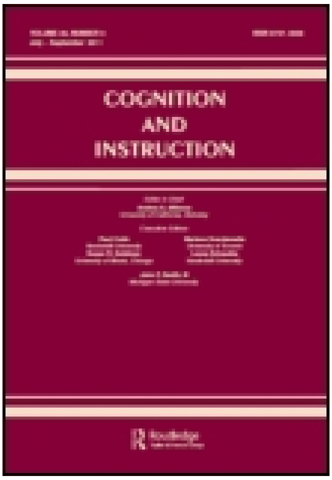

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Science Literacy in School and Home Contexts: Kindergarteners' Science Achievement and Motivation

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Science Literacy in School and Home Contexts: Kindergarteners' Science Achievement and Motivation

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We examined science learning and motivation outcomes as a function of children's participation in the classroom and classroom-plus-home components of the Scientific Literacy Project (SLP). The sample was comprised of kindergarten children in 4 low income, neighboring schools. Children in Schools 1 and 2 ($n = 120$) participated in the SLP science activities. Of these children, 79 participated in the classroom component of the SLP whereas 41 participated in both the classroom and home components. A comparison group of children in schools 3 and 4 ($n = 74$) participated in regular science activities. We identified science learning, achievement, and motivational benefits for the SLP groups. Additional benefits for children who participated in both the classroom and home components of the SLP were greater gains in general science knowledge, higher levels of positive self-competence beliefs for science, perceived family support for learning science, and independence for learning science.

It is well documented that, in the early grades of school, language arts are dominant in the curriculum and this leaves little room for other subjects, including science (Fulp, 2002). Early science instruction is fragmented, "lean" in its demands for conceptual understanding, and seldom aligned with recommended practices (Duschl, 2008; National Institute of Child Health and Human Development, 2005; Sackes, Trundle, Bell, & O'Connell, 2011). This state of affairs seems to be associated with adverse effects on students' science achievement (e.g., Sackes et al., 2011) and motivation, both vital contributors to students' educational success and career-related choices (Bouchey & Winston, 2004; Maltese & Tai, 2010). Reports that elementary grade students find science to be more difficult, less meaningful, and less interesting than other school subjects may reflect the lack of appropriate early science experiences (Andre, Whigham, Hendrickson, & Chambers, 1999).

There is growing emphasis on the need for instructional approaches that integrate science inquiry with literacy activities (Palincsar & Magnusson, 2001; Yore, Bisanz, & Hand, 2003). Some have argued that this integration in the early grades is likely to be an effective and realistic way to provide systematic and high quality science instruction (Marx & Harris, 2006). This has been the goal of the Scientific Literacy Project (SLP), a program of integrated science inquiry

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and literacy activities with a classroom and a classroom-plus-home component, intended for kindergarten children.

Thus far, our research from the first two years of the SLP, involving the development and trialing of the classroom component, has addressed children's science learning, their ideas about what science involves, and their motivation as a function of participation in different phases of the program (Mantzicopoulos, Samarapungavan, & Patrick, 2009; Patrick, Mantzicopoulos, & Samarapungavan, 2009a; Samarapungavan, Mantzicopoulos, & Patrick, 2008; Samarapungavan, Patrick, & Mantzicopoulos, 2011). In this study we focus on the third year of the SLP, when both the classroom and classroom-plus-home components were implemented fully. We extend our prior research by examining learning, motivational, and social support outcomes for kindergarteners who participated in either the classroom only or both classroom and home components of the SLP. We compare the SLP participants to peers who experienced the regular kindergarten science program only, without the addition of the SLP activities.

SCIENCE PROGRAMS FOR YOUNG CHILDREN

A handful of reform-driven science curricula that combine inquiry-oriented and literacy practices have been developed for children in preschool through the early grades of school. These programs include: (a) *Head Start on Science and Communication Program* (Hammrich & Ragins, 2002; Klein, Hammrich, Bloom, & Ragins, 2000); (b) *ScienceStart!* (Conezio & French, 2002; French, 2004; Peterson & French, 2008); (c) *Preschool Pathways to Science* or PrePS© (Gelman & Brenneman, 2004); (d) *Science: Parents, Activities, and Literature* (Science PALs; Shymansky, Yore, & Anderson, 2004; Shymansky, Yore, & Hand, 2000); and (e) *Integrated Science Literacy Enactments* (ISLE; Varelas & Pappas, 2006; Varelas et al., 2008). With the exception of Science PALs, a program designed to bridge school and home structures through science literacy activities, all other curricula are classroom-based.

Research on the programs just mentioned is not conclusive but does show some benefits on broad language tests, science-content knowledge, and science-related discourse (e.g., French, 2004; Klein et al., 2000; Peterson, 2009; Varelas et al., 2008). However, research is needed to examine reform-oriented efforts and their effects beyond broad achievement or language-specific outcomes. At the same time, the dearth of science-related assessments appropriate for young children presents a serious challenge for research that attends not only to children's science content knowledge but also to their understandings of the practice of science. Moreover, considering that knowledge and motivation co-evolve (Patrick & Mantzicopoulos, 2011), it's important to gain access to children's beliefs about their competence in science and their willingness and interest to engage with the discipline. Our work on the SLP attends to this set of issues through efforts to document learning and motivation within a multilevel framework that provides views of the SLP activities and outcomes from different lenses or planes (see also Rogoff, 2003). For example, within the social plane we document the activities, discourse, and artifacts associated with daily lessons, whereas within the individual plane we document children's conceptual and motivational development. We describe our approach to assessment in the next section.

THE SCIENTIFIC LITERACY PROJECT

Through a series of thematic units that address central science concepts and processes the SLP emphasizes: (a) inquiry relevant to kindergarteners, (b) integrated science and language instruction, and (c) coordinated home–school experiences. In the sections that follow, we outline the rationale for these components and the SLP approach to assessment.

Focus on Inquiry-Oriented Science

The SLP was developed in response to calls for science programs that provide young children with opportunities for authentic science inquiry experiences (e.g., Brown, Campione, Metz, & Ash, 1997; Metz, 1995, 1997). Although cognitive developmental research has documented constraints on children's ability to engage in self-directed inquiry, there is also growing evidence that targeted instruction facilitates the development of scientific reasoning (for a review see Zimmerman, 2007). Scientific thinking is supported when classroom norms foster systematic opportunities for children to build their knowledge over time by revisiting key themes and having opportunities to explain, justify, elaborate, rethink, and respond to their own and their peers' ideas (Schauble, 2008). Providing inquiry experiences in the early school years involves crafting programs that foster science learning by engaging children with the processes and epistemic frameworks of science and moving away from instantiations of the discipline as discrete bits of knowledge and decontextualized skills (Brown et al., 1997; Driver, Leach, Millar, & Scott, 1996; Duschl, 2008; Kuhn & Pease, 2008).

Although different positions have been articulated regarding appropriate goals for science learning (for reviews see Duschl, 2008; Lehrer & Schauble, 2006), the SLP's approach is consistent with the view that learning is situated in specific contexts (e.g., home and school; also see Samarapungavan et al., 2008, 2011), where children are encouraged to express their models of the world, generate and share evidence and explanations related to that evidence, and revise their understandings. We thus view learning as grounded in socially negotiated practices that support the construction and evaluation of domain-specific knowledge based on shared epistemic norms, language, and values (Driver et al., 1996; Kelly, Chen, & Crawford, 1998; Knorr-Cetina, 1999; Sandoval, 2005).

Key to the development of the SLP activities—subsequently supported by children's reports (Mantzicopoulos et al., 2009)—was the notion that young children begin school with few, if any, ideas about what science involves. Thus, it was important to identify experiences and tasks that would be meaningful and real for children and that would promote their thinking and talking about the natural world around them. Therefore, for developmental, experiential, and practical reasons, the main focus of the SLP themes involved biological science (e.g., living things, marine life, life cycles). Specifically, developmental research has documented young children's significant interest in nature as reflected in their active and ongoing information seeking: toddlers and young children generate many more questions about the biological world than about any other domain (Chouinard, 2007). Also, children's capacity for learning about biological concepts is manifested early on, so that well before entering kindergarten children possess a wealth of biological knowledge. For example, young children can predict biological phenomena, make causal inferences, categorize natural kinds, and are aware that compared to inanimate objects plants and animals grow, develop and die, can heal spontaneously following injury, and have different internal architectures (Ahn et al., 2001; Gelman & Opfer, 2004; Greif, Nelson, Keil, & Guitierrez, 2006; Inagaki & Hatano, 2006). From an experiential standpoint, children's everyday experiences with plants and animals create a relevant, appropriate, engaging, and accessible context for the study of biology. From a practical standpoint, we believed it was important to capitalize on teachers' stated focus in biology. Doing so afforded us the opportunity to bring together parts of their science activities and provide conceptual coherence in the kindergarten science curriculum around key concepts (also highlighted in the science content standards), thus shifting the focus from the typical instruction on isolated skills and knowledge. Over a 2-year period, in collaboration with the kindergarten teachers, we finalized six units (outlined in the Method section) that addressed sets of carefully selected themes (e.g., biological structure and function, biological adaptation, life cycles) so that student learning would be focused on important knowledge to be revisited across the units rather than on brief exposure to stand-alone topics as was the case previously. Unit activities were structured around the goal of enhancing children's understanding of inquiry through involvement in experiences that would help them (re)construct their models of the world by building their knowledge of the epistemic and social practices of science.

Integration of Inquiry and Literacy Activities

Within each unit, literacy activities were structured to complement and support children's inquiry experiences through the use of inscriptional tools and reading materials. In the SLP, student notebooks and classroom idea boards supported written language and offered opportunities for children to articulate and communicate their ideas. Children were encouraged to use different strategies (e.g., drawing pictures, pasting photographs, dictating text to adults, pasting word labels, using the classroom's word wall, and using invented spelling) to record observations or express their understandings during different phases of the investigations in which they were involved (for examples see Patrick, Mantzicopoulos, & Samarapungavan, 2009b). These types of inscriptional activities provided a flexible, dynamic, and sharable means for children to represent their thinking and participate in the construction of knowledge with their peers and teachers (Anderson, 1999; Barab, Hay, Barnett, & Squire, 2001; Latour, 1990; Lemke, 1990; Roth & McGinn, 1998).

The reading program was informed by research on: (a) effective literacy interventions (Jordan, Snow, & Porche, 2000; Karweit & Wasik, 1996; Morrow & Young, 1997; Whitehurst et al., 1999) and (b) the key role of picture books in young children's learning (Paris & Paris, 2003). Reports that instruction in the early grades is based primarily on fictional narrative, with little attention to expository materials (Duke, 2000), guided our decision to select reading resources that afforded opportunities for learning from high quality informational texts. Using this type of text addresses concerns that reliance on fictional narrative in the early school years supports a narrow set of reading skills and is a barrier to children's interest and learning from the expository science texts that they encounter later in school (Duke, 2000; Hall, Sabey, & McLellan, 2005).

Reading technical text and using discipline-specific language and linguistic devices (e.g., drawings, pictures, tables, charts) to communicate with others are essential to scientists' work (Goldman & Bisanz, 2002; Norris & Phillips, 2003). Science text, therefore, when used within authentic contexts for science inquiry, mediates collective knowledge construction (Baker & Saul, 1994; Ford, 2006; Klein, 2006; Palincsar & Magnusson, 2001), and provides additional avenues for children's entry into the social languages that are used by communities of scientists to construct shared knowledge and meanings (Gee, 2004).

Our goal was for instruction to foster the integration of science and literacy while acknowledging and maintaining the disciplinary integrity of each (Dickinson & Young, 1998; Huntley, 1998; Stoddart, Pinal, Latzke, & Canaday, 2002). Based on research that children's learning and motivation in particular domains are grounded in domain-specific experiences (Aunola, Leskinen, Onatsu-Arvilommi, & Nurmi, 2002; Helmke & van Aken, 1995), we expected that the balance of inquiry and literacy experiences would be associated with children's understanding of the process of science, their content knowledge and perceptions of what they learn in school, as well as their motivation for science (beliefs about their science competence and liking of science).

Supporting Beneficial Discourse Patterns Through Home–School Connections

Early interactions with parents are an important context for children's learning. Parent–child conversations facilitate children's cognitive representations by directing attention to relevant cognitive, social, and emotional features of events, either in the process of being experienced or as parents and children reminisce about them (Beals, 1993; Beals & Snow, 1994; Fivush, Haden, & Reese, 2006; Haden, 2010). Laboratory studies as well as research on parent explanatory talk during informal family activities (e.g., visits to science exhibits) show that children routinely engage in conversations with family members about the natural world (e.g., Ash, 2003; Crowley et al., 2001). Moreover, research on the origins of scientists' interest in science points to both teachers and family members as important contributors (Maltese & Tai, 2010).

However, and probably for reasons that include parents' lack of familiarity with science, there are few systematic efforts that involve home–school collaboration around science. One exception that has been implemented across the elementary school years, including kindergarten, is *Science, Parents, Activities, and Literature* (Science PALs; Shymansky et al., 2000; 2004). Science PALs uses fictional literature to engage parents and children in science-related conversation and activities, but there is limited published research on this program. Although we differ from Science PALs in the choice of texts (i.e., fiction vs. informational books) we share the view that engaging parents and children in shared reading activities may be a non-threatening avenue to promote home–school continuity and parent–child discourse about science.

The SLP home component was coordinated with the science book reading activities of the classroom. Our rationale was based on evidence about: (a) the importance of shared book reading activities for parents and children (Bus, van Ijzendoorn, & Pellegrini, 1995; van Kleek, Stahl, & Bauer, 2003) and (b) successful reading interventions with young children, noted earlier in this article. Our goal was to develop a set of common tools for parents and teachers to use when reading science texts and discussing them with children. Weekly home activities were designed to: (a) actively engage children in science book-reading, (b) encourage parent–child communication about science and school through the use of portable science notebooks, and (c) promote parents' skills to engage in science-related conversations with their children during the course of everyday routines. We expected that the added parent–child SLP activities would benefit children's learning and motivation over and above participation in the SLP classroom component through added opportunities for model reflection and elaboration. In addition, we hypothesized that children who experienced both the SLP classroom and home component would report higher levels of support for learning science compared to their SLP classroom-only and regular classroom peers.

Approach to Assessment

Our approach to assessment is multilevel and premised on theoretical assumptions about what it means to learn science. As we have noted earlier in this and our previous studies (e.g., Samarapungavan et al., 2008, 2011), SLP is consistent with the view that science learning emerges from children's engaged participation in the practice of science through sets of experiences that support the articulation, co-construction, evaluation, and revision of knowledge based on shared classroom norms. As students engage in science learning experiences situated in the particular practices of their classrooms and families they develop knowledge about the disciplinary content and concepts, epistemic norms (e.g., frameworks for evaluating knowledge) and procedures, and the discipline itself.

Motivation, too, co-evolves with and is inseparable from learning within the culture-specific meaning systems that children participate in (Patrick & Mantzicopoulos, 2011; Turner & Patrick, 2008). Thus, along with learning content, children construct motivational beliefs as they encounter, coordinate, reorganize, and appropriate the shared motivational resources of the classroom context. Motivational constructions include children's beliefs about their ability to learn science and interest in doing so and the inherent difficulty involved and personal relevance of learning science. Thus, our earlier work on understanding students' social meanings about science (Mantzicopoulos et al., 2009) forms the background that informs the development of our motivational assessments.

The situated nature of learning and motivation has important implications for assessment. Our approach to assessment is guided by sociocultural frameworks that examine activity across distinct yet interdependent layers or planes and view children's development while considering the contextual affordances that support it. Following Rogoff's (2003) scheme, events can be thought of at different levels of specificity within social and individual planes, and activity in one cannot be sufficiently understood without reference to the other. Thus, although consideration of development within a specific plane necessarily places the central focus on *that* plane, other planes are still active and visible (albeit less clearly) in the background. In instructional contexts, assessments at the social plane permit the documentation of activities, artifacts, and discourse processes that support participation and meaning making. Assessments designed to document growth at the individual plane shift the focus onto the child by documenting his or her appropriation of specific science concepts, knowledge, or motivational beliefs. This approach is consistent with multilevel assessment frameworks (e.g., Hickey, Zuiker, Taasoobshirazi, Schafer, & Michael, 2006; Ruiz-Primo, Shavelson, Hamilton, & Klein, 2002) that define evaluation tools in terms of their distance from the instructional context. For example, immediate- and close-level assessments document activity in the social plane. Immediate-level assessments may include analysis of artifacts such as notebook entries produced by students in the context of an instructional activity, whereas close-level assessments may include documentation of the discourse context and the associated products within it to provide a view of the curriculum as it is instantiated in different contexts. At the individual level, proximal and remote assessments document student learning at various levels of distance from the instructional context. Proximal assessments measure student knowledge across areas addressed by a curriculum, whereas remote assessments are represented by standardized, norm-referenced tests that are not designed with attention to specific curricula or standards (Hickey et al., 2006, p. 184).

In this study we used assessments at the social (classroom and family context) and individual levels. Our social level assessments included documentation of the instructional context of the SLP and comparison (COMP) classrooms (e.g., discourse practices and examples of student work) and the discourse characteristics of parent–child shared book reading. These assessments were based on the assumption that children's understandings of what it means to do science, their knowledge about its content and processes, and their motivation emerge at the collective level first, as socially shared, language-mediated experiences and are dependent on the affordances available in different contexts (classrooms and families).

Assessments at the individual level included both proximal (researcher-developed) and remote (standardized) measures. Consistent with the view that coherent science experiences facilitate the coevolution of competencies across cognitive, social, and motivational domains (e.g., National Research Council, 2007; Newcombe et al., 2009; Sandoval, 1995), we have constructed assessments to document children's growth in these interrelated domains. The measures developed for this project provide information on children's: (a) science learning (e.g., their knowledge about the content and processes of science; Samarapungavan, Mantzicopoulos, Patrick, & French, 2009; Samarapungavan et al., 2011); (b) beliefs about the provision of opportunities for learning science and other subjects (e.g., reading and math) in school (Mantzicopoulos et al., 2009); (c) motivation (e.g., personal beliefs and attitudes about science; Mantzicopoulos, Patrick, & Samarapungavan, 2008; Patrick et al., 2009a); and (d) beliefs that their social environments (home and school) value and support involvement with science. These measures are considered proximal (Hickey et al., 2006; Ruiz-Primo et al., 2002). They were designed to address key science concepts that are highlighted in the standards and covered in the curriculum (Samarapungavan et al., 2009) or key motivational dimensions (self-competence beliefs and liking of science) and beliefs about science learning opportunities and social support that we expect would be associated with science experiences in different contexts (Mantzicopoulos et al., 2008; Patrick et al., 2009a).

In addition to proximal assessments, we used norm-referenced scales of science knowledge and passage comprehension from a standardized measure as a remote assessment tool. Although not aligned to standards and far removed from the instructional context, remote level measures do have implications for administrators and policymakers who are interested in the impact of programs on broad achievement indices (Hickey et al., 2006). Together, our proximal and remote measures were intended to inform our understanding of children's science learning and motivation across the different instructional contexts examined in this investigation. The social-level assessments were integral to providing the backdrop against which the proximal- and remote-level assessments necessarily rested.

EVIDENCE OF THE SLP'S EFFECTIVENESS IN THE DEVELOPMENT AND PILOT YEARS

Research during the SLP's first 2 years documented the nature of teaching and learning within specific units (e.g., Samarapungavan et al., 2008, 2011) and suggested that kindergarteners profit from participation in literacy-rich, inquiry-focused science experiences. Individual interviews with children as well as analyses of episodes of classroom discourse and notebook inscriptions showed that the children frame meaningful questions, make predictions about outcomes, observe and record evidence, communicate findings, and represent and revise their knowledge. Moreover, SLP participation was related to children's perceived competence for and liking of science (Mantzicopoulos et al., 2008; Patrick et al., 2009a). We have found that SLP children were more likely to develop and appropriate social meanings about science that reflected the language, content, and processes learned during experiences with the SLP inquiry and literacy activities (e.g., Mantzicopoulos et al., 2009). In contrast, same-grade peers who did not participate in the SLP tended to hold stereotypical views of science as involving magic (e.g., changing rabbits into people) or dangerous activities (e.g., mixing chemicals that blow up)—markedly different meanings from those constructed by children in the SLP.

Recent research suggests that without high quality science instruction, young children from economically disadvantaged backgrounds do not make gains in science knowledge over the course of the school year (Greenfield et al., 2009). Though not a major focus of the SLP, we examined this issue in the current study. We expected that because of the strong emphasis on early literacy in kindergarten, SLP and comparison children would make comparable language-related gains from fall to spring. However, we expected differences in levels of science knowledge over time as a function of participation in inquiry-oriented (SLP) experiences.

GOALS FOR THE PRESENT INVESTIGATION

The objective of the present study was to examine learning, motivation, and social support outcomes with a new sample of children who participated in the full implementation of either the SLP classroom only or classroom-plus-home components. We extend our prior work in a number of important ways. First, we include a comparison sample of children (COMP) who attended kindergarten in neighboring public schools and did not participate in the SLP activities. Second, we compare the COMP group with two groups of kindergarteners in public school classrooms where the teachers implemented the SLP activities in the fall and spring. One of these groups (SLP-CLASS) participated in the classroom activities only, whereas the second (SLP-CLASS-HM) participated in both the SLP home component activities and the SLP classroom program. Third, we provide baseline data on all children, collected before the onset of the SLP activities, something that we have not done with previous cohorts.

After documenting the social context of science learning in the SLP-CLASS, SLP-CLASS-HM, and COMP environments, we used a range of individual-level measures (standardized and researcher-developed) and obtained information about the children's development. Our data were derived from a variety of sources (observers, teachers, parents, and the children themselves). We investigated group differences over time (fall to spring) across three science-related domains: (a) general knowledge about science and language achievement, (b) learning about the content and processes of science, and (c) perceptions of what science topics or activities children learn about in kindergarten. In addition, we investigated end-of-year differences on children's motivation for science (e.g., science competence beliefs, liking and interest in science) and documented children's perceptions of teacher and family support for learning science.

METHOD

Participants

Overview. The participants were recruited from a pool of 243 kindergarten children in four suburban schools, two of which served as the SLP and two as the COMP sites. The schools were in the same district and were selected after reviewing their demographic and achievement characteristics, provided by the state's Department of Education. All served large numbers of low-income students, were geographically close, were comparable in their achievement characteristics, and had large numbers of students underperforming on the state's annual achievement tests. The SLP activities were implemented during the regular kindergarten (half-day) program. Demographic information (i.e., gender, race/ethnicity, free or reduced-cost lunch status, parent report of whether a language other than English was spoken at home) for the final sample of children in the SLP and COMP groups are summarized in Table 1. Information about the recruitment procedures for each group and teacher characteristics as well as evidence on group comparability are provided next. Consent forms were available in Spanish and English and bilingual project members were available to provide information about the project to parents whose language preference was Spanish. None of the teachers (SLP or COMP) spoke Spanish.

TABLE 1
Demographic Data for Children in the SLP and COMP Groups

	SLP Groups									
	SLP Class Only n = 79		*SLP Class +Home n = 41*		*SLP Total n = 120*		*COMP Group n = 74*		*Sample Total n = 194*	
Demographic Characteristics	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*
Gender										
Female	40	50.6	19	46.3	59	49.2	37	50.0	96	49.5
Male	39	49.4	22	53.7	61	50.8	37	50.0	98	50.5
Race/Ethnicity										
Caucasian	55	69.6	20	48.8	75	62.5	37	50.0	112	57.7
African American	4	5.1	4	9.7	8	6.7	5	6.8	13	6.7
Hispanic	14	17.7	15	36.6	29	24.2	22	29.7	51	26.3
Other/Multiracial	6	7.6	2	4.9	8	6.7	10	13.5	18	9.3
Free or Reduced Lunch										
Receives Free/Reduced Lunch	57	72.2	30	73.2	87	72.5	45	60.8	132	68.0
Self-Paying	22	27.8	11	26.8	33	27.5	27	36.5	60	30.9
No Data	0	0	0	0	0	0	2	2.7	2	1.0
Language Spoken at Home										
English	67	84.8	28	68.3	95	79.2	53	71.6	148	76.3
Spanish and English	12	15.2	13	31.7	25	20.8	18	24.3	43	22.2
No Data	0	0	0	0	0	0	3	4.1	3	1.5

SLP Groups. In Schools 1 and 2, 145 children in seven classrooms were invited to participate. We obtained informed consent from the parents of 136 children (i.e., 93.8% of the children who were enrolled in kindergarten) but at the end of the year there were pre/posttest data from 120 children. Of the 16 children who were excluded from the analyses: (a) four were assigned to special education because of severe needs (e.g., autism or emotional disabilities); (b) six children moved away; and (c) six enrolled late (e.g., in the second semester of kindergarten).

All kindergarten teachers in the two SLP schools ($n = 6$) volunteered to participate in the project. There were three teachers solely in School 1, two in School 2, and one who taught a half day in each school. All teachers were White females. Four teachers had participated in the development and piloting of lessons during the first two years of the SLP. Two new teachers joined the project in Year 3 because two original teachers had moved away from the area.

SLP Home and Classroom Component (SLP-CLASS-HM). Three of the four classrooms in School 1 served as the sites for the SLP-CLASS-HM activities. The fourth classroom in School 1 was assigned to the SLP-CLASS component because we were interested in keeping the conditions comparable for the teacher who taught both in Schools 1 and 2. The three SLP-CLASS-HM teachers held Bachelor's degrees, and their teaching experience ranged from 8–24 years.

We initially recruited 61 families from the SLP-CLASS-HM classrooms; however, 20 did not participate in the home component. These children, though, did participate in the classroom activities and were followed throughout the year. Reasons for nonparticipation in the home activities were that the families: (a) did not respond to the follow-up invitations from the SLP team or (b) stated they did not have time for the science literacy program because of work-related or other obligations.

SLP Classroom Component only (SLP-CLASS). There were 79 children who participated in the SLP-CLASS activities. They included all children from School 2, one classroom in School 1 (as stated earlier, the teacher taught in both schools), and children from the other classrooms of School 1 whose parents did not participate in the home activities. Of the three SLP-CLASS teachers, two held Masters' degrees and one a Bachelor's degree. All were White females, and their teaching experience ranged from a first year teacher to 21 years experience.

Comparison Group (COMP). The COMP sample was drawn from five regular kindergarten classrooms in Schools 3 and 4. Children ($n = 98$) and teachers ($n = 4$) were invited to be part of a study on early science learning that involved documenting science lessons as well as children's science knowledge and motivation for science. All teachers in the two COMP schools agreed to participate. There were two teachers solely in School 3 (one had different morning and afternoon classes), one in School 4, and one who taught for a half day in both Schools 3 and 4. Teachers in the COMP group implemented their regular curriculum. All teachers were White females, held Bachelor's degrees, and their teaching experience ranged from 2–7 years.

We obtained informed consent for 82 (83.7%) of the 98 children who were enrolled in kindergarten to participate in the study but at the end of the year we had pre- and posttest data from 74 COMP children. Eight children moved away during the course of the year.

Group Comparability. We conducted a series of χ^2 tests to compare the children from the SLP-CLASS, SLP-CLASS-HM, and COMP groups on the demographic characteristics shown in Table 1 (sex, race/ethnicity, free or reduced cost lunch status, and language spoken at home). There were no significant group differences across any of these characteristics.

We also examined differences in teachers' views about how science was positioned in the kindergarten curriculum within the district. Teachers in all groups expressed comparable views. They noted that although science is important for children to learn, current district mandates to document extensive reading and math instruction made it extremely difficult to fit science into the curriculum. Also, because there were no requirements to document science instruction or teach particular science content, teachers perceived no institutional encouragement to teach science. Despite this, COMP teachers and SLP teachers—prior to beginning SLP activities—said they were able to include science content most weeks. Teachers chose different weekly themes, many of which were science-related, and in this context children read about science and engaged in science activities.

The four COMP teachers and four of the six SLP teachers expressed comparable comfort with teaching kindergarten science and preparedness to do so. Only one SLP teacher—new to SLP—said preservice courses in science teaching benefited her; no teacher credited inservice courses as helping her science instruction. Two veteran SLP teachers (i.e., were teaching SLP for the third year) were happy getting ideas from other teachers and the internet, and a third told us, "If it was something I didn't know much about, you know, we didn't cover it." The other two SLP teachers (one new to SLP and part of the SLP-CLASS group, and one veteran in the SLP-CLASS-HM group) were less comfortable with science. They expressed low confidence in teaching science at the beginning of the project. For example, one of these teachers told us, "Science is not my big field. . . . My [lesson] files are not real big and I didn't have a lot of books, so I looked at this as an experience for, I'll probably learn maybe more than the kids." These two SLP teachers also did not feel well prepared to teach science. For example, one of these teachers said, "I just didn't think they [i.e., college classes] were very effective. It was kind of like a blow-off class." All four COMP teachers said they were confident in teaching science, although none felt sufficiently prepared from inservice or preservice courses to do so. One said she hadn't had a class on teaching science, so "I think [it's] probably just sort of luck because [science] was something that I'm interested in." Another told us, "We had to take a lot of science classes [in my teacher education program] but I don't really think that it helped me in any way <u>teach</u> science. . . . I learned most of my science information by teaching science at the Super Saturday [gifted enrichment] program, by doing research for my lessons."

Assessments and Procedure

Assessments at the social level were used to provide data on the fidelity of the SLP classroom and home components and document the context of the: (a) instructional activities in the SLP-CLASS and COMP classrooms and (b) shared-reading home activities. At the individual level, proximal and remote measures were used to (a) establish the comparability of the SLP-CLASS, SLP-CLASS-HM, and COMP groups at baseline and (b) examine group differences at the end of the program. An outline of the measures and the time of administration is shown in Table 2.

TABLE 2
Outline of Measures Administered in the Fall and Spring of the School Year

Measure	*Respondent*	*Content*	*Time of Administration*	
			Fall	*Spring*
Social Level Measures				
Documentation of the SLP Classroom Component	Classroom Observer	Fidelity of Inquiry Activities Rubric Fidelity of Reading Activities Rubric	Continuous	
		Videotaped Observations (to document the nature of participation)	Continuous	
Documentation of the SLP Home Component	Parent	Home Reading Program (Parent logs & activity sheet)	Continuous	
	Parent–Child Dyad	Shared Book Reading Videotaped Observations		X
Individual Level Measures				
WJ–III	Child	Science Knowledge	X	X
		Passage Comprehension	X	X
Science Learning Assessment	Child	Science Concepts	X	X
		Science Inquiry Processes	X	X
What I Learn in Kindergarten (WILK)	Child	Reading & Math	X	X
		Science	X	X
Children's Motivational Beliefs for Learning Science (PISCES)	Child	Perceived Competence in Science Content		X
		Perceived Competence in Science Processes		X
		Science Liking		X
Teacher Rating Scale of Children's Motivation for Science	Teacher	Motivation for Learning Science		X
		Need for Support in Science		X
Children's Perceptions of Support for Learning Science	Child	Support from Teacher		X
		Support from Family		X

Fidelity Measures for the SLP Groups.

Children's attendance during the SLP classroom implementation. Children's presence in the classroom during each SLP lesson was recorded by a classroom assistant (i.e., an SLP researcher assigned to the classroom). We recorded partial attendance (i.e., .5, .25, .75) when children left the classroom or arrived late (e.g., for speech therapy, from a doctor's visit). From these data we calculated the proportion of SLP lessons that each child was present for as an indicator of attendance during the SLP inquiry and literacy activities.

Teachers' fidelity with enacting the classroom component. Two different rubrics were used to track teachers' implementation of the inquiry and reading activities. We also videotaped 170 SLP lessons (22–37 per teacher) in Year 3 of the study.

Fidelity of inquiry activities. The rubric for fidelity of the inquiry activities documented teacher behaviors and student participation. It was completed by SLP classroom assistants trained to apply the rubric reliably using videotaped lessons from the previous two years of the SLP.

During the lessons, classroom assistants made notes as needed and then filled out the rubric shortly after the lesson was completed and they had left the classroom. The inquiry fidelity rubric involved rating the teacher's: (a) explanations and modeling of target concepts; (b) scaffolding student participation through questions, suggestions, and responses to children's ideas; (c) scaffolding use of inscriptional tools during the activities (e.g., idea board, science notebooks); and (d) scaffolding use of SLP manipulatives. We used a 3-point rating scale: 0 indicated that the criterion was not met, 1 indicated that the criterion was partially met (e.g., there was not sufficient follow-up), and 2 indicated that the criterion was fully met.

We conducted initial reliability estimates for the inquiry fidelity rubric as follows: We selected one videotaped inquiry lesson from Units 1, 2, and 3, respectively. Each lesson was taught by a different teacher. An SLP researcher, blind to the classroom assistants' ratings, used the fidelity rubric to independently rate the videotaped inquiry lessons. For each of these lessons, we calculated the percentage of agreement between classroom assistant and the independent rater across all categories. The average interrater agreement across the three lessons was 88%. In examining the areas of disagreement we found that most of the disagreements were associated with the criterion "teacher scaffolds use of inscriptional tools." Classroom assistants were therefore provided further training on using the rubrics for this category.

Fidelity of reading activities. The implementation of the reading activities was rated from videotaped data, obtained for 78 lessons (ranging from nine to 15 lessons per teacher), using an adapted version of the Teacher Reading Behavior Checklist (Powell & Diamond, 2005). The rubric included the following teacher behaviors: (a) providing background information prior to the book reading, (b) asking closed- and open-ended questions intended to promote understanding of the material and to provide linkages between the content and children's experiences, (c) scaffolding connections between the reading and children's experiences with the inquiry activities, (d) defining new science vocabulary, (e) acknowledging and responding to children's questions or comments, and (f) children's interest and engagement during the reading. We used the same 3-point rating scale described for the fidelity of the inquiry activities to rate the extent to which the criteria under consideration were met. Ratings were averaged for each teacher across the SLP reading sessions for each criterion. The first author rated all the lessons after establishing reliability with the two coauthors on six reading lessons. Interrater agreement ranged from 80% to 100%, with a mean of 93%.

Parents' fidelity with the home component. Parents' participation in the home component was monitored in three ways. First, each packet of home component materials (sent home with the children) included a Science Reading Record sheet (SRR) and a set of stickers for children to place on the sheet each time they read the book. The SRR was intended as a record-keeping tool for the families who noted the dates they read the books each week, as well as made comments about the book reading including children's questions or comments. Home visitors (i.e., SLP researchers assigned to specific families) collected the SRRs that parents completed in addition to samples of children's work (e.g., completed science or literacy activity sheets).

The second way we monitored parents' use of the program was through their home visitor, who contacted the parents at approximately 2-week intervals. Parents were asked whether they had received and read the books, whether they had any questions, if and how they were using the book-reading strategies, and how children responded to the books and the book reading.

To assess parents' use of the reading strategies directly, we analyzed videotapes from the shared book readings of 40 randomly selected parent–child dyads who read *Life Cycle of a Bean* (Royston, 1998) in the spring. This book was unfamiliar to parents and children in both groups. Parents were paid $10 and the book was given to the child. For this analysis, 20 dyads were selected from the families who participated in the SLP-CLASS-HM component and another 20 pairs were selected from the families whose children participated in the SLP classroom-only component (SLP-CLASS). We used an expanded version of the rubric that was applied to code the book reading sessions conducted by teachers during the SLP classroom activities. The book coding rubric included 11 specific reading criteria (outlined in Table 7, where analyses are also reported later in this article) intended to document specific interactions during the book reading. We used the same 3-point rating scale described for the fidelity of the classroom inquiry reading activities to rate the extent to which each criterion was met. In addition, we recorded the time (in minutes) for each reading session to document the time spent by each dyad on the book reading. Finally, two other criteria were used to examine reading engagement separately for the parent and the child by coding the extent to which: (a) the parent read with expression and (b) children were interested and engaged during the reading. We used a 3-point scale. For parent engagement, 0 indicated that the parent read in a monotone without acknowledging the child, 1 indicated that the parent read the book in an acceptable tone but did not engage the child, and 2 indicated that the parent read in an engaging manner, exhibiting signs of positive affect during the reading and was attentive to the child. For child engagement, 0 indicated that the child showed several signs of inattention (e.g., constant fidgeting, looking away from the book, leaving the book reading session, asking "Are we done yet?"), 1 indicated that the child listened attentively, and 2 indicated that the child showed several signs of interest in the book by pointing to pictures, making spontaneous comments, asking questions, and showing positive affect.

Once the coding rubric was established, the first two authors independently coded five video-recorded book readings randomly drawn from the 40 cases. The second author was blind to the status (SLP-CLASS vs. SLP-CLASS-HM) of the families in the video recordings. We calculated interrater agreement by comparing scores and dividing the number of agreements by the total number of agreements and disagreements. Disagreements were resolved through discussion. Coder agreement was 87.1%. The first two authors then divided and scored the remaining cases.

Science Lessons in Comparison Classrooms. We conducted classroom observations and teacher interviews in the comparison schools to document their typical science activities. We videotaped, and later transcribed, four different science lessons taught by each of the teachers, which they selected as being typical for them. We also conducted semi-structured interviews with teachers to investigate aspects of their science instruction (e.g., "What do you do for science in kindergarten?"; "How do you figure out what to do and how much time to spend?"). The interviews lasted approximately 40 minutes, were audiotaped, and transcribed.

Child Baseline and Outcome Measures. All measures were administered to children individually by trained researchers during regular school time in a quiet area of the school. The measures were administered over three sessions of 15–20 minutes to avoid taxing children's short attention spans. Baseline measures were administered in late August and September, before the onset of the SLP activities. Outcome measures were administered in the spring (late April and May). Examiners were blind to the SLP-CLASS or SLP-CLASS-HM status of the children.

Science Learning Assessment. The Science Learning Assessment (SLA; Samarapungavan et al., 2009) was developed to assess kindergarten children's understanding of concepts targeted in the SLP and specified in state (Indiana Department of Education, 2006) and national content standards (i.e., Center for Science and Mathematics Education, 1996) as well as the Benchmarks for Scientific Literacy (American Association for the Advancement of Science, 1993). The design of this measure was informed by the National Goals Panel's recommendations for early childhood assessments (Shepard, Kagan, & Wurts, 1998) and items were mapped to content standards representing two broad subscales, labeled Scientific Inquiry Processes (12 items) and Science Concepts (15 items).

The format of the items on both subscales involve the examiner showing three pictures (each on a separate card, one correct and two incorrect) to the child and asking him or her a question that can be answered verbally or by pointing to the correct pictures (e.g., "Which of these can you use to look at something very small such as a bug?"). Responses are scored 1 (*correct*) or 0 (*incorrect or not answered*).

Items in the Scientific Inquiry Processes subscale measure young children's functional understanding of the nature and processes of scientific inquiry across the following broad areas: (a) inquiry as a process of asking questions, making predictions, and gathering observations about the world (e.g., "Here is a picture of a frog. These girls—shown in pictures by the examiner—ask questions about the frog. Listen to each question and tell me which girl asked a science question: 1. What does the frog eat? 2. Do you like the frog? 3. Can I call the frog Lilly?"); (b) the fit of scientific ideas to empirical evidence (e.g., "Here is a picture of a fish—examiner shows picture of a black and white striped fish. Here are three boys—examiner shows pictures of the boys. I will tell what each boy said about a fish. 1. That fish has black and white stripes. 2. I have a pet goldfish at home. 3. Fish like to swim in groups. Which of these boys saw the fish in this picture?"); and (c) the use of scientific tools in gathering recording, evaluating, and sharing data (e.g., "Here are some tools we use to do science"—examiner shows pictures of a science notebook, a magnifying glass, and a stopwatch. "Which of these can you use to help you remember what you saw?").

Items in the original Science Concepts subtest measure children's understanding of specific science content and concepts related to living things (e.g., understanding that living things have structures and traits that enable them to survive, that living things need food, that living things respond to the environment, and that living things have life cycles). Two items assessing concepts of motion were added in Year 3 of the study. An example of an item from the Science Concepts subscale is: "Here are some pictures of animals—examiner shows pictures. Which of these is NOT camouflaged? 1. Orange goldfish in green pond water; 2. Brown/grey toad on brown/grey tree trunk; 3. Grey moth on grey tree bark."

Psychometric evidence on the SLA included a test of its instructional sensitivity, an evaluation of item difficulty and discrimination indices, a construct validity test of its dimensional structure through confirmatory factor analysis and correlations with other measures of achievement and science knowledge, and a reliability estimates measure (Samarapungavan et al., 2009). Alpha coefficients, based on data from previous samples as well as the current sample, are .71 and .75, respectively, for the Science Inquiry Processes subscale and .70 and .72, respectively, for the Science Concepts subscales. The SLA subscales have small to moderate correlations with the Woodcock-Johnson Test of Achievement III (WJ–III) Science Knowledge subtest (ranging from .29 to .50 across previous samples, *p*s $< .05$).

Woodcock-Johnson Tests of Achievement III. Compared to the proximal nature of the SLA, the WJ–III (Woodcock, McGrew, & Mather, 2001) is an individually administered standardized assessment that is not aligned to content standards and is far removed from the content and process of the instructional context. Nevertheless, remote-level measures such as the WJ–III do have implications at the policy level when the impact of programs is evaluated on broad achievement indices (Hickey et al., 2006). We selected two subtests: Passage Comprehension and Science Knowledge. The Passage Comprehension subtest assesses the child's vocabulary and comprehension skills and ability to understand language when it is being read. It requires use of semantic and syntax cues as the child identifies missing information in each question. The Science Knowledge subtest is part of the Academic Knowledge cluster of the WJ–III and assesses general knowledge in biological and physical sciences. The items draw on a narrow set of vocabulary and general knowledge skills, and prompt for children's recall of labels for things (e.g., names of animals) and processes (e.g., the process of littering is called pollution). This measure does not include items that probe young children's conceptual understanding of scientific inquiry processes such as observing, predicting, measuring, and recording data, or hypothesis testing. In this study, we use the WJ–III Science subtest as an indicator of children's general knowledge about science.

Psychometric information for the Passage Comprehension subtest and the full Academic Knowledge cluster includes 1-year test–retest reliability for 2–7-year-olds (.84) and split-half-reliability for 4–6-year-olds (.92). Correlations of the WJ–III with other achievement measures are reported in the test's technical manual (McGrew & Woodcock, 2001) as evidence of the test's validity.

Children's Perceptions of What I (Will) Learn in Kindergarten. Children's Perceptions of What I (Will) Learn in Kindergarten (WILK; Mantzicopoulos & Patrick, 2007a) assesses children's beliefs about the opportunities for learning different content (science, language arts, and math) during the kindergarten year. It is made up of items that ask children whether or not they do (or, at the beginning of the year, whether or not they will) learn about reading, writing, math, and science content and processes in kindergarten (e.g., "In school we [will] learn about numbers"). Items are scored dichotomously ($1 =$ yes; $0 =$ no). Principal axis factor analysis (with oblique rotation) using data collected from 407 kindergarteners in the spring of kindergarten (Years 2 and 3 of the project) supported two broad factors: Learning about Reading and Math (Factor 1, $\alpha = .67$; 7 items) and Learning about Science (Factor 2, $\alpha = .91$; 13 items). Examples of reading and math items include: "In school we [will] learn to count"; "in school we [will] learn about letters"; "... about numbers"; "... about shapes"; "... about books." Examples of science items include: "In school we [will] learn about how living things grow," "... we [will] learn how to make observations."

Puppet Interview Scales of Competence in and Enjoyment of Science. The Puppet Interview Scales of Competence in and Enjoyment of Science *(PISCES;* Mantzicopoulos & Patrick, 2007b) measures children's motivational beliefs about science with three subscales: Perceived Competence in Science Content (10 items, $\alpha = .82$), Perceived Competence in Science Process Activities (9 items, $\alpha = .85$), and Liking of Science (7 items, $\alpha = .76$). In previous work (Mantzicopoulos et al., 2008) we have used exploratory factor analysis to establish that young children differentiated between their competence in science (i.e., how good they think they are in science) and their liking of science. In the present study we have added items that allow us to split children's science competence beliefs into two subscales that reflect separately their beliefs about competence in science content and processes. Sample items include: "I know why living things camouflage" (Perceived Competence in Science Content), "I know how to ask questions like a scientist" (Perceived Competence in Science Process Activities), and "I have fun learning about the animals that live in the ocean" (Liking of Science).

The administration procedure used for this assessment involves two puppet characters that facilitate children's responses: One puppet makes a positive statement (e.g., "I know how to use different tools to learn about science") and the other puppet follows with a corresponding negative statement ("I don't know how to use different tools to learn about science yet"). The child is then asked to indicate agreement with one of the two puppets. Questions are counterbalanced by whether a positive or negative statement is read first, and each puppet makes both positive and negative statements. The scoring is dichotomous and the total administration time is approximately 15 minutes. Details on the development of the PISCES along with specific psychometric information are provided in Mantzicopoulos et al. (2008).

Perceptions of Support for Science Learning. The Teacher Support for Learning Science measure (Mantzicopoulos & Patrick, 2007c) is a four item self-report scale that is scored on a 3-point Likert format (1 indicates no, 2 indicates sometimes, 3 indicates all the time). Examples of items are "My teacher tells me that I am good at science," "My teacher helps me understand things about science," and "My teacher tells me that I can be a scientist." The Family Support for Learning Science measure is comprised of six dichotomously-scored items. Sample items are "I read science books with my family," "My family helps me learn more about science," and "My family tells me that I can be a scientist." Alpha coefficients based on the current sample are strong ($\alpha = .82$ and $\alpha = .80$ for the teacher and family support subscales, respectively).

Teacher Rating Scale of Children's Motivation for Science. Utilizing the Teacher Rating Scale of Children's Motivation for Science (Patrick & Mantzicopoulos, 2008), teachers rated each child on motivation indicators for learning science using a 5-point scale; anchors are 1 (*not at all, very little*); 3 (*moderate*); and 5 (*a great deal*). The two-dimensional structure of this measure was established with exploratory factor analysis using data from Year 3 of the SLP. We used oblique (promax) rotation (with principal axis factoring to extract the factors) because we expected the factors to be intercorrelated. Based on the results of the factor analysis we created scale scores by averaging the items on each scale. Factor 1 (Interest in Learning Science; 7 items, $\alpha = .92$) assessed teacher perceptions of how interested children are in science (e.g., "How excited or enthusiastic is he or she during science?"; "How hard does he or she try in science?"). Factor 2 (Need for Support vs. Independence for Learning Science; 7 items, $\alpha = .93$) reflected teacher perceptions of children's independence versus need for support during science learning (e.g., "How much support does he or she need from you in science?"; "How much encouragement does he or she need from you in science?").

Context of the SLP Science Lessons

SLP Classroom Component. The SLP activities were implemented as part of the regular kindergarten program in the two SLP schools. The content of the inquiry and literacy activities was created in collaboration with the SLP teachers who shared with us science topics that they had taught the previous years as well as topics that they were interested in teaching. The SLP, collectively, addressed all the state kindergarten science standards (i.e., nature of science, observing and communicating science, force and motion, living things, and comparing similarities and differences; Indiana Department of Education, 2006). As noted in the introduction, the general focus of the project was on children's understanding of living things and their characteristics. Over the course of the activities, children learned about the properties of living things, how to distinguish living things from nonliving things, and how living things adapt to their environments or habitats. In addition, we included a unit on force and motion because motion was listed in the state science standards for kindergarten and the teachers specifically requested our help with teaching it. This unit was based on observations of various types of motion and simple experiments to help children think about how slope and surface influence the motion of objects. In addition, the unit provided opportunities for children to discuss differences in movement between living and nonliving things.

Throughout the SLP activities our goal was for students to develop a sense of what it means to do science. However, we were aware that the scientifically normative counterparts of the ideas in the SLP curriculum were beyond the reach of typically developing kindergarteners. Therefore, we did not expect that children would develop normatively accurate scientific concepts from their inquiry activities. An important goal was for teachers to scaffold children's understanding of the role of thought, inference, and prior experience as they began to construct approximations of scientific concepts and develop a language for thinking about science.

Key themes or ideas about the nature and processes of scientific inquiry, biological structure, function, adaption, and motion were integrated into six units across the year. The SLP activities were designed to provide children with opportunities to construct, develop, and revisit key ideas during the course of the program. In Year 3 of the project (i.e., the focus of the present study), we implemented the six thematic units outlined in Table 3. A separate list of references for the children's books used in the project is also provided at the end of this article. Key concepts targeted in these units are reported in Samarapungavan et al. (2011) and Mantzicopoulos et al. (2009).

SLP science lessons were taught by the regular classroom teachers for approximately 60 minutes, twice a week, for a period of 20 weeks. The first four units spanned 10 weeks in the

TABLE 3
Outline of SLP Inquiry and Literacy Activities Included in the SLP Units

Unit	*Weeks*	*Description*	*Readings*
What is Science?	1.5	Children are introduced to the key themes of the SLP (i.e., that science is the study of the natural world and that children can do science through planned and purposeful investigations in which they examine and revise their models of the world by gathering and interpreting empirical data). Teachers introduce children to scientific inquiry through simple experiments (e.g., examining what happens to a variety of objects such lemonade mix, salt, beans, and a metal paper clip, in water). The teachers scaffold discussions about what it means to do science.	*Science is everywhere* (Yu, 2006) *Amazing scientists* (Pitino, 2007)
Living Things	3.5	Children explore important topics in biology such as: (a) differences between living and nonliving things; (b) habitats and how living things are adapted to their habitats; (c) structure and function, or how animal bodies enable them to function and survive. Children learn about these concepts by observing living things in their environments (i.e., by going on nature walks to observe living and nonliving things, recording observations in their science notebooks with digital photographs, drawings, and writing).	*Living things* (Trussell-Cullen, 2001). *Living things need water* (Street, 2001) *Amazing plants* (Santiago, 2006) *Plants and animals live here* (Wong, 2006) *Whose eye is it?* (Mantzicopoulos, 2006)
Tools	1	Children learn about several tools for observing and measuring (e.g., a ruler, magnifying glass, balance scales, etc.) and use these during their own investigations throughout the SLP activities. For example, teachers introduce children to simple measurement of length with a ruler using inches as a unit of measurement. The teachers facilitate a discussion of using a uniform starting point and uniform units for measuring length. Teachers also introduce the use of a balance scale as a tool to determine which of two objects is heavier. The goal of this unit is to give children simple, functional tools for observing and recording things such as relative size.	*How scientists observe* (Mulcahy, 2006) *Let's measure with tools* (Casteel, 2006)

(Continued on next page)

TABLE 3
Outline of SLP Inquiry and Literacy Activities Included in the SLP Units *(Continued)*

Unit	*Weeks*	*Description*	*Readings*
Force and Motion	2	Children investigate how things move. The inquiry unit is based on observations of various types of motion. Children discuss differences in movement between living and nonliving things, and conduct simple experiments to determine how factors such as the slope and relative roughness of ramp surfaces influence how fast objects move down the ramp.	*Force and motion* (Ramirez, 2007) *Playground science* (Pitino, 2006)
Life Cycles	5–6	Children learn about growth and development, revisiting and extending concepts introduced in the Living Things unit. Unit activities introduce children to concepts that growth involves changes that occur in organisms throughout their lives and that living organisms change in many different ways. Children observe the development of chicken eggs and tadpoles to learn about the life cycles of different living things and their patterns of growth and development.	*Isn't it strange?* (Polette, 2004) *The life of a butterfly* (Murphy, 2005) *The penguin chick* (Wooley, 2001) *Life cycle of a frog* (Royston, 1998) *Life cycle of a chicken* (Royston, 1998) *Life cycles of animals* (DaSilva, 2006)
Marine Life	5–6	Children investigate marine life and the properties of living things. The inquiry unit is based on observations of animals in a saltwater aquarium. It is designed to help children explore important topics in biology such as the differences between living and nonliving things; habitats; and how living things are adapted to their habitats, structure and function, or how animal bodies enable them to function and survive.	*Living things are everywhere* (Smith, 2005) *Fish* (Swartz, 2002) *Kelp* (Douglas, 2005) *What is an ocean?* (Hughes, 2005) *What lives in a shell?* (Zoehfeld, 1994) *Fish that hide* (Swartz, 2002) *What's it like to be a fish?* (Pfeffer, 1996)

first half of the year, and the final two units were taught over 10 weeks in the second half of the year.

Each classroom was assigned an SLP member to assist the teacher with the implementation of the activities. Although classroom assistants did not teach lessons, teachers typically assigned assistants to supervise small group activities if there were multiple, simultaneous activity stations. Classroom assistants also helped children with writing or recording in their science notebooks, delivered supplies and maintained materials (e.g., aquariums), collected fidelity and notebook data, and were on hand every science lesson so that questions or potential issues could be communicated to the SLP team for an immediate response.

Details both about the theoretical rationale underlying the classroom SLP activities and examples of inquiry and literacy activities from the first 2 years are described in Samarapungavan et al. (2008, 2011), Mantzicopoulos et al. (2009), and Patrick et al. (2009b). Additional examples are provided in the Fidelity of Implementation subsection of the Results.

Teacher training and implementation of the classroom component. At the start of the project the teachers were unfamiliar with inquiry-based teaching but were interested in learning more about it. During Year 1, the authors met with the teachers on several occasions to develop shared understandings of what it means to teach and learn science and to construct a framework for implementing the project. Additionally, during the first two years the teachers piloted activities associated with the development of the units and provided feedback to the authors. Year 3 SLP activities were planned jointly with the teachers during meetings held at the end of Year 2.

The teachers were provided with a set of teacher guides that: (a) described the instructional goals for each unit as well as the inquiry and literacy activities (in sequence); (b) included specific examples for implementing the SLP activities and scaffolding children's discussion and learning; and (c) provided relevant, disciplinary content for each activity (e.g., properties of living things, biological adaptation). All materials (e.g., plastic cups and spoons, ramps, reading books, children's notebooks) were supplied by the SLP, and delivered prior to the beginning of each unit (classrooms had limited storage space). Perishable materials (e.g., cut flowers, ice) were brought to the classroom when needed. The teachers were also provided with links to websites with additional information on various science topics included in the SLP.

Prior to starting the SLP activities for the year, we conducted an after-school workshop with the teachers. It served as a follow-up to workshops about implementing the SLP and meetings with teachers, both held during the first two years of the project. The workshop covered the principles of the SLP, and provided an overview of SLP activities, readings, and materials for the units. In addition, we reviewed a range of instructional and management strategies for teachers such as use of activity centers, reading non-fiction texts, asking higher-order questions, incorporating unit activities within existing classroom routines (e.g., calendar time), eliciting students' questions and ideas, general student-centered strategies, and adapting literacy activities (e.g., writing in notebooks) to individual students' development. We held additional individual meetings with the two teachers new to SLP.

Over the course of the year SLP teachers, assisted by the classroom assistants, implemented the science inquiry and literacy activities. During this time we had an additional 11 meetings with the SLP teachers across the two schools. These were short, informal, after-school meetings, mostly with individual teachers, during which members of the research team had opportunities to discuss how the implementation was working, record suggestions for future revisions, and address issues that arose during the course of implementation. Additionally, teachers and classroom assistants used e-mail communications to address ad hoc issues or concerns that arose during instruction (e.g., requests for additional content information).

SLP Home Component. At the beginning of Year 3, before the classroom SLP activities began, parents of children from three SLP classrooms in School 1 were invited to participate in the home component of the study. The parents who accepted the invitation were then invited to learn about dialogic reading with their children by participating in one of three group training sessions held at the school. Invitations written in Spanish and English were sent to Spanish-speaking families, and at least one Spanish-speaking project member attended these training sessions. Parents who did not attend ($n = 11$) received the same training individually. The training introduced parents to read-aloud and dialogic reading strategies with the objective that parents would engage the children, as they read together, in meaningful conversations about each book.

Throughout the six units, children brought home a literacy packet at the end of each week with materials for the child to keep (the materials were developed and piloted in Year 2 of the project with children and families from Schools 1 and 2). The literacy packets included the non-fiction books children read in class, a parent book-reading guide for each book to aid parents in further exploring the science topics with their children (for an example see Scientific Literacy Project, 2009), activity sheets about science (e.g., recording characteristics of plants observed in a neighborhood walk) and literacy (e.g., practicing the letter of the week emphasized in the child's classroom), and a Science Reading Record sheet to track when the book was read. The book-reading guides were designed to help parents extend their children's vocabulary, comprehension, thinking skills, and mathematical concepts. The guides also presented examples of dialogic reading strategies that could be used with each specific book and were intended to facilitate parent–child scaffolded interactions (e.g., by asking questions, scaffolding comprehension and vocabulary development through attention to novel words, scaffolding connections between the text content and children's experiences). Examples of how the parents used these strategies are shown in the Fidelity of SLP Home Activities subsection of the Results.

Children in Spanish-speaking families received all materials (i.e., books, book-reading guides, activity sheets, reading records) in both English and Spanish. For books also published in Spanish, children were given copies of both the English and Spanish versions. For books published only in English, the text was translated (and back-translated by a second person) into Spanish and printed onto stickers, which were affixed to the corresponding page. The home visitor for these families was a bilingual, native Spanish speaker. Although all parents spoke some English, reports were that some preferred the Spanish-language version of the books. However, the books were also read to the children in English by other members of the household (sometimes older siblings) who were bilingual or by English-speaking caretakers.

Context of the Comparison Classroom Science Lessons

As we noted previously, many of the weekly themes were science related (e.g., amphibians, ocean life, the weather, the five senses, germs and staying healthy) and therefore children received some science instruction most weeks. Some themes were related to seasonal or cultural events such as learning about pollution and recycling on Earth Day, pumpkins (with a field trip to a pumpkin patch) in the fall, plants in the spring, or making predictions about how the green eggs and ham they made during Dr. Seuss Week would taste. The teachers also reported they sometimes integrated science with other subjects: one teacher used a reading program that included some science books (e.g., a book about bee facts), children did sorting while learning about the food pyramid, children wrote about science topics (e.g., insects), and teachers read books (often fiction) about science topics.

In order to provide some comparability with the SLP teachers, who received all science materials associated with the project, we provided COMP teachers with a budget for purchasing classroom materials of their own choosing. No COMP teacher chose to purchase materials for science instruction.

Of the 16 lessons we observed and recorded, all involved hands-on activities and in 13 the teacher also read a book. The different lessons, with their topics, activities, and books, are presented in Table 4. Excerpts from typical COMP classroom lessons are shown in the Results section. Additional examples of science activities and book reading in the comparison classrooms in Year 2 are given in Mantzicopoulos et al. (2009) and Samarapungavan et al. (2011). Although children in the COMP classes had some science instruction most weeks, according to their teachers, it was not possible to compare dosage with that received by children in the SLP classes. This was primarily because the nature of the science instruction in the two contexts was fundamentally different, as is illustrated in the excerpts in this study and others from previous SLP studies (e.g., Mantzicopoulos et al., 2009; Samarapungavan et al., 2011).

RESULTS

Social Context of Science Learning in SLP and COMP Environments

Overview of Analyses. We report on children's attendance to document that they were present during the classroom activities. In addition, we present descriptive data on the fidelity of implementation using the fidelity rubrics for the SLP classroom inquiry and literacy activities as well as for the home component. We use excerpts from videotaped classroom SLP lessons and from parent–child shared book reading conversations as evidence of the typical flow of the SLP activities. We also present excerpts from videotaped science lessons in COMP classrooms to illustrate differences between regular kindergarten and SLP science lessons. The transcripts represent typical, rather than exemplary, instances of instructional exchanges during the course of the inquiry and reading activities. The children's and teachers' names are pseudonyms.

Children's Attendance. We used a t-test to compare the SLP-CLASS and the SLP-CLASS-HM groups on attendance during the SLP lessons. There were no significant differences between the two groups. SLP-CLASS children, on average, attended 88% of the lessons; SLP CLASS-HM children attended 85% of the lessons. In addition, there were no differences in SLP and COMP children's school attendance during the year.

Fidelity of Classroom SLP Inquiry and Literacy Activities. We averaged the scores for each teacher across each criterion for all inquiry lessons and book reading activities. The findings for each classroom are shown in Tables 5 (inquiry activities) and 6 (literacy activities). Overall, the data indicate that all teachers implemented the SLP activities, albeit with some variability.

Inquiry activities. On average, teachers implemented the inquiry activities midway between partially and fully ($M = 1.5$, teachers' range = 1.3–1.7). That is, they modeled or explained target concepts, scaffolded student participation with questions or responses, scaffolded the use of inscriptional tools and manipulatives, and elicited student participation at least partially as intended. Ratings of student participation were generally high (1.4–2.0), whereas teachers' use

TABLE 4
Overview of Science Lessons Observed Across the Comparison Classrooms

Topic	*Reading*	*Activity*
Leaves	Maestro, B. (1994). *Why do leaves change color?* HarperCollins.	• Teacher led a whole class review of a chart the class had previously made about leaves. • Children made leaf rubbings at their seats.
Apples		• Children colored an outline of an apple to match the color of the apple they had brought from home. Children pasted their apples, grouped by color, on a chart to graph frequency of different colored apples. • Children watched the teacher make applesauce.
Life cycle of plants	Bauer, J. (2007). *Sunflower life cycle*. Scholastic.	• Children glued five pre-cut outlines onto paper to create a plant, glued labels beside the parts (flower, stem, roots, leaves), and colored the parts.
	Bauer, J. (2007). *Sunflower life cycle*. Scholastic.	• As a class, they discussed what living things need. • Children placed pictures on an idea board to show whether the thing in the picture was living or nonliving. • A group "planted" a lima bean seed in a wet paper towel in a plastic bag. Children wrote what they did in a journal and wrote a prediction of whether or not it would grow. • Another group cut out plant parts and labels from a worksheet, assembled and glued them onto paper, then colored it.
	Krauss, R. (1945). *The carrot seed*. Harper Collins.	• As a class, they made a list of things they know about plants. • Children colored an outline of a plant and glued on labels of the parts of a plant. • While the class completed the worksheet, children were called in pairs to the teacher and together each planted a grass seed in a pot.
	Levenson, G. (1999). *Pumpkin circle: The story of a garden.* Tricycle Press.	• With children sitting on the floor in a circle, the teacher cut the top off a pumpkin, then passed it around so the children could look and touch inside. • As a class, they made a list of things they could do with a pumpkin. • Children sampled roasted pumpkin seeds. • Children continued with the project of making a model of the pumpkin life cycle (i.e., paper cut-out shapes connected with yarn to resemble a vine).
Life cycle of a butterfly	Neye, E. (2000). *Butterflies*. Grosset & Dunlap.	• As a class, children created a list of what caterpillars and butterflies have in common and what each has uniquely. • Children cut out different shapes (each showing a stage of the butterfly life cycle) from colored paper and put together to make a book detailing the life cycle.
Insects	Canizares, S., & Chanko, P. (1998). *What do insects do?* Scholastic.	• The teacher paused three times while reading the book; during the pause children wrote on their slates something they remembered from the book.
Spiders	Mrs. B. (2008). Science facts. In S. West (Ed.), *Read well lap book 3, Units 7, 8, 9: Spiders, worms, and bugs, oh my!* Sopris West Educational Services.	• As a class, they created a chart listing facts they had learned about spiders.

(Continued on next page)

TABLE 4
Overview of Science Lessons Observed Across the Comparison Classrooms *(Continued)*

Topic	*Reading*	*Activity*
		• To show spiders' body parts, children made spiders using two marshmallows, eight pretzels, and two M&M candies. Then, the children ate the spiders.
Animals and habitats	Downing, L. T. (1992). *Which pet to get?* Weekly Reader.	• As a class, they created a graph to show the children's favorite pets. Each child indicted a favorite by placing a Post-It note on a grid with five columns (dog, cat, fish, bird, other). • Children completed a worksheet matching four animals to where they live (e.g., dog to kennel, fish to bowl).
Animals in the ocean	Wallace, K. (1998). *Gentle giant octopus*. Candlewick Press.	• The class reviewed what they had learned in the week about animals that live in the ocean. • Children listened to a song about an octopus, and then they sang along. • At their seats, children drew a picture of an octopus showing what they had learned.
The five senses	Berger, M., & Berger, G. (2003). *You smell with your nose*. Scholastic.	• One center involved children smelling (with eyes shut) inside five paper bags held by the teacher. After each, they wrote what they thought it was (e.g., peanut butter, chocolate, pickle). At the end, the teacher showed the children, and they wrote down the correct answer. • In a hearing center children shook eight numbered plastic eggs and tried to identify by listening what was inside; then, they matched the number of each to pictures on a worksheet.
The heart	Berger, M., & Berger, G. (2005). *Your heart*. Scholastic.	• Children felt their heart rates on resting, then again after jumping around for a few minutes. • The teacher demonstrated how the heart works as a muscle by squeezing a full juice box in bursts over the sink. • As a class, they wrote what they had learned about the heart on a chart. • In one center, children listened to their own hearts with a stethoscope. They drew pictures of their favorite activities and wrote if their hearts would be pumping quickly or slowly while engaging in these activities.
Mixing colors	Walsh, E. S. (1989). *Mouse paint*. Vogager Books.	• At seats, each child had a pot of red, blue, or yellow frosting; the teacher added food coloring, and the children stirred the pots with pretzels and ate them. • Children used six paint pots (three primary colors, three pre-mixed: green, orange, purple) to paint coffee filters to make turkey feathers for a cut-out turkey.
Sinking and floating		• On a worksheet, children predicted whether or not seven items would sink or float. Then, in small groups, they observed what happened, and recorded on the worksheet.

TABLE 5
Fidelity Ratings for the SLP Classroom Inquiry Activities across the Six Units

		Inquiry Fidelity Criteria											
		Models/ Explains		*Scaffolds Participation*		*Inscriptional Tools*		*Manipulatives*		*Students Participate*			
Classroom	*Teacher*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*Grand Mean*	*SD*
1	Donnely	1.6	0.4	1.9	0.2	1.1	0.9	1.1	0.7	1.4	0.4	1.4	0.3
2	Cannon	1.5	0.6	1.1	0.3	1.1	0.8	1.3	0.7	1.5	0.5	1.3	0.2
3	Barr	2.0	0.1	1.8	0.2	1.6	0.8	1.0	0.5	2.0	0.1	1.7	0.4
4	Kellam†	1.7	0.4	1.6	0.8	1.5	0.8	0.7	0.3	1.8	0.4	1.5	0.5
5	Kellam†	1.7	0.2	2.0	0.1	1.5	0.8	0.8	0.6	1.8	0.2	1.6	0.5
6	Burke	1.3	0.3	1.2	0.2	1.1	0.6	1.1	0.3	1.6	0.3	1.3	0.2
7	Ruck†	1.5	0.3	1.5	0.3	1.3	0.6	1.3	0.3	1.6	0.4	1.4	0.2

Note. Ms. Kellam is listed twice in the table because she taught at both schools participating in the project. Models/Explains: Teacher models/explains target concepts; Scaffolds Participation: Teacher scaffolds students' participation by encouraging questions and responding to children's ideas; Inscriptional Tools: Teacher scaffolds use of inscriptional tools (idea board/science notebook); Manipulatives: Teacher uses SLP manipulatives appropriately; Students Participate: Students participate actively in class discussion.

†indicates teachers who used SLP activities for the first year.

TABLE 6
Fidelity Ratings for the SLP Classroom Reading Activities Across the Six Units

		Reading Fidelity Criteria							
			Questions						
Classroom	*Teacher*	*Introduces M (SD)*	*Closed-Ended M (SD)*	*Open-Ended M (SD)*	*Relate M (SD)*	*Novel Science Words M (SD)*	*Responds M (SD)*	*Interest/ Engagement M (SD)*	*Grand Mean M (SD)*
1	Donnely	1.9 (0.1)	2.0 (0.0)	1.6 (0.4)	1.9 (0.1)	1.9 (0.1)	1.9 (0.1)	1.9 (0.1)	1.9 (0.1)
2	Cannon	1.4 (0.6)	2.0 (0.1)	0.9 (0.9)	1.2 (0.8)	1.2 (0.4)	1.4 (0.5)	1.8 (0.4)	1.4 (0.4)
3	Barr	1.8 (0.3)	1.9 (0.2)	1.3 (0.6)	1.3 (0.4)	1.6 (0.3)	1.8 (0.3)	2.0 (0.0)	1.7 (0.3)
4	Kellam†	1.8 (0.4)	1.9 (0.1)	1.6 (0.1)	1.8 (0.4)	1.6 (0.7)	1.5 (0.6)	2.0 (0.0)	1.7 (0.2)
5	Kellam†	1.7 (0.6)	1.6 (0.2)	1.7 (0.6)	1.6 (0.5)	1.7 (0.6)	1.2 (0.4)	2.0 (0.0)	1.6 (0.2)
6	Burke	1.4 (0.4)	1.7 (0.4)	1.5 (0.4)	1.6 (0.4)	1.4 (0.4)	1.4 (0.8)	1.9 (0.2)	1.6 (0.2)
7	Ruck†	1.8 (0.4)	1.7 (0.5)	1.7 (0.5)	1.7 (0.4)	1.3 (0.7)	1.8 (0.4)	1.9 (0.2)	1.7 (0.2)

Note. Introduces: Teacher provides background information, connects the book to SLP activities; Closed-Ended Questions: Teacher asks one or more closed ended questions about the book; Open-Ended Questions: Teacher asks one or more open-ended questions about the book; Relate Questions: Teacher asked questions intended to help the children relate the information to other experiences; Novel Science Words: Teacher engages children in a discussion about the meaning of a new science word; Teacher Responds: Teacher acknowledges and responds to children's spontaneous comments or questions during the reading; Interest/Engagement: Children's interest and engagement during the book reading activities.

† indicates teachers who used SLP activities for the first year.

of manipulatives (0.7–1.3) and inscriptional tools (1.1–1.6) were lowest. Of note, the fidelity of teachers in their first year of using SLP inquiry activities was not appreciably different from those in their third year of participation (Ms = 1.5 vs. 1.4, respectively).

Literacy activities. Teachers' implementation of the literacy activities was slightly higher than for inquiry; their average fidelity ratings ranged from 1.9–1.4 ($M = 1.7$). That is, their practices were closer to full than partial implementation. Ratings of student interest were consistently very high (1.8–2.0), whereas teachers' use of open-ended questions was the least frequently used strategy and quite variable among teachers (0.9–1.7). Like for inquiry activities, the book reading practices of first- and third-year SLP teachers did not differ (Ms = 1.7).

Descriptive indicators of fidelity. In order to convey the nature of the teachers' and children's participation in the SLP lessons we next present excerpts from two teachers' lessons about life cycles, a unit that was fully implemented in the last year of the study and on which we have not presented evidence from classroom episodes in prior work. An outline of the transcription symbols is presented in the Appendix.

Excerpts 1 and 2: Introduction to life cycles (February 11, 2008). These excerpts came from the pre-inquiry activities in Ms. Donnely's classroom. The teacher introduced the Life Cycles unit by stating that every living thing has a life cycle, showed the children the big book *Living Things* (Trussell-Cullen, 2001), and reminded them that they read it when they were discussing "what makes a living thing a living thing!" as part of the Living Things unit activities. The children made spontaneous comments such as "A polar bear, it's a polar bear!" (referring to the book cover) and "We went outside looking for living things!" Ms. Donnely acknowledged these contributions and asked the children for additional examples of living things. The children contributed many ideas (e.g., a spider, monkey, snake, gorilla, lion, crocodile, worm, fish, cheetah, butterfly, horse, turtle, bird, zebra, vulture, elephant, eagle, shark, frog, killer whale, deer) and one child proudly identified himself as a living thing ("Me!").

Ms. Donnely:	Who else can name a living thing?// Yes, Brook?
Brook:	A flower!
Ms. Donnely:	Yes, Brook, a flower would be a living thing // What else is a living thing?//
Mary:	A rose, a rose, [a rose]!
Mel:	[a gorilla]
Ms. Donnely:	A rose, and that is a type of a flower. A rose is a type of a flower.//
Abe:	A dinosaur.
Ms. Donnely:	A dinosaur WAS a living thing . . .
Abe:	Yeah, but they all died!
Ms. Donnely:	They all died out! They are now . . . do you know what that big word that begins with "e" is?
Georgie:	Stinct!
Mary:	Extinct!
Nate:	Extinction!

Ms. Donnely: Extinction! They are extinct! That's very good. That means they were alive, but all of them are gone now. //
Nate: A bird!
Ms. Donnely: Bi:::rds are living things!//
Lane: A, a a a vulture!
Ms. Donnely: A vulture, right, 'cause it's a kind of . . .
Children: (calling out) A hawk! A bird! A hawk!
Ms. Donnely: A bird! That's very good!

Excerpt 1 shows how the teacher supported children's engagement in the discussion using a range of pedagogical strategies. These included acknowledging children's contributions, connecting and extending their responses, adding a temporal perspective ("A dinosaur WAS a living thing . . . ") when necessary, scaffolding children's use and comprehension of recently learned vocabulary ("Extinction! They are extinct . . . , that means . . . "), as well as scaffolding understanding of how objects are grouped into bigger categories (e.g., "A rose is a type of flower" or "A vulture, yes, 'cause it's a kind of . . . a bird").

Next, the teacher invited the children into a discussion about the characteristics of living things, noted contributions on the idea board, and introduced the theme of how things grow and develop. The idea board that resulted from this activity is shown in Figure 1. The children had brought pictures of themselves as babies, toddlers, and kindergarteners that were pasted on the idea board and together with the teacher (who also had brought pictures of herself as a baby, child, and grown-up) they discussed physical changes (e.g., having teeth, growing in size) from infancy to adulthood. To conclude the session, the teacher introduced the book *Isn't it Strange* (Polette, 2004; " . . . and this book is going to show us some of the animals and other living things that go through changes").

Ms. Donnely: (reads) "AN ACORN SPROUTS . . . " An acorn is what?
Marcy: A little nut!
Jamal: A seed!
Ms. Donnely: It is a nut, it is a se:::ed. That's right!
Leticia: It grows trees!
Ms. Donnely: (reads) "AND IT BECOMES A TREE" This little teeny tiny . . .
Nate: Squirrels, squirrels love those!
Ms. Donnely: They do!
Children: (in unison) They eat them!//
Ms. Donnely: (reads) "ISN'T IT STRANGE, HOW THINGS CHANGE? IN THE GARDEN HOUR BY HOUR . . . " so hour by hour these things change. Ah! "A TINY SEED BURSTS AND BECOMES A FLOWER." Does this, boys and girls, does this (points to picture of seed) look like this? (points to picture of sunflowers).
Elijiah: No!
Rodrigo: They started out different!
Ms. Donnely: So, as it grows and develops does it change?
Abe: It will grow and grow (shows growth with hand movements).

FIGURE 1 Idea board used in the lesson described in excerpt 1. The top portion of the idea board has been blurred to protect the anonymity of the participants (color figure available online).

Dana: (describes the growth of a sunflower) First it has the vine and then it has those leaves, the flower, and then it has the head, and the head is the middle part (the part of the sunflower that has the seeds).

Ms. Donnely: It changes just like we change! So do these plants! // What's in the middle of this sunflower?

Tasha: A bulb!

Ms. Donnely: What are those bulbs? (shows picture of sunflower seeds in the middle of the flower)//

Alicia: Seeds!

Ms. Donnely: Seeds. And the seeds are like what to the flower?

Graham: It like a, it's, it like a [little baby].

Ms. Donnely: [Remember what those seeds are going to grow into?] They are what? They are the babies (restating Graham's response) aren't they?

Rodrigo: The baby is inside them!

Ms. Donnely: Yeah! That's where the sunflower makes its babies! Right in there! When this dies it will make more, the seeds will continue on! They'll grow into more sunflowers, won't they?

Rodrigo: It will take care . . . the baby, he takes, takes care of himself, it takes care of itself (inaudible). But now it's up (points to the seed in the picture of the sunflower to show that the plant has grown) and then it got to take care of itself when it drops. It grows on and on and on.
Ms. Donnely: You got it Rodrigo! That's the life cycle!
Rodrigo: And it grows!

An important feature of the SLP activities is the provision of opportunities for children to draw on their experiences and knowledge as entry points into the process of science learning. Excerpt 2 illustrates how Ms. Donnely guided the discussion by encouraging children's contributions, prompting them to make analogies (e.g., " . . . and the seeds are like what to the flower?"), and supporting children's model articulation. Throughout the discussion children readily built and elaborated on each-other's contributions to provide additional details and explanations. For instance, Rodrigo picked up on Graham's idea that a seed is like a baby, and shared his understanding of the process by explaining how the seed (unlike humans or other animals), once it drops on the ground, grows all on its own. Comparable instances of model articulation have been reported with previous cohorts in SLP classrooms across different units of the program (e.g., Samarapungavan et al., 2011).

Excerpt 3: Observing and recording inside chicken eggs (February 21, 2008). This excerpt comes from the inquiry phase of the lesson in the Life Cycles unit, during which children observed chicken eggs, tadpoles, and painted lady caterpillars in Ms. Barr's class. Prior to this activity, children recorded their questions in their science notebooks and the teacher used the idea board as a way of fostering the groups' shared norms for scientific inquiry. The notebook entries reflected the diverse ways in which children represented their questions and included children's own writing and invented spelling, drawings, and dictated questions to the classroom assistant. Sample notebook entries and the idea board are shown in Figure 2. In the preparatory activities, the teacher prompted engagement by recording children's questions and predictions, noted the group's approach to the task (observations and recordings of eggs) and highlighted the socially shared aspects of science by leaving space on the idea board for recording children's findings and conclusions at the end of the task. In the observation activity that followed, each child looked inside an egg with an e-z-scope to see the developing chick and recorded observations in the science notebook. Ms. Barr outlined the activity to the class as follows:
Ms. Barr: After you get a look at it [inside the egg], as scientists
Aramis: (interrupting) [We draw it!
Ms. Barr: We need to draw what we see. That's right, Aramis. We draw it. (she holds up a sheet of paper) We draw at the top, that's the first thing we're doing today. We're looking at it. We're going to draw it. You draw what you see, and then at the bottom (of the paper you draw) your picture of What do you think it will be when it grows up? // As a scientist, I don't think they normally say "I know what's going to happen." They make a prediction. So you are all going to make a prediction. What you think it will look like when it grows up. So, as scientists, we will do more pictures as we see it, as we observe it. And at the very end, we will come up with our conclusion and we'll talk to each other about it. Cuz scientists are excited, when they get all done

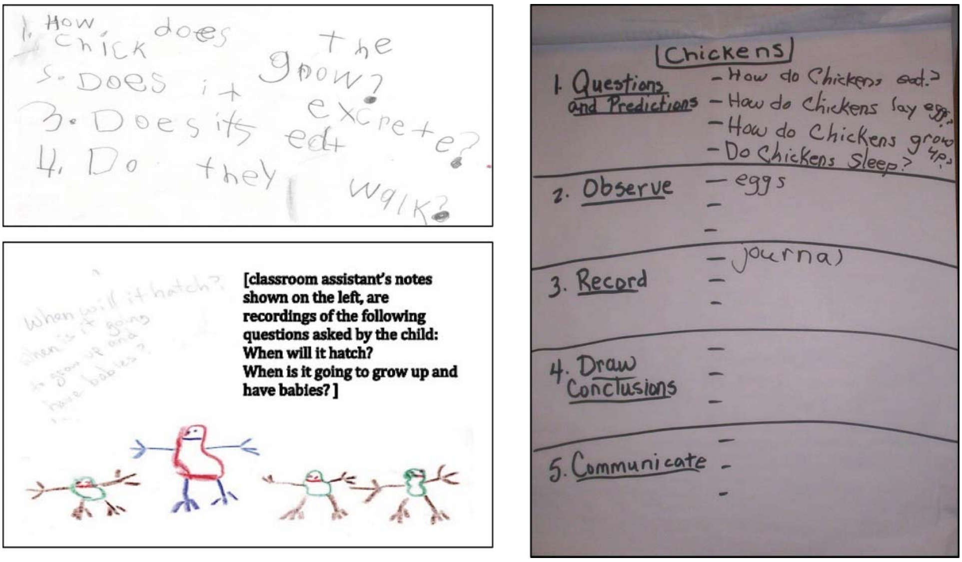

FIGURE 2 Classroom idea board (excerpt 3) and sample notebook entries contributed by children (color figure available online).

> and they come up with a conclusion. And they probably can call their moms and say, "Hey mom, you know what I just found out?" Just like you'll tell your moms and dads what you did at school. So we're going to be scientists today. We're going to observe what is in the incubator.

After this whole-class introduction Ms. Barr called children over to the incubator in small groups, where the children individually looked through the eyepiece to see inside the egg and recorded their observations in their notebooks as well as their predictions of what they thought would happen to the egg. Four examples from children's notebooks are shown in Figure 3 (inscriptions were made by the classroom assistant as the children talked about their drawings). All four children used shades of yellow and orange to represent what they saw through the eyepiece ("I saw orange") and three children predicted that the egg would turn into a chicken. The fourth child's prediction that the egg would turn into a penguin was probably related to the reading about a penguin chick that was included with this unit. Nevertheless, entries such as these are valuable because they may be used by the teacher as avenues for additional discussion and scaffolding children's model elaboration.

Fidelity of SLP Home Activities. Self-reported data from parents in the SLP-CLASS-HM component (collected biweekly by the home visitors) suggested that the parents consistently read the SLP books and engaged in discussions and short activities with their children. The evidence collected included parent logs and activity sheets that parents had completed with their children. Beyond this information, however, the analysis of the videotaped shared book readings provided

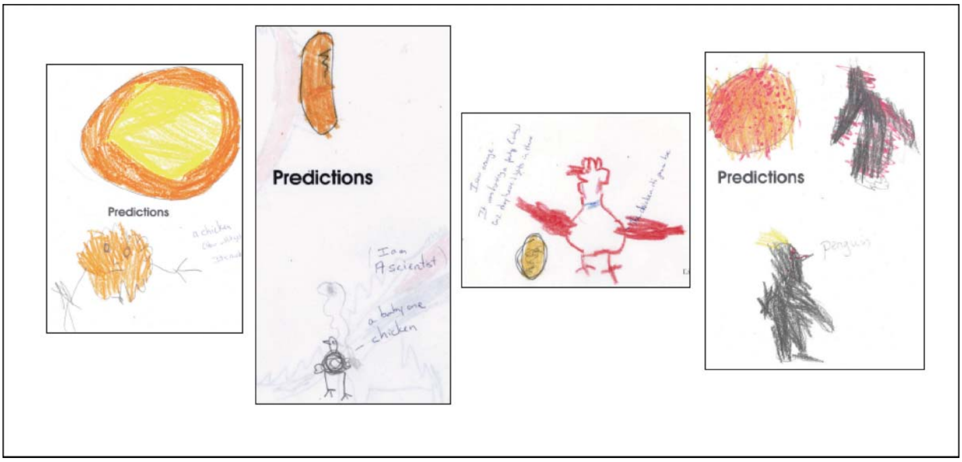

FIGURE 3 Sample entries from four children's notebooks in Mrs. Barr's class (excerpt 3; color figure available online).

important insights into the different strategies that SLP-CLASS-HM and SLP-CLASS parents employed when reading with their children.

Before proceeding with the analysis of the fidelity rubric associated with these activities, we examined the internal consistency of ratings across the specific reading strategy categories of the rubric using Cronbach's alpha. We obtained a strong estimate ($\alpha = 0.87$) and then: (a) created a total reading fidelity score by summing the scores on the specific items and (b) examined group differences via a *t*-test. A statistically significant *t*-test for the total score was followed by a series of *t*-tests on the individual items to identify specific differences between the two groups. Differences in the two engagement items (i.e., *parent reads with expression* and *child is interested and engaged during the reading*) were also examined via *t*-tests. Results are shown in Table 7.

We found significant differences favoring the SLP-CLASS-HM group on the total reading score, total reading time, and the two engagement criteria. Parents of the SLP-CLASS-HM children, compared to SLP-CLASS parents, used more scaffolding strategies, spent more time with the text, and were more engaged during the shared book reading. Similarly, the SLP-CLASS-HM children were rated higher on engagement during the reading (i.e., they interacted more with the reading material and made relevant comments during the reading) than their SLP-CLASS peers. On average, SLP-CLASS children showed signs of sustained attention during the reading. However, probably a reflection of children being typically silent as the parent read the book, the SLP-CLASS children did not engage with the text as their SLP-CLASS-HM peers did (who seemed at ease with making comments and/or asking relevant questions during the reading). Because of the small sample sizes we computed effect sizes to gauge the magnitude of the differences. Effect sizes ranged from moderate (on the engagement criterion) to large (on the total reading score and total reading time criteria).

The follow-up group comparisons on specific reading fidelity criteria showed clear group differences on most of the criteria. However, the means of both groups were relatively small and did not differ on strategies involving efforts to activate background knowledge prior to the book reading, to ask open-ended questions, and to draw attention to the sounds of letters and/or words.

TABLE 7
Analysis of Videorecorded Book Readings: Comparisons Between Randomly Drawn SLP-CLASS ($n = 20$) and SLP-CLASS-HM ($n = 20$) Parent–Child Dyads

Criterion	*Group*	*M*	*SD*	*t*	*ES*
General Reading and Engagement Criteria					
Total reading score	SLP-CLASS-HM	10.75	4.79	3.33**	1.05
	SLP-CLASS	5.65	4.90		
Total reading time	SLP-CLASS-HM	7.88	2.93	2.83**	0.90
	SLP-CLASS	5.39	2.61		
Parent interest & engagement	SLP-CLASS-HM	1.55	0.51	2.03*	0.66
	SLP-CLASS	1.10	0.85		
Child interest & engagement	SLP-CLASS-HM	1.90	0.31	3.38**	0.52
	SLP-CLASS	1.30	0.73		
Specific Reading Criteria					
Draws attention to structural features of book cover	SLP-CLASS-HM	1.56	0.51	3.76***	1.30
	SLP-CLASS	1.00	0.35		
Activates prior knowledge	SLP-CLASS-HM	0.44	0.71	1.22	0.39
	SLP-CLASS	0.20	0.52		
Asks closed-ended questions	SLP-CLASS-HM	1.25	0.79	2.46*	0.77
	SLP-CLASS	0.60	0.88		
Asks open-ended questions	SLP-CLASS-HM	0.40	0.75	0.98	0.31
	SLP-CLASS	0.20	0.52		
Scaffolds participation	SLP-CLASS-HM	1.80	0.41	3.42**	1.12
	SLP-CLASS	1.15	0.75		
Scaffolds connections	SLP-CLASS-HM	1.00	0.97	1.93	0.61
	SLP-CLASS	0.45	0.83		
Draws attention to text	SLP-CLASS-HM	1.50	0.76	3.07**	0.96
	SLP-CLASS	0.75	0.79		
Defines words	SLP-CLASS-HM	0.85	0.93	1.26	0.68
	SLP-CLASS	0.50	0.83		
Draws attention to letters and sounds	SLP-CLASS-HM	0.25	0.55	0.61	0.19
	SLP-CLASS	0.15	0.49		
Responds and acknowledges child	SLP-CLASS-HM	1.50	0.69	2.90**	0.92
	SLP-CLASS	0.80	0.83		
Uses text to support math knowledge	SLP-CLASS-HM	0.40	0.68	2.63*	1.18
	SLP-CLASS	0.00	0.00		

Note. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Also, despite acceptable effect sizes, there were no statistically significant differences between the groups on defining new words and scaffolding connections between children's experiences and the information found in the text.

Examples of Parents' Fidelity. Parallel to our reporting of the classroom activities, we present, in Table 8, excerpts of parent–child talk to convey the nature of the shared book reading and ways that parents supported their children's learning of science, reading, and mathematics. Typical examples of parent strategies are shown for specific reading fidelity rubric criteria.

TABLE 8
Typical Examples from Coded Parent–Child Dialog

Accessing the Child's Background Knowledge Prior to the Book Reading	
Eduardo and his Mom:	
Mom:	(looks over title page with Eduardo) What do you think that you're going to see in the book?
Eduardo:	Beans, how they're born,
Mom:	How what is born?
Eduardo:	The bean.
Mom:	What are beans? What do you think beans are?
Eduardo:	Beans.
Mom:	They are beans, but what are they?
Eduardo:	Um, they're small balls that we can eat.
Mom:	(reads) "BEANS ARE SEEDS THAT GROW IN PODS. WE EAT MANY KINDS OF BEANS INCLUDING KIDNEY BEANS, BLACK-EYED PEAS, AND FAVA BEANS."
*Asking Open-Ended Question*s	
Jennifer and her Mom:	
Mom:	(reads) "INSECTS COME TO DRINK THE NECTAR." What kinds of insects do you think come to drink the nectar?
Jennifer:	Bees (pause), and caterpillars, and butterflies?
Cara and her Dad:	
Dad:	(Dad had read the segment about bees collecting pollen on their hairy legs) What if they didn't have hairy legs? Would it still work?
Cara:	Mmmmm - (non-committal).
Dad:	(laughing) Maybe not so good.
Scaffolding Participation Through Comments and Book-Related Behaviors (e.g., Pointing to Pictures)	
Michael and his Mom:	
Mom:	What are these? (points to picture of different kinds of beans).
Michael:	Black-eyed beans.
Mom:	And these are fava beans (points to picture of fava beans)
James and his Mom:	
Mom:	It's growing, isn't it? (points to picture of bean). Yeah, that's the bean. It grew out of it.
Scaffolding Connections Between the Reading and Children's Experiences or Other Knowledge	
Greta and her Mom:	
Mom:	(pointing) So there is the stalk, it's like between an umbilical cord (inaudible) and the bean.
Jennifer and her Mom:	
Mom:	(reads) "A FIELD OF BEANS." Do we have these kind of fields in Indiana?
Jennifer:	Aha. Daddy used to live in it once, but it had beans and corn.
Mom:	Do you remember what kind of beans?
Jennifer:	um, no! Actually . . . (pauses as she is thinking)
Mom	(whispering in Jennifer's ear) S . . . s . . . s..oy beans?
Jennifer:	Soy beans!
Drawing Attention to Sounds of Letters or Words	
Michael and his Mom:	
Mom:	(p. 4) That's beans. That's a little b.
Michael:	(p. 8) That says steam.
Mom:	Stem.
Michael:	Stem.
Mom:	It seems like it says steam, but there's no A in it.

(Continued on next page)

TABLE 8
Typical Examples from Coded Parent–Child Dialog *(Continued)*

Drawing Attention to New Words and Defining Them	
Cara and her Dad:	
Dad:	What's that word? It's what birds do when they come out of their shell?
Cara:	Hatch.
Dad:	That's what hatch is. To be born out of an egg.
Chris and his Mom:	
Mom:	(reads on p. 30) "... RICH PEOPLE WOULD NOT EAT FAVA BEANS BECAUSE THEY THOUGHT THEY WOULD DAMAGE THEIR SIGHT."
Chris:	What's sight?
Mom:	How they see. They thought they would damage their eyes and they wouldn't be able to see.
Responding to Child and Acknowledging His or Her Comments and Questions	
Larissa and her Dad:	
Dad:	(reads on p. 11) "... FLOWER BUDS BEGIN TO FORM."
Larissa:	Just like buckeyes daddy.
Dad:	Just like buckeyes!
Jillian and her Mom:	
Mom:	(reads about the stalk and asks) See the beans and the little tiny stalks?
Jillian:	It kinda looks like hearts.
Mom:	They do look like hearts.
Using the Text to Support Children's Mathematical Knowledge	
Jennifer and her Mom (counting and estimation):	
Mom:	How many pods do you think there are?
Jennifer:	(counts) 1, 2, 3
Mom:	(prompting for estimation). Well, how many do you think you're gonna have?
Jennifer	Can I count?
Mom:	No, we're not going to count right now.
Jennifer:	Um, 27!
Mom:	27?
Jennifer:	That's a lot!
Mom:	Aha!
Chris and his Mom (making size comparisons):	
Mom:	(reads) "IN JUST FOUR MONTHS A FAVA BEAN GROWS FROM A SEED TO A PLANT AS TALL AS AN ADULT PERSON." It's a tall plant, isn't it?
Chris:	What about, like dad?
Mom:	I don't know if they grow that tall or not. That'd be pretty tall, wouldn't it?
Chris:	Yeah!

Comparison Classroom Science Activities. We now present excerpts from two teachers' lessons about life cycles; the excerpts are typical of the science lessons we observed in the comparison classrooms. The lessons shared similarities with many SLP lessons; the teachers addressed science content through book reading and activities (outlined in Table 4) that required children to provide answers, they related the topic to the children's experiences, and presented science concepts and vocabulary through non-fiction texts. Moreover, the children appeared engaged and interested.

Excerpt 4: Butterfly life cycle activity (April 17, 2008). The following excerpt came from an activity during a lesson about the life cycle of a butterfly in Ms. Milne's class. Ms. Nash, a kindergarten intervention teacher (assigned by the school), assisted Ms. Milne with the lesson.

Ms. Milne:	We're going to make our butterfly book (she is holding one that she has already made), and your butterfly book is going to look something like this, but your butterfly book doesn't look like this yet. And I put brand new sharpened colored pencils in everybody's can because some of these (pointing to the areas to color) are really small. // (The children are given a sheet of paper with an outline of a butterfly, and they color it. It will form the cover of their book.)
Ms. Milne:	What I want you to do, and I want you to listen very carefully. I want you to take scissors! And do you see that big black line that goes all the way around the outside of your butterfly? I want you to cut along that outside line. Now when you get up to his antennas, you're going to have to make a little bit of a curve. Do your very best to stay on the line. (Children begin cutting out the butterfly shapes.)
Jackie:	Do not cut his antennas off.
Ms. Milne:	Nope, don't cut his antennas off, you'll have to cut around them. Then he would be antenna-less.
Ben:	(laughs) That would be an antenna-less butterfly.
Stacey:	Just like my mom calls me toothless.
Ms. Milne:	Just like you're toothless, huh? You're going to have to do a lot of cutting today.
Stacey:	No!
Ms. Nash:	We're going to cut out all the pages in our book. //
Ms. Milne:	Ms. Nash is going to pass around. What comes after (corrects herself) no, no, no. What's the first thing that happened?
Students:	(chorus) Egg.
Ms. Milne:	They lay eggs. So you are going to get a green piece of paper (with an outline of an egg), and you're going to cut around that. But you know what, thank heavens this one doesn't have an antenna so we don't have to worry about it.
Students:	(call out responses) "Yay!" and "Yay, no antennas."
Ms. Milne:	No antennas.
Ms. Nash:	Alright, you can go ahead and start cutting again. // (to Alicia) Good job. Now put that one aside (i.e., cover page) and cut out your green paper, your egg. (The children are cutting.)
Ms. Milne:	Okay, so we've got our egg that we are cutting.
Ms. Nash:	(to Sam) Are you taking your time? Because look at this, look at this paper. I want to show you something. I see a lot of black line on there (meaning he hasn't been cutting on the line). Are you taking your time and doing a nice job?
Ms. Milne:	(to Sarah) Stay on the lines.
Sarah:	I know. I'm trying to.
Ms. Milne:	I know it's hard.
Sarah:	I know.
Ms. Nash:	What comes after the egg? (Some students say "Caterpillar.") That's right. That's going to be this bright orange sheet.

Ian: Bright orange?
Ms. Nash: Bright orange. (Students gasp in excitement.)
Ms. Milne: Got lots to do. (Students make comments such as “I like cutting out”; “It hurts!”; and “I’m going slow so I can go down the lines.”)
Ms. Nash: Alright, what comes after the caterpillar? (Children call out different things: “egg,” “butterfly,” “chrysalis.”) Yeah, we’re just going to go straight to the pupa.
Student: Pupa.
Ms. Nash: Yep.

Despite some similarities, there were considerable differences between this lesson and those within the SLP classrooms. As we found with a previous cohort of comparison children (Samarapungavan et al., 2011), beyond the few, isolated efforts to prompt children’s recall of factual knowledge (e.g., egg, butterfly, chrysalis, pupa) there were no attempts to engage the children with the language and processes of science. Moreover, there was no evidence that the children were aware of epistemic norms and practices that were shared and used in their classrooms as they progressed through their science activity. There were very few open-ended questions, and children mostly listened or responded within Initiation-Response-Evaluation (I-R-E; Mehan, 1985) sequences. There were no instances when the teachers pressed for elaboration, explanation, or understanding; the teachers did not scaffold children’s model articulation and elaboration. The children, unlike their SLP peers, did not spontaneously respond to or elaborate on each other’s contributions as the lesson unfolded. The lesson focused on skills such as cutting using a pair of scissors, and the shared norms that were frequently emphasized included neatness, staying “on the lines” when cutting, and responding with the right answer to the teachers’ factual recall questions (e.g., “what comes after the caterpillar?”; “pupa”). The children were given opportunities to use representational tools (they were instructed to make a butterfly book). However, the teacher’s introduction to the task (“your butterfly book is going to look something like this”) made it clear that the children were expected to produce a single, common illustration that paralleled the teacher’s. Unlike the SLP group, COMP children were not encouraged to think about and represent their own models of the butterfly’s life cycle.

Excerpt 5: Reading of Sunflower Life Cycle (April 22, 2008). This second excerpt from the COMP classrooms typifies the science book reading we observed in the regular science classrooms. It occurred during the first of Ms. Reeve’s lessons about plants. The book, *Sunflower Life Cycle* (Bauer, 2007) was similar to those used in the SLP in that it was an informational text with clear, attractive photographs and used vocabulary specific about plants (e.g., stem, bloom, pollen).

Ms. Reeve: We’re gonna start talking about flowers and plants this week. And today I’m going to read a story about the life cycle of a flower, and the title of our story is *Sunflower Life Cycle* and this story is by Jeff Bauer. I want everyone to sit on their pockets with their legs crossed and their hands in their laps, and their voices (pause to let children respond)
Children: (chorus) Off.

Ms. Reeve: Alright. (starts reading) "LOOK AT THIS BEAUTIFUL FIELD OF BRIGHT SUNFLOWERS. THIS BOOK WILL TELL YOU ALL ABOUT THEM. SUNFLOWERS ARE PLANTS. SO IS EVERYTHING IN THIS GARDEN. PLANTS ARE LIVING THINGS. BUT THEY DO NOT MOVE AROUND LIKE ANIMALS. PLANTS STAY IN ONE PLACE AND GROW. SOME PLANTS HAVE FLOWERS. SOME PLANTS HAVE VEGETABLES OR FRUITS. BOTH ANIMALS AND PEOPLE DEPEND ON PLANTS FOR FOOD." So animals depend on the flowers to get nectar. That's what they eat. (She points to the photos of a humming bird and a butterfly each drinking nectar from flowers.) And we depend on the vegetables and fruits that grow, like tomatoes and watermelon, because that's what <u>we</u> eat. (continues reading) "THERE ARE MILLIONS OF KINDS OF PLANTS IN THE WORLD. DO YOU KNOW WHAT MAKES ALL OF THEM ALIKE?" They all need three things. Do you guys know what they need?
Travis: (calls out) Water.
Ms. Reeve: Shhhh, I want you to raise your hand. Miley, what's one thing?
Miley: You put the seed in the dirt and you cover it up.
Ms. Reeve: Well that's the first step to growing a flower. But what do they need? What do they have to have in order to live? Bernard?
Bernard: Water.
Ms. Reeve: Huh?
Bernard: Water.
Ms. Reeve: They need water. (Teacher signals for Serena to answer.)
Serena: Um::::. ((long pause)) They need, um:::.
Ms. Reeve: What the . . . what's that big yellow thing up in the sky?
Serena: Uh, sun.
Ms. Reeve They need water, they need the sun, and they need . . . Andrea?
Andrea: They need dirt.
Ms. Reeve: They need dirt, or soil.
Austin: (calls out) Or, or, or food.
Ms. Reeve: (resumes reading) "THEY ALL BEGAN AS TINY SEEDS! LET'S TAKE A LOOK AT THE LIFE CYCLE OF A SUNFLOWER TO SEE HOW A PLANT GROWS. THESE ARE SUNFLOWER SEEDS. THEY GET PLANTED IN THE SPRING. THEY NEED WARMTH AND RAIN TO GROW INTO FLOWERS." So, can you plant flowers in the winter outside?
Children: (chorus) No.
Ms. Reeve: No. Well, one, it's really cold and they could freeze. And there's not a whole lot of rain. And if you do water a flower outside in the cold, it'd freeze, right? (Children make sounds of agreement.)
Briana: (calls out) Like this. (She pretends to be frozen solid.)
Ms. Reeve: (to Briana) Alright. (continues reading) "RAINWATER WETS THE GROUND. IT SOFTENS A SEED UNTIL IT BURSTS OPEN."

Once again, despite the similarities—reading a non-fiction book about a life cycle—there were clear differences between the SLP and COMP classrooms. These included the predominance of teacher talk, and few opportunities for dialog among students as well as between students and their teacher. There was no evidence that the lesson and the accompanying reading were linked to key themes that spiraled through the curriculum, affording opportunities for children to revisit their knowledge over time and build on it. This perhaps was an important constraint on children's ability to engage in elaborated talk (e.g., offering examples, building on ideas, offering explanations about processes and mechanisms) during the lesson. Yet, in addition, the teacher prompted for simple yes/no answers and then proceeded to provide causal explanations without giving children the opportunity to do so (e.g., "Well, one, it's really cold and they could freeze. And there's not a whole lot of rain. And if you do water a flower outside in the cold, it'd freeze, right?").

Teachers' accounts of their regular kindergarten science lessons, and our observations of them, appear consistent with published accounts (e.g., Dickinson & Young, 1998; Furtak, & Alonzo, 2010) of typical science instruction in elementary school. Evidence shows that although classrooms may be equipped with structures (e.g., science or nature areas) and materials intended for science learning, instruction places little emphasis on inquiry-oriented science discourse that supports understanding by pressing for reasoning, explanation, elaboration, or argumentation (e.g., Greenfield et al., 2009; Sackes et al., 2011; Tu, 2006).

Analysis of Individual-Level Differences Across the SLP and COMP Groups

Preliminary Analyses and Plan. Examination of the variables' distributional properties revealed acceptable variability and no outliers. Although the distributions for some of the measures were skewed, this was not unexpected. For instance, the negative skew (–1.03) for the PISCES Science Liking subscale is consistent with established developmental trends for young children, who generally hold overly positive motivational beliefs (Harter & Pike, 1984; Marsh, Ellis, & Craven, 2002). Similarly, the negative skews on the WILK subscales at the beginning of the year (ranging between −1.26 and −2.65) reflect children's over-optimistic expectations about the learning opportunities in their kindergarten classrooms. At the end of the year the negative skew of the WILK other school subjects scores (Reading and Math) indicates children's recognition that they experienced the math and language arts activities assessed by the WILK such as learning about letters and numbers. At the same time the smaller skew (–.88) for the WILK science scores is expected given the differences in the opportunities for learning science in the SLP and COMP schools.

The deviations from normality observed for some of the study's variables do not counterindicate the tests of significance used in this study (e.g., MANOVA, as described later in this article). These tests are robust to deviations from normality, even for distributions that are considerably skewed, particularly when no outliers are present and the sample sizes are not small (>30; Hair, Black, Babin, Anderson, & Tatham, 2006; Stevens, 1992). Descriptive statistics on all measures are provided along with the results of significance testing in the next sections.

The main purpose of this study was to examine group differences (SLP-CLASS, SLP-CLASS-HM, COMP) over time (fall to spring) across three science-related domains: (a) general knowledge about science and language achievement, (b) learning about the content and processes of science, and (c) children's perceptions of opportunities for learning science (science topics or activities) in kindergarten. In addition, we investigated end-of-year differences on children's (a) motivation for science based on child and teacher reports and (b) children's perceptions of teacher and family support for learning science. However, prior to conducting analyses to investigate these differences, we: (a) examined the bivariate correlations among the measures examined in this study and (b) focused on the SLP group in order to investigate the relations between the individual outcomes with the level of SLP implementation and teacher experience.

Correlations Among Measures. The findings of the correlational analysis support the construct validity of the SLP-developed individual-level measures and are shown in Table 9. The SLA Science Concepts and Science Inquiry Processes subscales correlated significantly with the other science-related measures used in this study, including: (a) the WJ–III Science Knowledge subtest; (b) children's beliefs about opportunities for learning science content (Learning about Science subscale) assessed by the WILK; (c) teacher ratings of children's interest in science and need for teacher support for science learning; (d) children's perceptions of science liking, competence beliefs in science content, competence beliefs in science processes; and (e) support for learning science from teachers and parents.

Children's reports on the WILK Science subscale correlated significantly ($p < .05$) with other variables used in this study. The strength of the coefficients ranged from small (e.g., .19 with WJ–III Science) to moderate (e.g., .39, .49, and .48 with the SLA Scientific Inquiry Processes, SLA Science Concepts and the PISCES Science Liking subscales, respectively), to moderately strong (e.g., .73 with the PISCES Competence in Science Processes subscale).

Comparable patterns of relations were identified for the PISCES subscales. In addition, scores on the PISCES Perceived Competence in Science Processes and the Perceived Competence in

TABLE 9
Correlations Among Outcome Measures

	1.	*2.*	*3.*	*4.*	*5.*	*6.*	*7.*	*8.*	*9.*	*10*	*11.*	*12.*
1. WJ–III–Science												
2. WJ–III–PC	.16*											
3. SLA–SC	.30**	–.01										
4. SLA–SIP	.29**	.04	.61**									
5. WILK–R&M	.07	.10	.00	.03								
6. WILK–S	.19*	–.05	.49**	.39**	.41**							
7. PISCES–PCSC	.12	.03	.35**	.24**	.22**	.63**						
8. PISCES–PCSP	.17*	.02	.49**	.37**	.24**	.73**	.79**					
9. PISCES–SL	.25**	.08	.40**	.32**	.25**	.48**	.59**	.58**				
10. TRMS-Interest	.26**	.21	.22**	.19*	.02	.10	.16*	.21**	.18*			
11. TRMS-Support	–.24**	–.28**	–.23**	–.19*	–.12	–.14	–.16*	–.18*	–.19*	–.57**		
12. Family Support	.18*	–.04	.34**	.26**	.22**	.53**	.50**	.55**	.40**	.16*	–.33**	
13. Teacher Support	.14	–.05	.41**	.27**	.32**	.76**	.57**	.65**	.48**	.10	–.22**	.57**

Note. $^{*}p < .05$; $^{**}p < .01$.

1. WJ–III Science Knowledge; 2. WJ–III Passage Comprehension; 3. SLA Science Concepts; 4. SLA Scientific Inquiry Processes; 5. WILK Learning about Reading and Math; 6. WILK Learning about Science; 7. PISCES Perceived Competence in Science Content; 8. PISCES Perceived Competence in Science Processes; 9. PISCES Science Liking; 10. Teacher Ratings of Motivation for Science—Interest in Learning Science; 11. Teacher Ratings of Motivation for Science—Need for Support vs. Independence; 12. Children's Perceptions of Family Support for Learning Science; 13. Children's Perceptions of Teacher Support for Learning Science.

Science Content subscales were strongly correlated. For theoretical reasons, however, we retained them as distinct scales and accounted for this overlap by including them in a single MANOVA in our analysis of outcomes (see next section).

The WJ–III Passage Comprehension subscale had relatively small correlations with teacher ratings of children's need for support versus independence in learning science, but as expected it did not correlate significantly with the remaining measures used in the study. Children's perceptions of support for science from parents and teachers were moderately correlated.

Comparability of SLP Students Based on Level of Implementation and Teacher Experience With the SLP. Before investigating differences between the SLP and COMP groups, we focused on the SLP group and conducted two sets of exploratory analyses. The first set examined whether differences in the teachers' levels of SLP implementation were differentially related to child outcomes. This was accomplished by conducting a series of regression analyses to document the effect of implementation on each post-SLP (spring) outcome. For the measures in which baseline data were available (i.e., WJ–III, SLA, WILK), we entered the corresponding pre-SLP score (e.g., the SLA Science Concepts and Scientific Inquiry Process subscale scores) in Block 1 and the teacher's combined inquiry and reading fidelity score in Block 2. For the motivation and social support outcomes, which were not administered at the beginning of kindergarten, we entered the teacher fidelity scores in Block 1. The effect of implementation was not significant for any of the analyses, probably as a result of the limited variability in the teacher implementation scores.

The second set of analyses examined differences between new and veteran SLP teachers. Recall that in the third year of the SLP implementation four teachers had been with the project from the beginning, whereas two teachers, who were newly hired in the district, joined the SLP in its final year. We conducted a series of MANOVAs to examine whether differences in teacher experience (new vs. veteran SLP teachers) with SLP related to the individual-level outcomes. For the outcomes on which we had both baseline and end-of-year measures, we conducted three repeated measures MANOVAs [2 (Time–Fall to Spring) $\times$ 2 (Teacher Experience)], with dependent variables being (a) the WJ–III subscales, (b) the SLA subscales, and (c) the WILK subscales. Next, we computed three MANOVAs for the outcomes on which data were collected in the spring only. Each examined differences between new and veteran SLP teachers on children's motivational beliefs for learning science (PISCES subscales), their perceptions of family and teacher support, and teachers' ratings of children's motivation for science.

The main effect of teacher experience was not significant for the WJ–III, SLA, or WILK. Two significant multivariate effects were identified for children's perceptions of support for science learning, $F\ (2, 116) = 10.92$, $p < .001$, and teacher ratings of children's motivation for learning science, $F\ (2, 116) = 45.72$, $p < .001$. Specifically, children in the new teachers' classrooms reported lower feelings of teacher support for learning science ($M = 2.48$, $SD = .66$) compared to the children in the veteran teachers' classrooms ($M = 2.71$, $SD = .39$). Also, children in the new teachers' classrooms reported significantly lower family support for learning science ($M = .36$, $SD = .28$) than children in the veteran teachers' classrooms ($M = .61$, $SD = .30$). However, three of the four veteran teachers were in School 1 and had students participating in the family component of the project whereas none of the two new teachers did. Thus, this difference supports the validity of children's perceptions of family support and is not indicative of differences in teacher beliefs or strategies.

In summary, the main differences between SLP veteran teachers and those new to SLP seemed to be motivational in nature. Although we do not have data to identify the source(s) of these differences, we conjecture that new teachers, who had less experience with the SLP activities and children's responses to them, may have thought that their students needed more support to learn science concepts. Perhaps this lack of confidence was inadvertently communicated to the children who, despite being actively engaged and learning from the activities, thought that they needed more direction from their teachers. Teacher experience with SLP was not related to changes in children's science knowledge or perceptions of their opportunities to learn science and other subjects in kindergarten.

Differences Among the SLP and COMP Groups. Next, we proceeded with the individual level analyses that were of primary interest in this study—differences between the three groups (COMP, SLP-CLASS, SLP-CLASS-HM). First, we conducted a MANOVA to examine the comparability of the groups at baseline using data on the three sets of individual-level measures collected at the beginning of the year before the SLP began (WJ–III, SLA, and WILK). There were no statistically significant group differences on any of the analyses.

After establishing the groups' comparability at the start of kindergarten, we used multivariate repeated measures analyses of variance to examine group differences as well as the interaction of Time (pre- vs. post-SLP) × Group (COMP, SLP-CLASS, SLP-CLASS-HM). Separate analyses were run on three sets of conceptually related dependent variables: (a) general science knowledge and reading achievement (WJ–III), (b) science learning and understanding of the processes and content of science (SLA), and (c) children's perceptions of what they learned in kindergarten (WILK). The sample sizes for this set of analysis were 190 (WJ–III), 182 (SLA), and 185 (WILK). These variations were due to some children missing a testing session in either the fall or spring of the school year. Results are reported in Table 10.

Lastly, we conducted multivariate analyses of variance (MANOVA) to examine post-SLP effects on: (a) children's motivational beliefs about learning science (i.e., beliefs about competence in science content and process and liking of science); (b) teachers' perceptions of children's motivation for science (i.e., interest and need for support vs. independence in science); and (c) children's perceptions of social support for science from parents and teachers. The sample size across these analyses varied from 184 to 193. Statistically significant multivariate effects were followed by univariate analyses and contrasts to identify the locus of differences. Results are reported in Table 11.

Differences in SLP and COMP children's science and reading skills over time. **S**tatistically significant multivariate effects were identified for Group and Group × Time (Table 10). All time effects (not shown in Table 10 due to space limitations) were also statistically significant, indicating that, regardless of group membership, children's scores increased over time across all variables examined in this analysis. In the next sections we report the results of the univariate analyses and contrast analyses conducted following the identification of a statistically significant multivariate effect. In repeated measures analysis, interaction contrasts are identical

TABLE 10
Results From the Repeated Measures Analysis of Pre-(Fall Baseline) and Post-(Spring) SLP Effects on Science Learning and Literacy

	Pre-SLP (Fall Baseline)		*Post-SLP (Spring)*					
	M	*SD*	*M*	*SD*	*Mean Gain Score*†	F_G	F_{TxG}	*df*
Woodcock-Johnson III						4.11**	3.84**	4, 372
Science Knowledge						3.69*	7.41***	2, 187
COMP	10.78	2.32	12.01	1.62	1.23[a]			
SLP-CLASS	11.45	1.95	12.92	1.66	1.47[a]			
SLP-CLASS-HM	10.44	2.32	12.85	2.01	2.41[b]			
Passage Comprehension						0.12	0.28	2, 187
COMP	5.08	1.79	7.37	3.40	2.29			
SLP-CLASS	5.07	1.48	7.12	2.62	2.05			
SLP-CLASS-HM	5.29	1.27	7.12	2.70	1.83			
Science Learning Assessment						14.87***	20.41***	4, 356
Science Concepts						25.20***	39.73***	2, 179
COMP	5.74	2.20	6.23	1.96	0.49[a]			
SLP-CLASS	5.90	2.12	9.58	2.26	3.68[b]			
SLP-CLASS-HM	5.15	2.09	10.15	2.05	5.00[c]			
Scientific Inquiry Processes								
COMP	4.17	2.08	4.51	2.56	0.34[a]	20.65***	16.67***	2, 179
SLP-CLASS	4.46	1.81	7.58	2.57	3.12[b]			
SLP-CLASS-HM	4.53	1.85	7.35	2.60	2.82[b]			
What I Learn in Kindergarten (WILK)						29.26***	20.52***	4, 362
Learning about Reading & Math						0.04	1.86	2, 182
COMP	0.94	0.12	0.92	0.12	–0.02			
SLP-CLASS	0.91	0.18	0.95	0.12	0.04			
SLP-CLASS-HM	0.91	0.20	0.95	0.13	0.04			
Learning about Science						42.81***	39.34***	2, 182
COMP	0.77	0.30	.41[a]	0.28	–0.36[a]			
SLP-CLASS	0.82	0.27	.88[b]	0.17	–0.06[b]			
SLP-CLASS-HM	0.78	0.28	.91[b]	0.12	–0.13[b]			

Note. *$p < .05$; *$p < .01$; ***$p < .001$.
†Different superscripts indicate significantly different interaction effects indicating differences in group means over time (fall to spring).

to contrasts of gain scores (Levin & Marascuilo, 1977) as are the four interactions contrasts that were conducted to identify changes in group means from the start (T1) to the end of the SLP period (T2):

$$\psi_1 = (\mathrm{COMP}_{\mathrm{T1}} - \mathrm{COMP}_{\mathrm{T2}}) - (\mathrm{SLP}_{\mathrm{CLASS\text{-}HM}_{\mathrm{T1}}} - \mathrm{SLP}_{\mathrm{CLASS\text{-}HM}_{\mathrm{T2}}});$$

$$\psi_2 = (\mathrm{COMP}_{\mathrm{T1}} - \mathrm{COMP}_{\mathrm{T2}}) - (\mathrm{SLP}_{\mathrm{CLASS}_{\mathrm{T1}}} - \mathrm{SLP}_{\mathrm{CLASS}_{\mathrm{T2}}});$$

$$\psi_3 = (\mathrm{SLP}_{\mathrm{CLASS}_{\mathrm{T1}}} - \mathrm{SLP}_{\mathrm{CLASS}_{\mathrm{T2}}}) - (\mathrm{SLP}_{\mathrm{CLASS\text{-}HM}_{\mathrm{T1}}} - \mathrm{SLP}_{\mathrm{CLASS\text{-}HM}_{\mathrm{T2}}});$$

TABLE 11
Group Differences on Motivation and Social Support for Learning Science (Spring of Kindergarten)

	M	*SD*	F_{Group}	*df*	*p*
Children's Motivational Beliefs for Learning Science (PISCES)			26.71	6, 368	<.001
Perceived Competence in Science Content			52.23	2, 186	<.001
COMP	.32[a]	.23			
SLP-CLASS	.64[b]	.27			
SLP-CLASS-HM	.76[c]	.21			
Perceived Competence in Science Processes			87.84	2, 186	<.001
COMP	.28[a]	.27			
SLP-CLASS	.75[b]	.23			
SLP-CLASS-HM	.78[b]	.19			
Science Liking			25.38	2, 186	<.001
COMP	.59[a]	.29			
SLP-CLASS	.83[b]	.23			
SLP-CLASS-HM	.88[b]	.18			
Teacher Ratings of Motivation for Science			16.88	4, 360	<.001
Interest in Learning Science			4.54	2, 181	.012
COMP	3.54[a]	.89			
SLP-CLASS	3.93[b]	.73			
SLP-CLASS-HM	3.83[b]	.69			
Need for Support vs. Independence			22.84	2, 181	<.001
COMP	2.96[a]	.98			
SLP-CLASS	2.74[a]	.94			
SLP-CLASS-HM	1.79[b]	.61			
Perceptions of Support for Learning Science			42.47	4, 374	<.001
Family Support			48.33	2, 188	<.001
COMP	.19[a]	.27			
SLP-CLASS	.43[b]	.31			
SLP-CLASS-HM	.73[c]	.23			
Teacher Support			72.76	2,188	<.001
COMP	1.63[a]	.64			
SLP-CLASS	2.57[b]	.57			
SLP-CLASS-HM	2.73[b]	.37			

Note. Different superscripts indicate statistically significant differences between group means.

$$\psi_4 = (\text{COMP}_{\text{T1}} - \text{COMP}_{\text{T2}}) - [.5(\text{SLP}_{\text{CLASS}_{\text{T1}}} - \text{SLP}_{\text{CLASS}_{\text{T2}}}) + .5(\text{SLP}_{\text{CLASS-HM}_{\text{T1}}} - \text{SLP}_{\text{CLASS-HM}_{\text{T2}}})]$$

General science knowledge and reading achievement. The follow-up univariate analyses indicated that the groups were comparable on the WJ–III Passage Comprehension subtest. Even though their mean scores increased over time, $F(2, 186) = 127.65, p < .001$, the three groups continued to perform equally well on this subtest. However, statistically significant differences were identified on the WJ–III Science Knowledge scale. Specifically, the results of the interaction contrasts suggested the SLP-CLASS-HM group made higher gains over time in general science knowledge than the children in the other two groups, t_1 (187) = –3.77, t_3 (187) = –3.03

(ps < .001). In addition, Contrast 4 was significant and indicated that, over time, the SLP group demonstrated higher levels of science knowledge than the COMP group, t_4 (187) = –2.92, p < .01. Contrary to expectation, the difference between the COMP and SLP-CLASS group was not large enough to be statistically significant, t_2 (187) = –0.92, p = .36.

Science learning and understanding of the processes and content of science. Statistically significant effects were identified on both scales of the SLA. The contrast analysis indicated that the two SLP groups made comparable gains on the Scientific Inquiry Processes subscale, t_3 (179) = .50, p = .62. However, each of the SLP group means as well as the combined SLP group mean was significantly higher over time (all ps < .001) than the mean of the COMP group on the SLA Scientific Inquiry Processes measure [t_1 (179) = –4.10, t_2 (179) = –5.43, t_4 (179) = –5.57].

With respect to learning science concepts, there was evidence of a linearly increasing trend from the COMP to the SLP-CLASS-HM group. Specifically, the SLP-CLASS-HM group made greater gains over time than both the SLP-CLASS group, t_3 (179) = –2.39, p = .02, and the COMP group, t_1 (179) = –8.13, p < .01. At the same time, the SLP-CLASS group's gain was significantly greater than the COMP group's, t_2 (179) = –6.79, p < .001. The fourth contrast was also statistically significant, $t4$ (179) = –8.88, p < .001.

Children's beliefs about opportunities for learning different content in kindergarten (WILK). At the beginning of the school year, regardless of group membership, children were very optimistic about the many different things that they would learn about in school. However, at the end of the school year children's reports about what they actually learned kindergarten diverged by domain (i.e., science, reading, and math) and group.

Children's initial optimism was confirmed for reading and math; at the end of the year their reports of what they had learned were consistent with their estimates of what they would learn. There were no statistically significant group, time, or Group × Time interaction effects on the WILK Reading and Math subscale.

However, important changes were observed on children's perceptions of what they would learn (and what they thought they actually learned) in science. In the fall, SLP and COMP children held comparable expectations about science learning. As shown in Table 10, regardless of group, children endorsed a high number (approximately 90%) of the WILK's science items. However, by the end of kindergarten reports on the science items of the WILK differed significantly by group. Children in both SLP groups identified over 87% of the science content and processes contained in the WILK as having been learned. The contrast comparing the two SLP groups over time was not significant, t_3 (182) = –.96, p = .34.

In comparison, the COMP group's initial optimism was not borne out at the end of the year; those children endorsed about 40% of the WILK Science items. That is, COMP children reported learning less about science compared to either the SLP-CLASS-HM group [t_1 (182) = –7.41, p < .001], the SLP-CLASS group [t_2 (182) = –7.60, p < .001], or the combined SLP group [t_4 (182) = –8.85, p < .001].

Children's Motivation and Support for Learning Science. This analysis (Table 11) examined findings based on measures that were administered at the conclusion of the six SLP unit activities (spring of kindergarten). Statistically significant F-statistics were followed by planned contrasts, three of which examined pairwise group differences (i.e., ψ_1 = COMP - SLP-CLASS-HM; ψ_2 = COMP - SLP-CLASS; ψ_3 = SLP-CLASS – SLP-CLASS-HM) and a fourth that tested the difference in the COMP group mean against the combined means of the two SLP groups. Weights for the latter contrast (ψ_4) were: 1 (COMP), –.5 (SLP-CLASS), –.5 (SLP-CLASS-HM).

Children's motivational beliefs about learning science (PISCES). Statistically significant effects were identified across each of the three PISCES subscales. The contrast analysis showed that the two SLP groups did not differ significantly on the Competence in Science Process [t_3 (186) = –.65, p = .52] and Science Liking [t_3 (186) = –.95, p = .35] subscales of the PISCES. Also, for both these variables each SLP groups' mean (contrasts 1 and 2) and the combined mean of the SLP groups (Contrast 4) were significantly higher than the means of the COMP group ($t_{1process}$ (186) = –11.82; $t_{2\text{process}}$ (186) = –10.55; $t_{4process}$ (186) = –13.12; $t_{1\text{liking}}$ (186) = –6.06; $t_{2\text{liking}}$ (186) = –6.02; $t_{4\text{liking}}$ (186) = –7.11; all ps < .001).

With respect to children's perceptions of competence in science content, the SLP-CLASS-HM group's mean was significantly higher than the SLP-CLASS group's mean, t_3 (186) = –2.66, p = .009, as well as the COMP group's, t_1 (186) = –9.27, p < .001. Also, the SLP-CLASS group's mean for self-competence in science content was significantly higher than the mean of the COMP group, t_2 (186) = –7.92, p < .001. These findings support a linearly increasing trend from the COMP to the SLP-CLASS-HM group.

Teachers' perceptions of children's motivation for learning science. There were significant group differences in teacher ratings of children's interest in learning science and their need for support during science. The contrast analysis on the means for Interest in Learning Science indicated a significant difference between the means of the SLP-CLASS and the COMP group, t_2 (181) = –2.96, p = .003 as well as between the combined SLP and COMP groups, t_4 (181) = –2.75, p = .007. In both cases, the SLP children were rated by their teachers as more interested in learning science. However, there were no differences between the two SLP groups, t_3 (181) = .69, p = .49, and the difference between the SLP-CLASS-HM and COMP groups, t_1 (181) = –1.83, p = .07, was not large enough to reach statistical significance.

Findings identified from the analysis of teacher-rated need for support versus independence in science included no significant differences between the SLP-CLASS and COMP group means, t_2(181) = 1.42, p = .16. However, all other contrasts were statistically significant. The SLP-CLASS-HM children were perceived by their teachers as more independent and needing less support for learning science than either the SLP-CLASS, t_3(181) = 5.50, p < .001 or the COMP children, t_1(181) = 6.52, p < .001. Overall, the SLP teachers reported that their students were more independent science learners than the COMP teachers, t_4 (181) = 4.90, p < .000, who rated their students as needing more support for learning science.

Children's perceptions of support for learning science. Children in the SLP-CLASS and SLP-CLASS-HM groups reported that their teachers provided comparable levels of support for learning science, t_3(188) = –1.46, p = .15. Both groups of SLP children, however, also stated that their teachers provided more support for them learning science than did the COMP children, $t_1(188) = –10.08$, $p < .001$ (COMP vs. SLP-CLASS-HM) and $t_2(188) = –10.35$, $p < .001$ (COMP vs. SLP-CLASS). As expected, the contrast examining the difference between the COMP group mean versus the combined SLP group means also was significant, $t_4(188) = –12.03$, $p < .001$.

Results along expected directions were identified from the contrast analysis of children's perceptions of family support for learning science. Specifically, the SLP-CLASS-HM group reported significantly more family support for learning science than either the SLP-CLASS, $t_3(188) = –5.55$, $p < .001$ or the COMP group, $t_1(188) = –9.78$, $p < .001$. Conversely, COMP children reported the lowest levels of family support for science. Their mean was significantly lower than the mean of the SLP-CLASS children, $t_2(188) = –5.15$, $p < .001$ and the combined mean for both SLP groups, $t_4(188) = –9.05$, $p < .001$.

DISCUSSION

In this study we examined outcomes associated with young children's participation in the classroom and home components of the Scientific Literacy Project (SLP). Using a pretest–posttest control group quasi-experimental design, we provide evidence about the efficacy of the SLP for kindergarten children across indicators of science learning, general science knowledge, motivation, and perceived social support from parents and teachers for learning science. In doing so, we add to the literature in several important ways. First, we contribute to the field through the development of a number of domain-specific, science-related assessments designed to document outcomes across key areas of interest. Second, we provide additional evidence that, when given opportunities for participation in integrated science inquiry and literacy activities, young children develop their knowledge about science. This not only includes general science knowledge but also the structuring of conceptual understandings of science as a domain that comprises its own content and epistemic processes. Third, we establish that learning about science in kindergarten does not compromise language learning, a key focus of the kindergarten curriculum. Fourth, we show that children's motivation for learning science is tied to their experiences in specific settings—home and school in the present study. And fifth, the results indicate that the SLP activities present a realistic curricular option that kindergarten teachers with a range of experiences are able to instantiate with reasonable to good fidelity. These include teachers in their first year of using SLP activities, first year teachers, and teachers with more than twenty years of experience who have not used reform-based teaching practices. In total, our findings offer strong evidence that racially diverse kindergarteners from primarily low-income backgrounds can engage in developmentally appropriate and meaningful science learning through planful and supported school and family involvement.

The Need for Developmentally Appropriate Science-Related Assessments

Although there are a number of standardized and researcher-developed measures for documenting young children's reading and math skills, nothing comparable exists for the assessment of science learning and conceptual understanding or other important social–motivational outcomes related to science learning. This measurement limitation probably accounts for the lack of empirical data on children's science learning and science-related beliefs associated with participation (vs. non-participation) in the reformed-oriented, early science programs described in the literature (e.g., French, 2004; Gelman & Brenneman, 2004). Therefore, in the SLP we began to address a significant gap in the research on early science learning by constructing a number of technically sound, instructionally sensitive, and developmentally appropriate proximal assessments for: (a) documenting children's learning and social–motivational outcomes and (b) conducting comparisons across different instructional programs. Three of our measures (i.e., SLA, PISCES, WILK), developed and used with earlier samples, show solid psychometric properties based on data from the current and earlier samples. Also of note, our measures involve multiple informants (i.e., children's, teachers', and observers' views) and are examined within a social framework that address different learning contexts (i.e., home and school)—another strength of our study.

Learning About Science in Kindergarten

Although there is no clear consensus about what good early science instruction should involve, there is agreement across a number of sources that science learning should comprise domain-specific, contextually relevant themes; these would in turn support children's engagement in the process of inquiry by asking questions, making predictions, gathering data through observations and tools (that facilitate the process of observing and recording findings), evaluating the fit of evidence to their predictions, drawing conclusions, and sharing their findings with others (Samarapungavan et al., 2011). Because literacy-rich experiences are thought to be a critical component of such curricula (Marx & Harris, 2006), and of science as a whole, we focused in the SLP on the use of high quality informational texts to accompany the inquiry activities.

We have documented that the salience and types of science activities that children experience at home and school have implications for their learning. This conclusion is supported by data on a widely used standardized measure of general science knowledge (WJ–III) as well as the SLA, which documents children's learning of the scientific inquiry processes just outlined and the development of concepts associated with life science (both targeted also in the state standards).

All groups of children started the year with comparable levels of science knowledge and skills. However, by the end of the year-long project, the SLP children made greater gains in knowledge and understanding compared to their regular classroom peers. Specifically, the SLP children expanded their general knowledge about science significantly more than did the COMP children. Furthermore, the SLP children also learned more about specific science concepts and content as well as about epistemic processes that are integral to the practice of science. These findings reflect children's increasing experience with the content and processes of science as enacted in the context of the SLP activities. They are in line with the view that in instructional environments where teachers scaffold the development of inquiry skills through modeling, questioning, and the use of inscriptional tools, children also build rich content knowledge and conceptual understanding (Brown et al., 1997; Lemke, 1990). Moreover, the findings support our results from previous years that participation in science inquiry experiences facilitates children's functional understanding of inquiry (Samarapungavan et al., 2008, 2011).

The results for the COMP children are consistent with recent evidence that without explicit and sustained participation in the process of doing science, young children are unlikely to make gains in their knowledge and conceptual understanding. For instance, Greenfield et al. (2009) have shown that Head Start children who, over the course of the school year, received ongoing support in literacy, made significant gains in their readiness for that domain but not in their readiness for science. Similarly, in our study, although both COMP and SLP children experienced growth in their language comprehension skills, only the SLP children experienced gains in science learning.

Of note, there were benefits associated with participation in the home component of the SLP, over and above those garnered from the classroom component. The benefits were specific to measures of science content knowledge—general science knowledge and knowledge of science concepts addressed in the SLP. The home component was an extension of the SLP's classroom literacy activities. Parents were supported in reading the SLP books with their children two to three times (or more) during the week and engaging in dialog during the reading; fidelity data suggest this occurred. Thus, our study confirms that kindergarteners, although they remember and can talk about relevant book content after a single reading of developmentally appropriate informational text (Mantzicopoulos & Patrick, 2010), continue to learn and deepen their understanding with multiple readings (Morrow & Gambrell, 2000).

SLP children's gains in science learning were accompanied by perceptions that they had learned about science content and processes during the school year. At the beginning of school, regardless of condition, children were very optimistic about what they might learn during the kindergarten year and responded affirmatively to nearly every item of the WILK that assessed literacy (e.g., we will learn about reading), math (e.g., we will learn about numbers), and science (e.g., we will learn about the tools that scientists use). However, by the end of the school year, there were differences in children's reports on the Science subscale of the WILK. Specifically, the majority of children who received the regular kindergarten instruction reported that they did not learn as much about the science content and process skills referred to in the WILK (e.g., they were less likely to agree with items such as "We learn about how living things grow" or "We learn to make observations"). Even though the COMP children participated in many different science activities (recounted to us by their teachers and documented in videotaped observations), their lessons differed substantially from those in SLP classrooms. Specifically, despite integration of the science content with literacy and art, there was little attention to disciplinary integrity. There was no explicit science discourse and no evidence of shared norms for science as a process of constructing, evaluating, and sharing knowledge The lessons were generally taught as stand-alone activities with little press for understanding and model articulation. We suspect that this is why the majority of the children who received regular instruction did not express awareness that they learned science in kindergarten.

Does Science Learning Detract from the Literacy Focus of Kindergarten?

An initial concern of the teachers, who underscored the key role of literacy and math (to a somewhat lesser extent) in their curriculum, was that the inclusion of science activities would compromise children's literacy skills. Although, for primarily logistical constraints, the measurement of children's language development was not a main focus of the SLP, evidence from different sources may be used to addresses these concerns, at least in part. Data from an objective measure of reading comprehension (WJ–III), children's reports on the WILK, and teacher interviews, suggested that the systematic inclusion of science during the school year was not harmful to children's literacy learning.

Although the SLP and COMP groups gained differentially on objective measures of science learning, as well as differed on perceptions of the science they learned, they did not differ on reading comprehension. Children in all groups made similar gains on the WJ–III measure of general literacy, and had analogous perceptions of what they learned in reading. The kindergarten teachers further noted that literacy activities (including both reading and writing) were clearly supported as children engaged with science:

> You know, I look at the kids, they're writing, they're spelling, they're reading, and so really (pause) they're pretty much where I want them to be. (They're) where they need to be to be able to go on to first (grade). (Ms. Donnely)

> No, I don't think they missed out (on literacy, reading and writing). I think it (science) made it richer, because I would have been reading a big book of some other kind anyway, and we would have talked about, you know (voice trails off) . . . Now most of the big books are non-fiction, versus a predictable text. (Ms. Burke)

These findings suggest that incorporating approximately two hours per week of science into a previously full kindergarten schedule did not detract from children's literacy development.

Children's Developing Motivation and Support for Learning Science

At the end of kindergarten, children who experienced the regular kindergarten science curriculum reported relatively low levels of competence in science, and moderate levels of liking science. On the other hand, children with the same demographics who participated in the year-long SLP program expressed, on average, significantly greater enjoyment of science and more positive beliefs about their science knowledge and their ability to do science. This is noteworthy because a significant body of literature shows that students' enjoyment and perceived competence of a subject lead to effort, positive engagement, and achievement (Eccles, Wigfield, & Schiefele, 1998; Simpkins, Davis-Kean, & Eccles, 2006; Wigfield & Eccles, 2002). Furthermore, our findings are consistent with reports about positive changes in older students' attitudes as a result of participation in science programs that, like SLP, are inquiry-oriented, involve exploration with meaningful materials, emphasize dialogically oriented classroom discussion, and make science exciting (Vargas-Gomez & Yager, 1987).

In interpreting our results, we note parallels with research on young children's social experiences with learning to read. Nolen (2001), for example, showed that the types and variety of tasks that teachers use, as well as the amount of time they allocate to activities, communicate how much those tasks are valued and impact children's motivation. Perhaps this is one reason why children in the home component expressed beliefs, paralleled by their actual greater science achievement, that they were more competent in science content. At the same time they said they both liked science just as much as their SLP-CLASS peers did and were just as competent with respect to knowing the processes of science. Thus it appears that participation in the home component literacy activities, with its greater emphasis on supporting the learning of the science concepts that children learned during the SLP classroom activities, was associated with the children's actual levels of science knowledge as well as their perceived competence in that domain.

Overall, our findings are consistent with the notion that perceived and actual competence are grounded in and co-evolve as a consequence of children's experiences in their social environments (Patrick & Mantzicopoulos, 2011; Wigfield et al., 1997). Academic experiences are related to the development of beliefs about school competence in different domains, and some researchers have provided evidence for a causal path from experience to beliefs (Chapman & Tunmer, 1995; Wigfield & Karpathian, 1991). For example, research shows that experiences with reading (e.g., Aunola et al., 2002; Chapman, Tunmer, & Pronchow, 2000) and mathematics (e.g., Helmke & van Aken, 1995), including successes or difficulties during the learning process, influence children's enjoyment of these subjects, beliefs of their competence, and their actual achievement. Thus, the nature and extent of the SLP activities arguably communicated to the kindergarteners that science is worthwhile, exciting, and not out of reach for them, in addition to conveying a salient and realistic notion of what science involves.

Limitations and Directions for Future Research

The findings of this investigation must be evaluated in light of the study's possible limitations. One limitation is lack of random assignment of schools and classrooms to the different instructional conditions. To control for this limitation we made several efforts toward ensuring the comparability of the COMP and SLP groups. First, we selected schools within the same district that had comparable sociodemographic and achievement environments, as documented by state-level data. In these schools, teachers' accounts of their typical science instruction were similar and no teacher had engaged in reform-oriented practices prior to the SLP. Whereas SLP teachers, on the whole, had more years of teaching experience, they had not received relevant professional development related to science teaching prior to the SLP.

Second, we documented that the students across the SLP and COMP conditions were comparable on demographic (gender, ethnicity, free-lunch status, language spoken at home), broad achievement (WJ–III Science Knowledge and Passage Comprehension), specific science learning (SLA Science Concepts and Scientific Inquiry Processes), and perceptions of opportunities for learning science, reading, and math (WILK) in kindergarten. However, there may have been a self-selection bias within the SLP-CLASS-HM group; the families who opted to complete this component may have differed from those who opted out in ways that we did not measure and that ultimately affected children's outcomes. Thus the study results do not support a definitive causal path linking participation in the SLP to child outcomes.

Another limitation of the study is that the examiners were not blind to whether children were in the SLP versus COMP condition (they were only blind to the two SLP conditions). Given the longitudinal nature of the project and the benefits of keeping trained project personnel stable over time, it was unrealistic to implement blind assessments across the SLP and COMP conditions. However, we controlled systematic examiner bias through careful training of assessment personnel and ongoing reliability checks across all measures where human judgment was involved.

These limitations notwithstanding, we identified learning and motivational effects for children associated with both the classroom and the combined classroom-plus-home components of the SLP, despite less than ideal circumstances. For example, the teachers implemented the SLP activities in half-day kindergarten programs that had an already full schedule and an almost exclusive emphasis on literacy. Furthermore, in the participating schools, student achievement was lower than average on the state assessements. Parents, too, tended to have little if any education beyond high school and, anecdotally, many told us they had not enjoyed science in school or been successful at it. However, it should also be acknowledged that programs such as the SLP are generally not easy to implement fully without several sources of support (classroom assistance, materials, teacher professional development).

Although our findings support the promise of developing coherent instructional approaches to inquiry science in the early school grades, and connecting school and home activities, future research is needed that examines approaches like SLP implemented with other early elementary grades. Our study does not indicate whether the outcomes were the result of specific features of the SLP (e.g., conceptually coherent science experiences over time) vis a vis the unsystematic and superficial exposure to science in the COMP classrooms. Researchers may wish to tease apart the relative effects of inquiry and literacy experiences, however given the very real time constraints on instruction and the prominent role of language arts in the early years of school, such results may be of limited practical value.

The current study also raises questions about children who participated in these types of activities during kindergarten but whose first grade science was more typical (i.e., sporadic; disjointed; focused on science facts, art, and fiction) rather than as a process of asking and answering meaningful questions over the course of coherently structured experiences. For example, to what extent will they apply the central concepts focused on in kindergarten to what they learn in later years? Will their motivation for science stay positive if the inquiry- and literacy-based activities are not continued in subsequent years? Do programs such as the SLP that engage young children with informational science texts affect children's concurrent or future reading preferences (e.g., informational vs. fictional books)?

Science educators continue to argue for including inquiry science within young children's regular school experience (NRC, 2007). Our findings, based on young, ethnically diverse kindergarteners from low-income families, who attend schools that are not exemplary, suggest that children from all social circumstances can benefit from this curricular approach. However, ongoing research is also needed to document the relations of aspects of science-related instructional programs with both short- and long-term learning and social–motivational outcomes.

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APPENDIX: OUTLINE OF TRANSCRIPTION SYMBOLS

[	Overlapping utterances spoken by two or more people at the same time
//	Break in the transcript, move to a later section
. . .	short pause
. . . . . .	longer pause
CAPS	Emphasis
"CAPS"	Teacher reading from book
:::	short sound stretch
::: :::	longer sound stretch
!	Animation
?	Rising intonation
**	Softness
()	Transcription notes