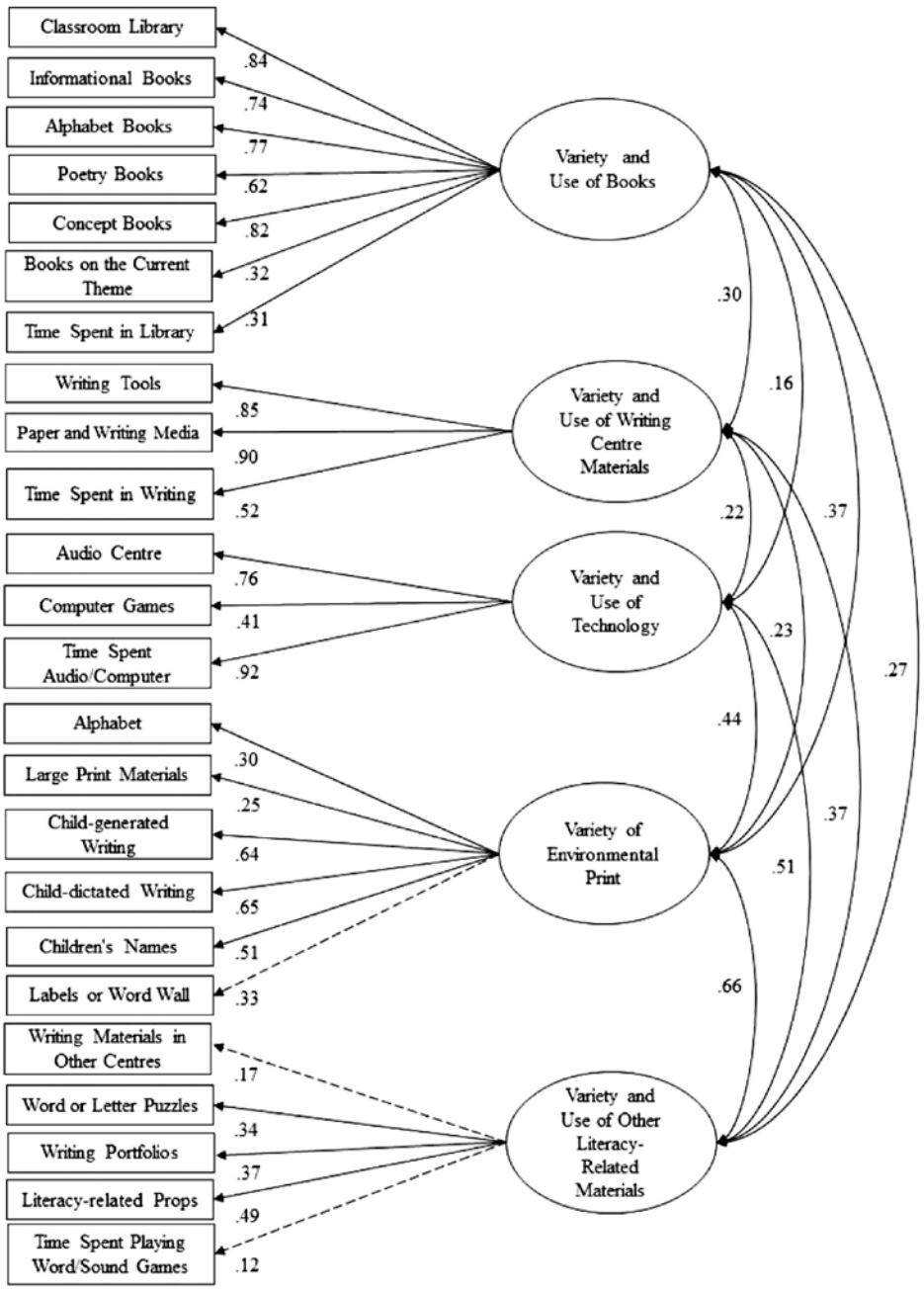

Figure 1. Five-factor model of physical literacy environment. Dotted lines indicate a non-significant factor loading. The ***p***-value for the 'labels or word wall' loading was trending towards significance, ***p*** = .06. Loadings for both the writing materials in other centers and time spent playing word/sound games were non-significant (***p*** = .22 and ***p*** = .22, respectively) but were included in the model for theoretical purposes (Kim and Mueller, 1978).

Reliability and validity. As the physical literacy environment was best considered as multi-dimensional, our secondary aim was to examine the reliability and validity of these dimensions as measured by the CLOP. We used common procedures to establish the reliability and validity of the measures, test– retest correlations and concurrent validity analyses (Kim and Mueller, 1978).

Reliability was examined through test–retest correlations comparing autumn CLOP scores to spring ones. Because different items used different scales on the CLOP measure (e.g. 0, 1, 2, 3+ versus present (1) or absent (0)), factor scores for each dimension were extracted from Mplus as a means of representing the overall scores for each component. Descriptive results are available in **Table 3**. For test–retest reliability, results indicated that the autumn factor scores on the CLOP for all five dimensions were positively and moderately correlated with the spring factor scores (see **Table 4**). This shows that there is some stability in the physical literacy environment across time.

To determine concurrent validity, correlations between the five dimensions of the physical literacy environment and other standardized and validated measures (i.e. educators' beliefs about literacy and CLASS instructional support domain) related to classroom quality were examined. Overall, the results indicated significant correlations between these measures and four of the five physical literacy dimensions, as presented in Table 4. Notably, there were no significant associations between the variety and use of the technology dimension and educators' beliefs about literacy or the CLASS instructional support domain. However, technology is not addressed in either the beliefs measure or the CLASS; therefore, it stands to reason that this dimension would not be correlated with these measures.

Table 3. Descriptive statistics for the five dimensions of the physical literacy environment as measured by the CLOP (n = 245).

Factor	***M***	***SD***	*Min*	*Max*
Variety of books	−.03	.84	−2.51	1.67
Writing center materials	.00	.87	−1.72	2.00
Technology	.04	.75	−1.13	1.91
Environmental print	.02	.75	−1.67	2.50
Literacy materials	.02	.70	−1.59	2.29

Descriptive information reflects the extracted factor scores from the 5-factor CFA. The latent constructs were constrained to have a mean of zero.

Table 4. Correlations between autumn CLOP scores and measures used to for test–retest reliability and concurrent validity.

	2.	*3.*	*4.*	*5.*	*6.*	*7.*	*8.*	*9.*	*10.*	*11.*	*12.*
1. Variety of books – Autumn	.35**	.22**	.48**	.41**	.52**	.16*	.12	.33**	.24**	–.15*	.18**
2. Writing center materials – Autumn	–	.26**	.31**	.51**	.24**	.43**	.09	.26**	.28**	.14*	.14*
3. Technology – Autumn		–	.56**	.68**	.20**	.29**	.43**	.37**	.41**	.12	.11
4. Print environment – Autumn			–	.86**	.23**	.28**	.23**	.49**	.45**	.20**	.19**
5. Literacy materials – Autumn				–	.25**	.33**	.26**	.46**	.47**	.19**	.20**
6. Variety of books – Spring					–	.34**	.16*	.48**	.43**	.06	.12
7. Writing-center materials – Spring						–	.21**	.41**	.61**	.17**	.08
8. Technology – Spring							–	.46**	.58**	.01	–.01
9. Print environment – Spring								–	.88**	.08	.15*
10. Literacy materials – Spring									–	.11	.12
11. Educators' beliefs about literacy										–	.11
12. CLASS instructional support											–

* $p > .05$; ** $p > .01$

Discussion

The purpose of this study was to investigate the dimensionality of the physical literacy environment in ECE classrooms. As a secondary aim, we conducted a preliminary examination of the reliability and validity of these dimensions as measured by the CLOP. Whereas current measures of the physical literacy environment typically conceptualize the physical literacy environment as two constructs (Smith et al., 2002; Wolfersberger et al., 2004), the findings from the present study indicate that there are five dimensions measured by the CLOP. These dimensions not only reflect some previously identified by other researchers (i.e. variety of books and writing-center materials), but also broaden our conceptualization of the physical literacy environment to account for technology, environmental print and literacy materials. Although elements of these dimensions may have been embedded within the subscales of other measures, this study demonstrated that, at least for environmental print and technology as measured by the CLOP, these are separate dimensions of the physical literacy environment. These dimensions, as well as the implications for using the CLOP to measure the physical literacy environment and address practice, are discussed in turn.

Implications of the multi-dimensionality of the physical literacy environment

Our findings about the multi-dimensionality of the physical literacy environment have important implications for how the field of ECE conceptualizes and measures classrooms both in research and in designing environments for children. This study indicates that the physical literacy environment is not a singular or even a two-dimensional construct; rather, the physical literacy environment is multi-dimensional. When evaluating or examining the physical literacy environment, researchers should account for the multiplicity of dimensions within the environment. Specifically, this may mean measuring aspects of the environment beyond the presence of books and writing-center materials. For educators and those seeking to improve practice, considering the environment as multi-dimensional can help ensure that educators attend to multiple important components of the environment.

This may also be important for understanding relations or associations between the physical literacy environment and children's development. Although researchers have examined connections between individual features of the environment and children's outcomes (e.g. Clark and Kragler, 2005; Guo et al., 2012; Neuman and Celano, 2001; Vukelich, 1994; Zhang et al., 2014), few have examined how the multi-dimensional environment is related to children's learning. It may be that the overall, multi-dimensional environment is predictive in different ways than other two-dimensional models. It may also be that some aspects of the physical literacy environment have stronger associations with children's outcomes than others. We may need to be more specific in our investigations of the physical literacy environment and in examining which dimensions of the physical literacy environment are associated with which specific child outcomes.

Dimensions of the physical literacy environment

Variety and use of books and variety and use of writing-center materials. We were not surprised to find that both the variety and use of books and the variety and use of writing center materials are separate dimensions and that each factor had reasonable reliability and validity, given the way that the physical literacy environment has been frequently conceptualized and studied in the ECE literature (Neuman et al., 2008; Smith et al., 2002). Additionally, much of the research on the physical literacy environment has focused on the classroom library and writing center

(Clark and Kragler, 2005; Morrow, 1990; Neuman and Celano, 2001; Neuman and Roskos, 1997; Zhang et al., 2014). For example, the ELLCO, the ECERS and the CLEP all account for the presence of dedicated writing and book areas as well as the corresponding materials in their measurement of the physical literacy environment. Moreover, many professional development efforts already focus on enhancing the presence and arrangement of these items in classrooms in efforts to improve outcomes for children (e.g. Clark and Kragler, 2005; Neuman and Roskos, 1992), and classrooms are often well resourced with these materials (e.g. Gerde et al., 2015). Thus, it seems that these aspects should continue to be considered in evaluations of and efforts to improve the physical literacy environment. However, results of the current study indicate that these are not the only dimensions that should be considered.

Variety of environmental print. Notably, the variety of environmental print also had good factor loadings as well as reasonable reliability and validity as its own dimension of the physical literacy environment. Although other measures, such as the ELLCO and ECERS, include these items in the writing factor, our findings suggest that environmental print is a separate dimension of the physical literacy environment. This is not surprising in light of research on the importance of environmental print in the classroom (Dowhower and Beagle, 1998; Loughlin and Martin, 1987; Vukelich, 1994). This finding, however does have implications for the way that researchers conceptualize the physical literacy environment and suggests that environmental print may need to be considered separately both when evaluating environments and when seeking to improve physical literacy environments. This focus could help researchers better understand the associations between environmental print and children's outcomes as well as help to guide efforts to improve this aspect of the physical literacy environment.

Integrating and using print in the environment may be particularly difficult for educators to enact as this involves more than the purchase of materials and their placement. Educators may need assistance in making strategic efforts to incorporate children's print, which has been found to be related to children's learning (Dowhower and Beagle, 1998; Graves et al., 1996; Loughlin and Martin, 1987), and educators may need assistance in helping children engage with environmental print. Moreover, emerging evidence suggests that there can be too much print in the environment, which perhaps leads to off-task behavior (Fisher et al., 2014), and educators may need assistance in finding the right balance of environmental print.

Variety and use of technology. In this study, the variety and use of technology also emerged as its own dimension of the physical literacy environment. This is important as, up to this point, technology has not been considered an individual dimension of the physical literacy environment, in part, because these types of items have only recently been included in measures of the physical literacy environment. The rise of tablets, electronic books, smart boards, access to the Internet and various other technology in classrooms represents a new dimension of the physical classroom. As technology and access to technology increase, this study highlights the importance of conceptualizing technology as a separate dimension of the literacy environment. Importantly, there is emerging research that technology can be used to enhance children's outcomes (Brown and Harmon, 2013; Kelley et al., 2015). Yet, given that the use of technology is relatively new for most preschool classrooms, much remains to be learned about how having these tools within the physical literacy environment supports children's language and literacy learning. Additionally, more information is needed about how ECE educators plan for or use emerging technology in their classrooms, particularly given the role that children's engagement with materials serves within this dimension. Thus, more information is needed about how to integrate technology into the physical literacy environment and instruction to improve outcomes for children. This may be particularly challenging for researchers as technology is continually evolving and expanding. Finally, given evidence that technology may be limited in preschool classrooms (Plowman et al., 2010), researchers and those designing professional learning experiences will need to consider how to support teachers in integrating more technology into the classroom.

This rapidly increasing availability and diversity of technology may contribute to the non-significant concurrent validity of the variety and use of the technology dimension and indicates a need for further consideration as the field attempts to measure the physical literacy environment. It is difficult to keep measurement tools up-to-date with the rapid increase of these materials in the environment. In fact, the CLOP, which was designed to include more technology-related items, only accounted for the presence of computers, audio centers and games. It is possible that the CLOP did not fully capture the presence of newer technology (e.g. smart boards and tablets), and this might be related to the low validity findings. In addition, given the absence of references to technology in the validity measures, we should not expect to see a strong relationship between this dimension and those measures. As technology becomes more

available, both the expanding list of technology as well as how technology is related to practice will need further examination.

Variety and use of other literacy-related materials. Our findings suggest that literacy materials beyond books and writing materials may constitute their own dimensions of the physical literacy environment. The role of other literacy materials in the physical environment is important for educators and researchers to consider as they relate to children's outcomes. For example, literacy and literacy-related materials (e.g. word/letter puzzles) have been found to facilitate more engagement and interaction than other toys (Neuman & Celano, 2001). Similarly, in a study of preschool classrooms, Neuman and Roskos (1997) reported that the inclusion of these types of literacy items produced increased literacy-related play and activities. Thus, more focus on these materials within measures of the environment, by both researchers and educators, may contribute to understanding more about children's learning and improved child outcomes.

Importantly, however, of the five dimensions identified in this study, the variety and use of other literacy-related materials factor had low factor loadings and two items for which loadings were not significant. One explanation for this finding could be that the CLOP may not have accounted for the variety of literacy materials that could be present in an ECE classroom. Therefore, there was no robust representation of literacy materials as needed to validate this factor. Future research should broaden the category of literacy materials and examine other features of the physical literacy environment that may be included as other literacy-related materials. Further, little is known about how children engage with available literacy materials; this topic should be investigated in future studies.

Children's use of materials

We were surprised that items referring to children's use of materials were not a separate overall factor. Although we anticipated that use of materials would be its own dimension, children's use of various environmental materials was nested within that specific dimension (e.g. the item 'how many children spent three minutes or more in the classroom library' was an aspect of the variety of books factor). Materials use is an element of the physical literacy environment and it is directly connected to items' availability. This supports Baroody and Diamond's (2014) finding that

children's literacy interest and engagement in literacy activities is positively associated with literacy-related materials within the classroom environment. For those interested in improving the physical literacy environment and practice, it is important to note that presence and use are not the same. For example, Gerde et al. (2015) found that classrooms tend to be well supplied with writing materials; yet, there is a vast range in the use of these materials by educators and children. Thus, it may be that materials first need to be present, so that children have opportunities to use them; however, it is still necessary to examine the use of those materials within the environmental dimensions identified by this study. Researchers may need to consider this when describing or evaluating the physical literacy environment, specifically in relation to young children's outcomes.

Given the inclusion of the use of materials within the factor containing those materials, another rich area for future research may be how educators facilitate engagement with materials in the classroom. Whereas the structural aspect of the physical literacy environment is important, it could be that it needs to be considered in relation to the process domain of the literacy environment. Studies of literacy-rich play have shown that adult involvement can increase children's use of literacy materials (Neuman and Roskos, 1992). For example, McGill-Franzen et al. (2004) investigated the effects of adding libraries to classrooms and providing professional development on how to increase child engagement in literacy. They found that children performed better on measures of concepts of print, reading and writing vocabulary, and phonemic awareness. Similarly, Neuman (1999) examined the impact of introducing books into classrooms and found that when educators were trained in how to use books, children made significantly higher gains on several academic measures. Therefore, although the physical literacy environment is important, educator– child interactions can further increase the effectiveness of a high-quality classroom physical literacy environment. Future studies should examine the potentially positive effects of increased children's use of literacy materials with adult facilitation of literacy learning. Educators may need assistance in learning how to scaffold children's engagement with materials. This may be particularly important for the new dimension of technology, which may be less familiar to early childhood educators. Thus, this concept may need to be integrated into professional development efforts aimed at improving the physical literacy environment and classroom practice.

Limitations and future directions

One limitation of this study is that we demonstrate only moderate test–retest reliability on the autumn and spring CLOP scores. A possible explanation for this may be that educators made changes to their classroom over the course of the school year in ways that influenced the presence/absence of materials. More research that examines changes to the physical literacy environment over the course of the preschool year may be necessary. Also there was low concurrent validity between the CLOP and measures of educator beliefs and the CLASS instructional support domain. This may be a limitation of the selection of measures used to assess concurrent validity. Future studies that focus on validating this measure with other measures of the structural environment are warranted. However, given that the main purpose of this study was to understand the dimensionality of the physical literacy environment, the data were well suited to examine this question. Finally, as noted above, future research may also need to focus on expanding the items included in the dimensions of variety and use of technology and variety and use of other-literacy materials, in particular, other literacy-related materials that had low factor loadings.

Conclusion

This study demonstrates that the physical literacy environment is actually a multiple dimensional construct, shifting from traditional conceptualizations as a singular or dual construct. In addition to the books and writing center materials typically considered by researchers, environmental print, technology and perhaps other literacy-related materials are also their own dimensions. Our findings demonstrate that each of the dimensions is important to the environment independently and this suggests that they should be examined independently from each other. Importantly, embedded within these dimensions is children's use of materials. Thus, not only are the materials themselves important but also their use. Measures, such as the CLOP, which account for this multi-dimensionality of the physical literacy environment, may provide more accurate information to those interested in investigating and improving ECE classroom environments.

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