

RESEARCH ARTICLE

Examining CLASS dimensions as predictors of pre-k children's development of language, literacy, and mathematics

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The Improving Head Start for School Readiness Act of 2007 requires Head Start programs to monitor quality and demonstrate improvement. Many of these programs are using the Classroom Assessment Scoring System (CLASS; Pianta, La Paro, & Hamre, 2008) to do so. However, given the multidimensional nature of the instrument, policy makers and school personnel may find it difficult to identify starting points for professional development or training. In this study, we disaggregated the three CLASS domains (emotional support, classroom organization, and instructional support) to determine which specific dimensions within each domain are most strongly predictive of children's academic learning. To do this we examined a large sample of state-funded pre-k programs. Results based on hierarchical linear modeling revealed that three dimensions, Positive Climate, Productivity, and Concept Development, accounted for the majority of the significant relationships found among four academic outcomes. These results suggest that policies, professional development, and observations meant to change or monitor student academic achievement should first focus on these three dimensions of quality.

The experience of high quality teacher-child interactions is associated with the development of children's academic and social skills (Peisner-Feinberg et al., 2001; Hamre & Pianta, 2005; Curby, LoCasale-Crouch et al., 2009). Children who attend classrooms with higher quality social interactions in preschool are better equipped to cope with school tasks and are more likely to do well in school than children who attend lower quality classrooms (Peisner-Feinberg et al., 2001). For this reason, the Improving Head Start for School Readiness Act of 2007 requires Head Start programs to monitor social interaction quality, often done using the Classroom Assessment Scoring System (CLASS; Pianta, La Paro, & Hamre, 2008). However, the CLASS is a multidimensional framework with numerous quality indicators comprising ten dimensions of effective classroom interaction that are aggregated into three domains. As such, it may be difficult for school personnel to identify starting points for professional development or training. Furthermore, if programs achieve higher quality aggregated domains without attaining higher levels in the dimensions of quality most strongly related to children's outcomes, then there may be diminished impacts of the policy. The present study can inform more effective classroom interventions and professional development programs by providing a narrower set of target behaviors. In other words, if we want to improve one of the domains such as Emotional Support, where do we start? Should teachers smile more, be more enthusiastic, and provide verbal

affection and proximity to the students (i.e., positive climate) or should they focus more on identifying and responding to individual students' learning needs (i.e., teacher sensitivity)? The present study can help inform these decisions.

Teacher-Child Interactions

Children's experience of quality of the classroom environment is centered on the interactions they have with teachers and peers (Bronfenbrenner & Morris, 2006). High quality teacher-child interactions in classrooms are positively associated with children's academic and social development (Howes et al., 2008; Roeser, Eccles, & Sameroff, 2000). Because children's academic trajectories are established at an early age (Alexander & Entwisle, 1988; Peisner-Feinberg et al., 2001), and children's achievement varies substantially by their school environments (Hill, Bloom, Black, & Lipsey, 2007), it is important to identify the specific dimensions of teacher-child interactions that predict positive gains in children's academic outcomes.

One perspective researchers have taken in examining classroom interactions is the Classroom Assessment Scoring System (CLASS) Framework (Hamre & Pianta, 2007). The CLASS Framework identifies three global domains of classroom interactions (Hamre, Pianta, Mashburn, & Downer, 2007): Emotional Support, Classroom Organization, and Instructional Support. Scores on these domains are actually aggregates of 10 measured dimensions when using the CLASS instrument (Pianta, La Paro, & Hamre, 2008).

Emotional Support

Emotional Support refers to the ability of teachers to create a safe and warm atmosphere, respond to individual needs of children, and provide children with autonomy-supporting situations (Hamre & Pianta, 2007). Higher levels of Emotional Support have not only been associated with children's social outcomes such as having higher social competence and fewer problem behaviors (Mashburn et al., 2008; Wilson, Pianta, & Stuhlman, 2007), but it has also related to academic learning (Early et al. 2007; National Institute of Child Health and Human Development Early Child Care Research Network [NICHD ECCRN], 2003; Pianta, Belsky et al., 2008), and behavioral engagement (Downer, Rimm-Kaufman, & Pianta, 2007). Emotional Support is comprised of four specific dimensions: Positive Climate, Negative Climate, Teacher Sensitivity, and Regard for Student Perspectives.

Positive climate. One aspect of Emotional Support, Positive Climate, includes teacher-child interactions that focus on relationships, positive affect, positive communication, and respect (Pianta, La Paro et al., 2008). In classrooms with high quality Positive Climate, teachers form positive relationships with students. There is also evidence that the teacher has established trusting and supportive relationships with children (Battistich, Schaps, Watson, & Solomon, 1996; Birch & Ladd, 1998), which can be observed, for example, by the teacher putting hand on the back of a child while helping the child at a center. These teacher-child relationships have been linked to children's higher levels of engagement and achievement (Hughes & Kwok, 2007;

Hughes, Luo, Kwok, & Loyd, 2008) and lower levels of internalizing and externalizing behaviors (O'Connor, Dearing, & Collins, 2011).

Negative climate. Negative Climate describes the overall negativity in the classroom and is used as a reversed indicator of Emotional Support (Pianta, LaParo et al., 2008). Negative Climate includes measures of the degree of irritability, negative affect, and anger in the classroom. In general, classrooms that have some Negative Climate show verbal negativity and irritability, which includes the teacher and children raising their voices and using disrespectful language and sarcasm. For example, if a teacher shames a child for not knowing an answer, it is classified as Negative Climate. In relatively rare occurrences, teachers may display severe negativity, which include instances of bullying, physical punishment, and victimization. Negativity may, therefore, inhibit children's attention to academic material and reduce opportunities to learn.

Teacher sensitivity. Teacher sensitivity refers to the degree to which the teacher is aware of the children's academic and emotional needs and is able to respond to meet the children's needs (Wentzel, 2002). Highly sensitive teachers notice if and when a particular child might need extra support or attention. Furthermore, a sensitive teacher does not only notice when some children are struggling, but the teacher also knows how to respond to the children. For example, a teacher may know that a child is shy, so the teacher may give extra cues and encouragement to participate during a storybook reading (Curby, Rudasill, Edwards, & Perez-Edgar, 2011). Moreover, children in classrooms with teachers that provide high quality Teacher Sensitivity may be more comfortable seeking support from the teacher or participating in activities, thereby setting the stage for more academic learning.

Regard for student perspectives. Regard for Student Perspectives describes how well the teacher is able to incorporate the children's interests in class activities and encourage children to take responsibility and to express themselves (Pianta, LaParo et al., 2008). A teacher who shows high quality Regard for Student Perspectives is not over-controlling and allows children to have opportunities for choice and leadership (Hamre & Pianta, 2007). The teacher also encourages children to be autonomous and incorporates their ideas and interests into classroom activities. This autonomy and choice may increase children's engagement in academic material, and thereby provide a better environment for learning.

Classroom Organization

The second global domain of teacher-child interactions is Classroom Organization, which describes the extent to which the teacher is effective in managing the time, activities, and behavior of the classroom (Downer, Sabol, & Hamre, 2010; Emmer & Stough, 2001). High levels of Classroom Organization have been positively associated with children's self-control (Rimm-Kaufman, Curby, Grimm, Nathanson, & Brock, 2009) and academic achievement (Cameron, Connor, & Morrison, 2005; Ponitz, Rimm-Kaufman, Grimm, & Curby, 2009). Classroom Organization is composed of three dimensions: Behavior Management, Productivity, and Instructional Learning Formats.

Behavior management. High quality Behavior Management characterizes classrooms where children are actively involved in activities, where there are clear rules and routines that the children follow, and where there is little misbehavior (Pianta, LaParo et al., 2008). A teacher who provides high quality Behavior Management is proactive in managing children's behaviors (Bohn, Roehrig, & Pressley, 2004) and, if problems do arise, is effective in addressing and solving the problems before they escalate. The teacher minimizes misbehavior by establishing rules in the classroom so that the children know what is expected of them, and by drawing attention to positive behaviors. Conversely, chaos - when there is lack of good behavioral and the classroom could be described as unpredictable - may inhibit children's ability to concentrate on academic tasks (Kaplan & Berman, 2010).

Productivity. Productivity describes the degree to which a teacher is successful in managing time such that children always have something to do (Pianta, LaParo et al., 2008). A well-prepared teacher has materials ready and can, therefore, minimize instructional time being lost. For example, a teacher would receive lower productivity scores if she had to go make copies in the middle of an activity. A productive teacher reduces "down-time" by providing another activity for individual children when each child finishes a given activity, such as allowing children to look at books when they are done with an assignment. In addition, the teacher is effective in managing transitions from one activity or classroom to the next and, if appropriate, the teacher incorporates learning into transitions so that instruction time is maximized (Arlin, 1979). By always having an activity available to students, teachers are providing students more opportunities to learn, a key determinate of learning (Brophy & Good, 1986).

Instructional learning formats. Instructional Learning Formats describes the degree to which the teacher is able to capture children's interests, support their learning, and engage the children in classroom activities (Pianta, LaParo et al., 2008). A teacher who provides high quality Instructional Learning Formats uses a variety of modalities and materials, such as audio, visual, and movement modalities, to make the lesson interesting for the children. The teacher also effectively redirects children's focus on the lesson. In addition, children are actively involved in classroom activities and are engaged, for example, by having a conversation with the teacher. Engagement is critical element of learning and therefore it is likely that classrooms with higher levels of Instructional Learning Formats have children that are learning more (Fredricks, Bulumenfeld, & Paris, 2004).

Instructional Support

Instructional Support describes how well the teacher is able to promote children's learning and understanding of concepts and provide children with process-oriented feedback. Instructional Support has been found to predict positive outcomes in children's academic skills (Howes et al., 2008; Mashburn et al., 2008). Instructional Support domain is composed of three dimensions: Concept Development, Quality of Feedback, and Language Modeling.

Concept development. Concept Development describes the teacher's use of discussion and activities to support children's higher-order thinking skills and cognitive development (Battistich et al., 1996). The teacher uses *why* and *how* questions to promote children's analysis and reasoning skills. The children are also encouraged to be creative and to

come up with their own explanations and ideas. A teacher who provides high quality in Concept Development, helps the children understand new concepts by making connections to familiar concepts and to examples that are related to the children's own lives. There is some indication that Concept Development is the most salient aspect of Instructional Support. Curby, LoCasale-Crouch et al. (2009) used profiles of classrooms based on the CLASS measure to predict children's outcomes. The profile with highest levels of Concept Development, but not highest on anything else, had children with best academic outcomes.

Quality of feedback. Quality of Feedback describes the degree to which the teacher provides information to the children and encourages children to be involved in the lesson through scaffolding, feedback-loops, and encouragement (Brophy & Evertson, 1976). The teacher helps children understand concepts by providing hints and assistance. The teacher engages children in back-and-forth questioning and asks follow-up questions to encourage children to be involved. For example, a teacher gives feedback to a child about his performance by providing recognition when he shows effort. This focus on providing feedback that promotes student persistence may help children maintain a connection between effort and achievement.

Language modeling. Language modeling describes the degree to which teachers stimulate language learning through their interactions with children (Pianta, La Paro, et al., 2008). There are a variety of techniques that can promote language development such as asking open-ended questions, repeating what children say, and then extending it with additional language. Perhaps the most salient aspect is simply how much conversation there is both between teachers and children and among children.

Broad vs. Targeted Professional Development

Once behaviors have been identified for change, then interventions, in the form of professional development, can be developed that help promote change in those behaviors. Interventions can be generally thought of as existing on a spectrum from broad to targeted. Broad interventions focus on a wide constellation of behaviors. Their effects can be more diffuse, but they also are adaptable for a wide range of behaviors. For example, if a program adopts the use Cognitive Coaching (Costa & Garmston, 2002), the focus is on implementing a reflective process in which teachers are encouraged to think about their beliefs that undergird their behavior by working with a supervisor or peer coach. Because the focus is on building trust, facilitating, thinking, and developing autonomy (Center for Cognitive Coaching, n.d.), there is a large range of outcomes that may be of interest such as teacher-administrator working relationships, school climate, or even in-classroom behaviors.

Targeted interventions focus on discrete behaviors. In so doing, the intervention can be potent, but will only be applicable to those displaying those specific behaviors. For example, schools that adopted the My Teaching Partner professional development program (Pianta, Mashburn, Downer, Hamre, & Justice, 2008) have teachers send videos of their teaching to consultants who code the videos using the CLASS measure (Pianta, La Paro et al., 2008). Then specific dimensions are identified for development, and there is an online dialogue about ways to enhance performance in that dimension (Downer, Kraft-Sayre, & Pianta, 2009). One strength of

the My Teaching Partner program is that it targets specific behaviors while also adapting to the teacher making it applicable for a variety of teachers.

The Present Study

The purpose of the present study is to identify the dimensions that are most strongly related to children's language, literacy, and mathematics achievement gains. To accomplish this, we will examine a large sample of state-funded pre-k programs. We will then use nine dimensions of classroom quality as separate predictors of children's academic outcomes. In so doing, we will be able to identify the dimensions that are most consistently and strongly related to children's academic outcomes. By identifying dimensions that are most strongly related to academic outcomes, targeted professional development programs could be designed that specifically focus on improving the identified dimensions or pre-existing professional development could be prioritized.

METHOD

Participants

Data from the National Center for Early Development and Learning (NCEDL) were used for this study. The NCEDL conducted two longitudinal studies: The Multi-State Study of Pre-Kindergarten (Multi-State Study) and the State-Wide Early Education Programs Study (SWEEP Study) in pre-k classrooms in 11 states. The goal of these studies was to gather information on pre-k children and classrooms to understand variations between programs and how those relate to children's academic and social outcomes (Early et al., 2005). The children that participated in these studies represented nearly 80% of children in the US that attended state-funded pre-k programs at the time of the studies. Approximately 15% were part of a Head Start program (Early et al., 2005). The states chosen for these studies were picked specifically because the pre-k programs in the states had been running for many years, which indicated that they were stable and mature, and because the programs provided services to a large number of 4-year-old children. Data collections for the Multi-State Study took place during the school year of 2001-2002, which involved a stratified random sampling of 40 pre-k centers in each of six states. Data collections for the SWEEP Study took place during the school year of 2003-2004 and involved a stratified random sample of 100 state-funded programs in each of five states. One classroom was randomly selected from each eligible pre-k center. Teachers from each selected classroom sent packets home with the children that included (a) a consent form, (b) a family contact sheet, and (c) a demographic questionnaire. Data collectors determined which children were eligible to participate based on four criteria; eligible children (1) had a consent form from parents, (2) met the age criteria for kindergarten eligibility for the following year, (3) did not have an individualized education plan, and (4) spoke enough English or Spanish to understand simple instructions. From the eligible children, groups of four children, preferably two boys and two girls from each classroom were randomly selected to participate.

A total of 2938 children participated in either wave of data collection. Consistent with other published studies using these datasets (e.g., Mashburn et al., 2008), the present study

excluded 499 children and 39 classrooms from analyses because they either did not participate in the Spring assessment or were assessed in Spanish. Thus, participants included 2,439 children (1,194 boys and 1,245 girls) from 671 pre-k classrooms.

Measures

Quality of teacher-child interactions. The quality of teacher-child interactions was measured with the Classroom Assessment Scoring System (CLASS; LaParo, Pianta, Hamre, & Stuhlman, 2002; Pianta, LaParo et al., 2008). Trained observers assessed quality along nine dimensions using a seven point Likert scale where 1-2 indicates *low*, 3-5 indicates *mid-range*, and 6-7 indicates *high*. Assessments of quality were done during 30-minute cycles during a day consisting of 20 minutes of observation and 10 minutes of rating. The observations lasted from the time the children arrived at the center until they started naptime or, for those who attended half-day programs, until they went home. For each cycle, nine dimensions were coded: Positive Climate, Negative Climate, Teacher Sensitivity, Overcontrol, Behavior Management, Productivity, Instructional Learning Formats, Concept Development, and Quality of Feedback. Multiple cycles of observation (usually four) were averaged to form the dimension averages.

The present study used the 2002 version of the CLASS. The 2002 version of the CLASS (LaParo et al., 2002) differed from the published version of the CLASS (Pianta, LaParo et al., 2008) in two important ways. First, Overcontrol was included as a dimension of Emotional Support. Through an iterative process, Overcontrol (reversed) has since morphed into Regard for Student Perspectives (not reversed). Second, Language Modeling was not included in the measure as an indicator of Instructional Support.

Prior to data collection, raters attended a two-day workshop by the authors of the instrument. During the training, video segments of actual classrooms were used. Ultimately raters made individual ratings on five twenty-minute video segments. To be deemed reliable, raters had to be within 1 scale point of the master coded score on 80% of the dimensions across the video segments. All raters met or exceeded this criterion of reliability. During the spring, raters' reliability was again tested by dual coding in a classroom with a master coder. Raters' mean kappa was .73, with 93% of ratings within one scale point of the master coder.

Academic skills assessments. Children's academic skills were assessed at the beginning of the fall and at the end of the spring while they attended pre-k. The assessments included measures of children's receptive vocabulary, expressive language, rhyming, and applied problem solving.

Receptive vocabulary. The Peabody Picture Vocabulary Test- third edition (PPVT; Dunn & Dunn, 1997) was used to evaluate children's receptive vocabulary skills. In this test, a child is shown a set of four pictures and is asked to choose the picture that best represents the meaning of the word that the examiner reads out loud to the child. Both time points of measurement showed high internal consistency (Fall $\alpha = .95$; Spring $\alpha = .95$)

Expressive language. The Oral & Written Language Scale (OWLS; Carrow-Woolfolk, 1995) was used to assess children's use and understanding of spoken language. During this assessment the examiner reads a verbal stimulus while the child is looking at a card

with one or more pictures. Then the child is asked to respond by giving an oral answer, by completing a sentence, or by generating a new sentence. Both time points of measurement showed high internal consistency (Fall $\alpha = .90$; Spring $\alpha = .90$).

Rhyming. The Woodcock-Johnson III Tests of Achievement, Rhyming Subtest (Woodcock, McGrew, & Mather, 2001) was used to assess children's ability to rhyme. During the Rhyming subtest, children are told a word and are then asked to name a word that rhymes with the given word. The Rhyming scale has a range of 0-17, and is not standardized. Both time points of measurement showed high internal consistency (Fall $\alpha = .88$; Spring $\alpha = .89$).

Applied Problems. The Woodcock-Johnson III Tests of Achievement, Applied Problems Subtest (Woodcock et al., 2001) was used to assess children's emerging mathematical abilities. In the subtest, children are provided with a number of orally administered mathematics problems on quantity, simple addition and subtraction, questions about time and money. Both time points of measurement showed high internal consistency (Fall $\alpha = .81$; Spring $\alpha = .82$).

Data Analysis

To support disaggregating CLASS domains into their representative dimensions, correlations were computed among all dimensions. To determine which dimensions of classroom quality were most strongly related to academic outcomes, Hierarchical Linear Modeling (HLM) was employed (Raudenbush, & Bryk, 2002). HLM accounts for the fact that children were nested within classrooms—thus making their data inter-dependent and violating an assumption of most statistical tests. In HLM, unconditional models were first created that only accounted for the nesting of the data and provided an estimate of how much of the variance in the outcomes was due to nesting. The second step was to add in main effects for our Level-1 (child-level) model including: child's gender, ethnicity, whether or not the child's family is poor, the number of years of education the child's mother had, and the child's fall score on the same academic assessment. Then, we separately tested each of the nine classroom quality dimensions as predictors on Level 2 (classroom level) while controlling for the Level-1 effects.

RESULTS

Correlations between all nine CLASS domains are presented in Table 1. Among the four Emotional Support variables, absolute value of correlations ranged from .39 to .77. Among the three Classroom Organization variables, correlations ranged from .51 to .70. The two Instructional Support variables were correlated at .63. All variables within a domain were highly correlated, but in each instance, there was also a substantial amount of variance that was not shared. Even the highest correlation between Positive Climate and Teacher Sensitivity ($r = .77$) still suggests that over 40% of the variance was not shared. In fact, this was the only association in which the majority of variance was shared. Thus, these correlations support moving forward in our analyses with the disaggregated dimensions.

TABLE 1
Correlations and Descriptive Statistics for CLASS Dimensions

	1	2	3	4	5	6	7	8	9
Emotional Support Domain									
1. Positive Climate	-								
2. Negative Climate	-.56**	-							
3. Teacher Sensitivity	.77**	-.53**	-						
4. Over Control	-.36**	.50**	-.39**	-					
Classroom Organization Domain									
5. Behavior Management	.67**	-.51**	.63**	-.20**	-				
6. Productivity	.66**	-.45**	.63**	-.27**	.70**	-			
7. Ins. Learning Formats	.41**	-.13**	.46**	-.04	.51**	.62**	-		
Instructional Support Domain									
8. Concept Development	.35**	-.16**	.26**	.13**	.33**	.42**	.43**	-	
9. Quality of Feedback	.49**	-.22**	.41**	-.14**	.46**	.50**	.40**	.63**	-
Mean	5.31	1.51	4.73	1.55	5.00	4.51	3.92	2.09	2.04
SD	0.83	0.60	0.92	0.64	0.94	0.88	1.12	0.89	0.95
Minimum	2.43	1.00	1.91	1.00	2.14	2.00	1.00	1.00	1.00
Maximum	7.00	4.29	7.00	4.52	7.00	6.86	7.00	5.31	5.83

** $p < .01$

As indicated in the top portion of Table 2, unconditional models indicated that between 22-34% of the variance in the outcomes (based on the Intraclass Correlation Coefficients) was attributable to the classroom. This supported our use of HLM as an analytic tool because HLM was able to account for that shared variance at the classroom level.

TABLE 2
Results of HLM Analyses with CLASS Dimensions Predicting Child Academic Outcomes

	PPVT	OWLS	WJ RHYMING	WJ APPLIED PROBLEMS
Classroom Variance	68.94	40.43	3.54	36.50
Child Variance	135.43	127.96	12.71	130.20
Total Variance	204.37	168.39	16.25	166.70
ICC	0.34	0.24	0.22	0.22
<i>p</i>	<.001	<.001	<.001	<.001
Fixed Effects	<i>Coef.</i>	<i>Coef.</i>	<i>Coef.</i>	<i>Coef.</i>
Intercept	99.33***	95.95***	4.30***	101.14***
Gender (Male = 1)	-0.06	-0.46	-0.13	-0.73*
Ethnicity: Hispanic vs. White	-3.23***	-0.64	-0.55**	-0.17
Ethnicity: Black vs. White	-3.58***	-0.91	-0.48**	-1.95***
Ethnicity: Other vs. White	-1.27*	-0.8	-0.32	0.06
Poor	-1.10*	-1.45***	-0.35*	-0.94*
Maternal Education (years) ^a	0.22*	0.22*	0.14***	0.42***
Fall Score ^{ab}	0.67***	0.71***	0.78***	0.60***
Positive Climate ^a	0.72**	0.45*	0.03***	0.67*
Negative Climate ^a	-0.55	-0.21	-0.14	-0.77*
Teacher Sensitivity ^a	0.36	0.41*	0.01	0.34
Over-Control ^a	-0.01	0.14	-0.06	-0.18
Behavior Management ^a	0.50*	0.16	0.11	0.51*
Productivity ^a	0.64**	0.50*	0.07	0.59*
Instructional Learning Formats ^a	0.19	0.22	-0.02	0.01
Concept Development ^a	0.67**	0.95***	0.09	0.56*
Feedback ^a	0.47*	0.71***	0.15	0.13

^a variable was centered for analysis. * $p < .05$, ** $p < .01$, *** $p < .001$

Note. Level-2 variables were tested separately in different models.

The results for the child-level only HLM models are presented in the top half of Table 2. In terms of gender, there were no statistical differences between boys and girls except that boys tended to score slightly lower than girls on Applied Problems ($b = -0.73$, $p < .05$). In comparison to White children, Hispanic children scored lower on the PPVT ($b = -3.23$, $p < .001$) and Rhyming ($b = -0.55$, $p < .001$); Black children scored lower on PPVT ($b = -3.58$, $p < .001$), Rhyming ($b = 0.48$, $p < .01$), and Applied Problems ($b = -1.95$, $p < .001$); and the Multiracial/Other group of children scored lower on PPVT ($b = -1.27$, $p < .05$). Children from poor families scored worse on outcomes including: PPVT ($b = -1.10$, $p < .05$), OWLS ($b = -1.45$,

$p < .001$), Rhyming ($b = -0.35, p < .05$), and Applied Problems ($b = -0.94, p < .05$). Children who had mothers with more years of education scored higher on all outcomes including: PPVT ($b = 0.22, p < .05$), OWLS ($b = 0.22, p < .05$), Rhyming ($b = 0.14, p < .001$), and Applied Problems ($b = 0.42, p < .001$). Finally, scores on the same assessment given in the fall indicated that children who did better on the fall assessment did better in the spring in terms of PPVT ($b = 0.67, p < .001$), OWLS ($b = 0.71, p < .001$), Rhyming ($b = 0.78, p < .001$), and Applied Problems ($b = 0.60, p < .001$).

To evaluate our research questions, we separately tested each CLASS dimension as a predictor on Level-2. Each dimension was tested separately because of the high correlations (and related multicollinearity) among the variables. Furthermore, our research question is about which is the single best predictor, not which predictor is able to account for variance above and beyond the others. Results indicated that three dimensions accounted for 10 of the 16 significant relationships found among our four outcomes (Table 2). These three dimensions were: Positive Climate, Productivity, and Concept Development. Positive Climate was the only predictor that was significantly associated with all four academic outcomes: PPVT ($b = 0.72, p < .01$), OWLS ($b = 0.45, p < .05$), Rhyming ($b = 0.03, p < .001$), and Applied Problems ($b = 0.67, p < .05$). Productivity was significantly associated with three of the four academic outcomes: PPVT ($b = 0.64, p < .01$), OWLS ($b = 0.50, p < .05$), and Applied Problems ($b = 0.59, p < .05$). Concept Development was also significantly associated with three of the four academic outcomes: PPVT ($b = 0.67, p < .01$), OWLS ($b = 0.95, p < .001$), and Applied Problems ($b = 0.56, p < .05$). In every instance but one, when another predictor was also a significant predictor of the same outcome, at least one of the top predictor(s) (Positive Climate, Productivity, and Concept Development) had a stronger relationship. In other words, not only did they provide the most numerous associations, but they were also the strongest predictors. The only exception to this was that Negative Climate was the strongest predictor of Applied Problems ($b = -.77, p < .05$).

In terms of other associations, Teacher Sensitivity was associated with higher scores on the OWLS ($b = 0.41, p < .05$). Behavior Management was significantly associated with higher scores on the PPVT ($b = 0.50, p < .05$) and Applied Problems ($b = .51, p < .05$). Quality of Feedback was associated with higher scores on PPVT ($b = 0.47, p < .05$) and OWLS ($b = 0.71, p < .001$).

DISCUSSION

Previous work has indicated that domains of quality in classroom social interactions are predictive of children's developmental outcomes (Howes et al., 2008; Mashburn et al., 2008; NICHD ECCRN, 2003). Our results indicate that three dimensions of teacher-child interactions are most strongly driving these associations with academic outcomes: Positive Climate, Productivity, and Concept Development. These findings suggest that these three dimensions are most important for broadly supporting children's language, literacy, and mathematics development. Interestingly, each one of these dimensions is from a different domain. Positive Climate is a dimension of the Emotional Support domain; Productivity is a dimension of the Classroom Organization domain; Concept Development is a dimension of the Instructional Support domain. In other words, the dimensions that most strongly predicted the development of children's academic skills represented characteristics from all of the three global domains of teacher-child interactions.

Positive Climate, the single best predictor, was significantly associated with all four academic outcomes: receptive vocabulary (PPVT), understanding and use of spoken language (OWLS), rhyming (Rhyming), and mathematics skills (Applied Problems). High quality Positive Climate might help children learn because it allows for more effective academic instruction (Curby, Rimm-Kaufman, & Ponitz, 2009); children may want to learn and follow the teacher's lead because of the encouraging and positive atmosphere in the classroom. This positive climate is, in part, evidenced by the supportive relationships between teachers and children (Battistich et al., 1996). A teacher who provides high quality positive climate is able to make the children feel safe and view the teacher as supportive. These children then may be more likely to want to follow the teacher's lead and pursue goals that are important to the teacher, including wanting to learn (Wentzel, 1999). Furthermore, studies show that children have more problems adjusting to school when they experience conflicts with the teacher because the conflict becomes a stressor for the children (e.g., Birch & Ladd, 1997). Thus, teachers who provide high quality positive climate may be able to reduce stressors for children and allow for more time to be spent on instruction.

Productivity was associated with three of the four academic outcomes including children's receptive vocabulary (PPVT), understanding and use of spoken language (OWLS), and mathematics skills (Applied Problems). Teachers who provide high quality productivity maximize learning time for the children through smooth transitions between activities and by establishing clear routines and instruction for children. Children in these classrooms might develop better language and mathematics skills because they are spending more time engaged in these activities. Time on task is an essential ingredient to learning, and more time spent in learning activities gives students more opportunities to learn (Carroll, 1963; Brophy & Good, 1986; Ottmar, Decker, Cameron, Curby, & Rimm-Kaufman, in press). Moreover, in a classroom with high levels of productivity, the environment and the teacher are ready, which makes the lesson more effective.

Concept Development was also associated with three of the four academic outcomes including children's receptive vocabulary (PPVT), understanding and use of spoken language (OWLS), and mathematics skills (Applied Problems). This is consistent with work by Curby, LoCasale-Crouch et al. (2009) using these same data that suggested Concept Development was particularly salient in driving academic gains in pre-k. A teacher who provides high quality in Concept Development promotes children's analysis and reasoning skills, for example, by asking *why* and *how* questions (Hamre & Pianta, 2007). This might help children develop their vocabulary and support their learning of mathematical concept (counting, addition, and patterns). Furthermore, children's mathematics skills might be supported by the teacher actively making connections to children's previous knowledge and by using familiar concepts while teaching new concepts.

Other predictors were also associated with the outcomes, but none more so than Positive Climate, Productivity, and Concept Development. However, in no case was one of these other predictors significant when Positive Climate, Productivity, or Concept Development was not. In other words, the three predictors mentioned are the best *overall* predictors. To the degree that people are interested in particular outcomes (instead of the constellation of outcomes represented here), there may be cause to investigate the utility of the other dimensions.

Limitations and Future Directions

One limitation to our study is that the findings show correlational relations between the dimensions and children's academic outcomes; therefore, we cannot draw causal conclusions from the results. However, intervention studies have begun to show that there are some causal relations between specific teacher behaviors and children's academic outcomes. Hamre and colleagues (2010) found that when intervention teachers provided more consistent and precise exposure to literacy concept and knowledge the children showed more improvement in their print awareness and emergent literacy composite. Our results provide suggestions for which teacher behaviors are most strongly predictive for children's academic achievement gains. Thus, future intervention research could focus resources on manipulating Positive Climate, Productivity, and Concept Development.

Because we are interested in finding the most predictive elements, the present study employed a methodology whereby each dimension was used as a separate predictor. However, the ability of each of the dimensions to predict outcomes could have both shared and unique parts of the variance that are predictive. The present study cannot speak to whether it is strictly the unique portions of the dimensions that are predictive, but given the overall predictability of the domains found in past research, we expect that it is not simply the unique portions. Thus, future research can seek to model and untangle which aspects of the variance are related to different outcomes. Nonetheless, this study suggests that regardless of which portion of the variance is related to the academic outcomes, that positive climate, productivity, and concept development are the dimensions that have the strongest relations to these academic outcomes.

The present study used a version of the CLASS instrument (2002) that is mostly consistent with the current (2008), published version, but it is not the same. As mentioned in the measures section, one important difference is that the published version included the dimension of Language Modeling. It is likely that Language Modeling would be a potent predictor of language outcomes. Future research can investigate this possibility.

Implications

The results have clear implications for policy makers and school personnel including classroom observers. In terms of policy makers, the present study further supports the use of the CLASS instrument as a helpful tool in linking teacher behaviors to student outcomes, as it currently is being used in many Head Start programs. Furthermore, the present study suggests that monitoring of Positive Climate, Productivity, and Concept Development may provide the most efficient way to gauge the amount that children will grow academically.

For school personnel, results suggest targeting Positive Climate, Productivity, and Concept Development for professional development may provide the strongest levers to intervene on pre-k children's academic outcomes. However, we are not saying that these are the only important elements of children's experience in classrooms, rather that for those school personnel that use the CLASS and are focusing on academic outcomes, the sequencing and/or emphasis of professional development program should reflect these findings. For example, interventions, such as My Teaching Partner (Downer, Pianta, Fan, Hamre, Mashburn, & Justice, 2011) may want to first target positive climate, productivity, or concept development before moving on to target other dimensions if the program is being implemented to primarily focus on

academic outcomes. Importantly, behaviors that promote high quality interactions can be learned by teachers (Raver et al., 2008), which highlight the importance of training teachers in the behaviors that produce high quality teacher-child interactions.

The present study also holds important implications for those who conduct classroom observations. Observational research of classrooms takes much time and it can be difficult to become reliable on observational instruments. Thus, researchers and school personnel are often looking for ways to shorten observational instruments. The present study suggests that three of the nine CLASS dimensions may provide the greatest predictive power and, thus, observers could at least initially focus their resources on monitoring Positive Climate, Productivity, and Concept Development if they are primarily focusing on academic outcomes. This same logic can be applied to informal classroom observations conducted by school personnel. Want to know the quality of a teacher's interactions with children? Because a dimension from each domain was indicated in our analyses, the present study suggests that observers should focus on the positive emotional environment they provide, how well learning time is managed in the classroom, and how much they promote children's understanding of concepts.

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