Kindergarten Teachers' Perceptions of an Inquiry-Based Science Teaching and Learning Professional Development Intervention

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Abstract

Background: Scholars and education reformers alike have re-ignited the importance of teaching science in the elementary grades of the public schools of America by disputing the traditional belief that K-4 learners are too young to learn and function within the nature of science learning and experimentation. The consideration rests on the findings that young learners exposed to inquiry-science skills can develop thinking skills which cultivate analytical, evaluative and problem-solving abilities required for advanced grades. This study examines the impact of a 5-day professional development (PD) for Kindergarten teachers in inquiry-science teaching.

Aims: The 5-day PD was designed to provide a comprehensive experience of inquiry-based science concepts and pedagogy. Two follow-up 1-day PDs were conducted for additional support.

Sample: It was attended by 42 kindergarten teachers in the Los Angeles Unified School District, CA, USA.

Method: All participants attended the 5-day PD and responded to an 11 item pre- and post-PD survey addressing teachers' perceptions of their confidence levels and their concerns and interests in implementing the Full Option Science System (FOSS) inquiry-based science curriculum.

Results: The difference of means, paired-samples t tests and correlation measures show that the 5-day PD helped increase teacher confidence in teaching a science curriculum, reduced anxieties over a new teaching pedagogy, diminished doubts on resource-availability, and stimulated an increased desire to learn how to assess students' learning in science. Ten of the eleven queries showed statistical significance at the .01 level suggesting a high level of success attained in meeting the inquiry-science teaching and learning goals of this PD.

Conclusion: Two follow-up 1-day PDs were conducted at three and six month intervals. The 1-day return PDs showed a marked increase in the level of teacher confidence, peer collaboration, and ease in implementing inquiry-based science pedagogy within a new science curriculum.

Key Terms: Inquiry-Based Science, Professional Development, Teacher Perceptions.

幼兒園教師對探究式的科學教學與專業學習發展的看法

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摘要

*背景：*學者和教育界的改革者們都重新點燃了在美國公立小學應該教育自然科學的重要性，並質疑幼兒園到四年級生因太小而不適合學習自然科學和實驗的傳統看法。這是因為他們發現小朋友接觸探究式的科學教育能夠開發高年級生須學習的分析，鑑定和解決問題的能力。這五天的研究將要測驗幼兒園教師對探究式科學教學與專業學習發展的影響。

*目標：*這五天的幼兒園教師對探究式科學教學與專業學習發展的目的，是提供一個綜合探究式的科學教學理念和教學體驗，並附加進行兩次一 天性的教學與專業學習發展做為額外的復察。

*實例：*出席研究的是二十四名美國加州洛杉磯聯合學區的幼兒園教師。

*方法：*所有參與者都出席了為期為五天的教學與專業學習發展，並在參與前與參與後回答十一題教師對教學與專業學習發展看法的調查報告。這項調查報告包括老師的信心和他們選擇實行全方面探究式科學教學的關切與關注 。

*成果：*所有不同的方法，配對例子，和相關根據都顯示，這五天探究式的科學教學為幼兒園教師的專業學習發展提高了許多信心，降低新教學法的憂慮，減少懷疑資源的可用性，並增長評估學生對科學的學習方式。查詢十一 位裡面有關十位，零點零一（0.01）的統計值顯示，探究式的科學教學與專業學習發展是非常成功的。

*結論：*三至六個月中附加進行兩次一天性的教學與專業學習發展的額外復察。第1天回報教學與專業學習發展的教師提高了信心，與其它教師共同研究，並可以自在的實施新的探究式的科學教學。

主要名詞：探究式的科學教學，教學與專業學習發展，教師看法

Introduction

Scholars and education reformers alike have re-ignited the importance of teaching science in the elementary (K-4) grades of the public schools of America by disputing the traditional belief that K-4 learners are too young to learn and function within the nature of science learning and experimentation (Bybee, 1993; National Committee on Science Education Standards and Assessment and National Research Council {NCSESA and NRC}, 1996; Olson and Loucks-Horsley {Eds.} Committee on Development of an Addendum to the National Education Standards on Scientific Inquiry, Center for Science, Mathematics and Engineering Education and the National Research Council, 2000; Yager, 1993). More and more educators accept the evidence-based studies that elementary learners can also engage in learning science. Such consideration rests on the findings that young children exposed to the science content and processes early on become more skilled as they navigate through science content and processes in the advanced grades. They also attribute the study of science to the development of higher-order thinking skills which cultivate analytical, evaluative, and problem-solving ability all of which further scientific literacy (Hartshorne, 2005, Keeves, 1995; Kennedy, 1998; Rowe, 1992).

It is generally noted that K-4 teachers teach most, if not all school subjects and, at times, without adequate content knowledge and pedagogical background. This inconsistent and deficient educational development has severe implications when elementary teachers are required to teach science without a substantive background to do so (Darling-Hammond, 1999; Hartshorne, 2005; NCSESA and NRC, 1996). Hence, scholars recommend a concurrent attention to teachers' enhancement of content knowledge and pedagogical expertise as a critical piece of the solution to improve science learning and achievement in elementary classrooms.

Review of Literature

Importance of Inquiry-based Science Instruction in the Elementary Grades

Science courses have traditionally been taught in the deductive approach where the instructor first instructs students with concepts, ideas, and facts. This is followed with theoretical models accompanying textbook exercises. Eventually, students get an opportunity to experience real-life problems and find solutions (Prince and Felder, 2007). The accumulative nature of such knowledge is seen most worthy for immediate test purposes with an imprecise promise of future relevancy and in fact may deter motivation towards science literacy (Kardash and Wallace, 2001).

A contemporary approach to inspire students towards the study of science has been generated through inductive learning; where the instructor first presents the students with a specific examination and inquiry or a complex real-world problem to solve. While students observe, inquire and problem-solve they realize the importance of facts, skills and conceptual understandings which the teacher progressively imparts for students to learn (Bransford, Brown, & Cocking {Eds.} Committee on Developments in the Science of Learning, National Research Council,1999; Prince and Felder,2007). Inquiry-based learning resides under the broader purview of inductive teaching methods (examples are: discovery learning, problem-based learning, project-based learning and hybrid (problem/project-based) methods, and case-based learning) and estimated to be more effective to student academic achievement and the development of reasoning

(Colburn, 2006; Prince and Felder, 2007).

Several studies have found performance to increase among students with inquiry-based science instruction as compared to students who received text-based instruction (Chang and Mao, 1999; Johnson and Lawson, 1998; Musheno and Lawson, 1999). The noteworthy Valle Imperial Project in Science in Imperial County (California), USA, documented a 4-year implementation of an inquiry-based instruction using literacy strategies. This instructional approach has led to higher science achievement scores and an overall increase in reading, writing, and mathematics (Goldston, 2005; National Science Resources Center of the National Academy of Sciences and the Smithsonian Institution, 1997).

To this purpose, the National Academy of Science published The *National Science Education Standards (NSES)* in 1996. These standards articulate the vision of learning and teaching science in which all students with diverse interests, abilities, and experiences receive inquiry-based science learning. They advocate quality professional development (PD) for teachers to instruct science, engage in research on science teaching and learning, and communicate their learning with colleagues. The American Association for the Advancement for Science (1993), the National Academy of Science (1996), and the Committee on Development of an Addendum to the National Education Standards on Scientific Inquiry together with the Center for Science, Mathematics and Engineering Education and the National Research Council (CDANESSI, CSMEE and NRC) (2000), also recommend PDs for teachers of science learning through the perspectives and methods of inquiry where teachers actively investigate phenomena, and analyze and interpret the findings consistent to empirically accepted scientific understanding. A recent study reports the promising gains made on a 5-year PD of science teaching and learning of third grade teacher practices and perspectives and the challenges to integrate science, reading and writing, and math education (Lee, Adamson, Maerten-Rivera, Lewis, Thornton and LeRoy, 2008).

The CDANESSI, CSMEE and NRC, (2000) identified Five Essential Features of Inquiry that are embodied in the working of the 5-day PD from which this research presents teacher perceptions in initiating an inquiry-based science curriculum. These five features are:

1. to engage in scientifically oriented questions;
2. give priority to evidence in responding to questions;
3. formulate explanations from evidence;
4. connect explanations to scientific knowledge; and
5. communicate and justify explanations.

Purpose

This kindergarten PD was designed to help teachers expand their (a) knowledge of science concepts; (b) to provide teachers the opportunity to challenge their existing ideas, construct new ones, and resolve dissonance through the nature of inquiry-science; (c) support the needs of English Language learners within science learning; and (d) address teacher perceptions and confidence in the success of implementing inquiry-science.

Methodology

Participants

Forty-two voluntary Kindergarten teachers from the Los Angeles Unified School district (LAUSD) participated and were awarded a financial incentive for attending the 5-day PD. The classroom teaching experience of the teachers ranged from 1-36 years

within grades K-3. An additional breakdown of teaching experiences provided the following ranges: Eleven (11) teachers stated to having 0-5 years of teaching experience; thirteen (13) teachers reported to have taught within a range of 6-10 years; fourteen (14) teachers had a range of 11-29 years of teaching; and four (4) teachers had a range of 30-36 years of teaching experiences. Among the forty-two teachers only a few teachers had teaching experience in grades 1-3. During the time of the PD all forty-two teachers were teaching Kindergarten. All participating teachers had a completed Bachelor's degree (BA) and held a California Multiple Subject Teacher Credential Certificate qualifying them to teach all disciplines within grades K-8.

Participants also reported their years of teaching science in their classrooms: Twenty (21) teachers had a range of 1-5 years of science teaching; Nine (9) teachers reported to have science teaching for 6-10 years; Six (6) teachers had a range of 11-20 years of science teaching; Four (4) teachers had science teaching within a range of 21-29; and Two (2) teachers had a range of 30-36 years of teaching science.

The teachers taught science based on teacher and school initiatives leaving schools to adopt independent k-4 science textbook publisher promotions. Such textbook adoptions did not advocate inductive learning and was often accompanied with inadequate science kits/resources for whole class student participation in laboratory or experiment-based engagement on learning science. The LAUSD district wide initiative for the adoption of the FOSS curriculum and mandated 90 minutes of weekly science instruction in the k-4 classrooms supported research-based inductive pedagogy through inquiry-science instruction.

The PD consisted of a 5-day intensive inquiry-science intervention, with two follow-up 1-day PDs at the three-and six-month interval. They observed and compared two sets of animals from the FOSS[1] Life Science unit "Animals 2x2" (goldfish/guppies, land and aquatic snails, and isopods) in their natural environment to explore animal structures, behavior and habitat. In addition, the PD facilitators created an Animals 2x2 science immersion[2] unit to complement the FOSS Animals 2x2 unit. The PD facilitators consisted of a science content faculty expert, a pedagogy expert, and two K-4 elementary science lead teachers/coaches.

As a result of participating in this 1-week institute, participants would be expected to:

* implement the FOSS Animals 2x2 curriculum in their classrooms,
* understand the California Kindergarten Science Content Standards and Frameworks that students are required to learn in Animals 2x2 curriculum,
* develop the abilities to teach Animals using the instructional model, conceptual flow, and inquiry framework designed in the unit,

[1] FOSS (Full Option Science System) is a research-based science curriculum for grades K–8 developed at the Lawrence Hall of Science, University of California, Berkeley, and is an adopted curriculum by the LAUSD K-8 teachers. Correlations have been created between the FOSS program and a number of science standards, including the National Science Education Standards. FOSS California is designed and written to align completely with the Science Content Standards for California Public Schools and the Science Framework for California (www.fossweb.com/CA).

[2] Science "Immersion units" are teacher guides designed by SCALE (System-wide Change for All Learners and Educators) members to complement the science modular curriculum used for the PD intervention.

* develop an understanding of inquiry using the five Essential Features of Inquiry as defined by the *National Science Education Standards,*
* understand how integrated resources assist in developing students understandings of the key concepts and process skills in this unit

The "Science Inquiry[3] Map" (see Figure 1) illustrates the interconnections and highlights the often-cyclical nature of inquiry developed for the PD. The Science-Inquiry Map was developed by the SCALE partners (System-wide Change for All Learners and Educators) so students may develop explanations that lead to a new scientific query or how one may revisit evidence in the light of alternative explanations. In certain instances, depending upon subject matter, availability of time, student prior experiences, knowledge and skills, some features may receive more emphasis.

The Five-Day Inquiry-Science Professional Development (PD) Intervention

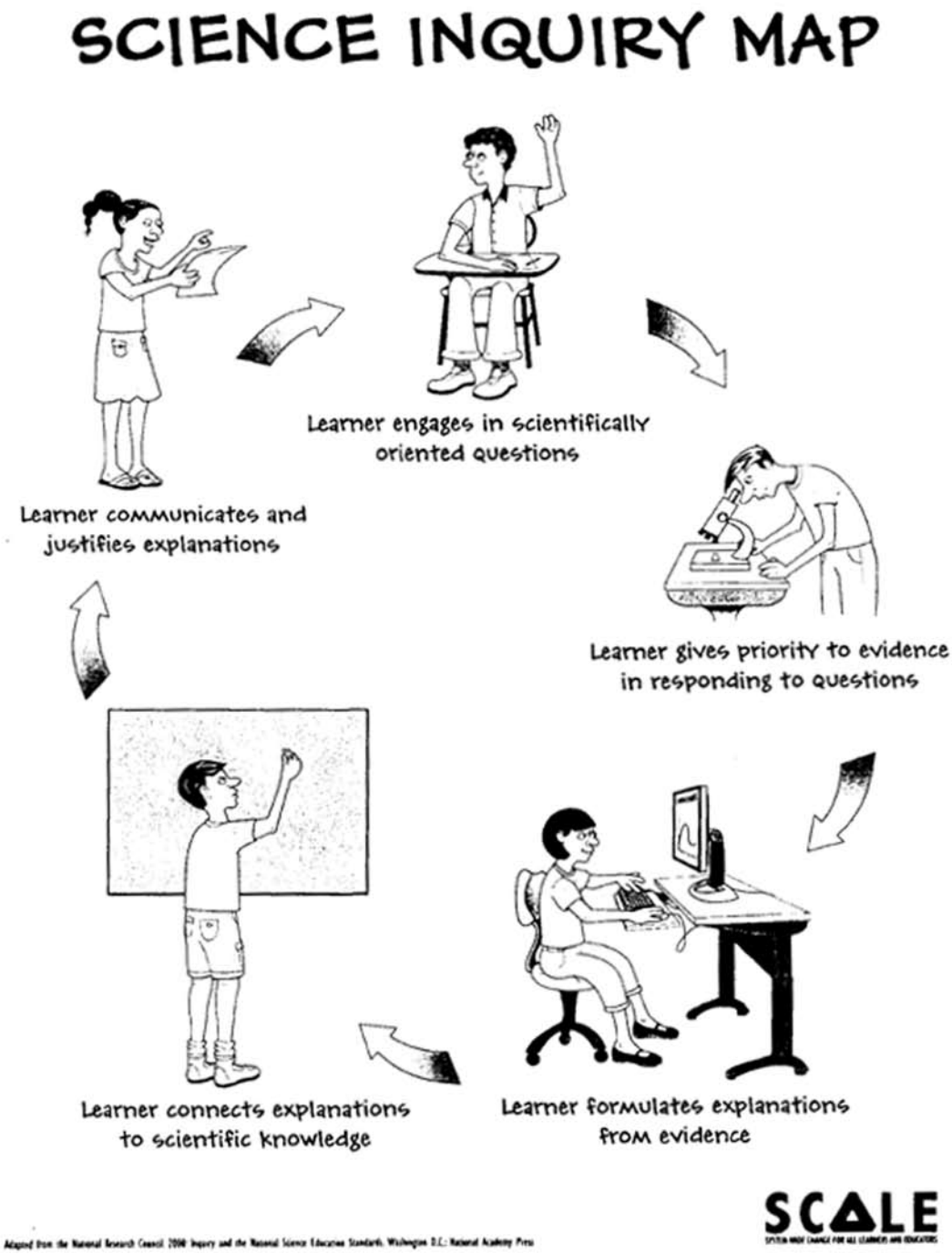
The PD institutes are part of a 5-year comprehensive SCALE grant partnership. This partnership embodies a national network of more than 50 working groups of educators and researchers focused on improving science teaching at all levels of the K-12 grades. The project includes the PD interventions at four major urban school districts (Denver Public Schools, Los Angeles Unified School District, Madison Metropolitan School District and Providence Public Schools). The 5-year inquiry-based science partnership involved three universities (University of Wisconsin-Madison, California State University, Dominguez Hills and California State University, Northridge).

Teachers Engage, Explore and Explain Their Inquires of Goldfish and Guppies

Day one commenced with all teachers engaging in the development of institute behavior norms, formation of collaborative working groups, participation in introductions and responding to the pre-PD survey questionnaire on perceptions and confidence levels of inquiry-based science teaching. The day proceeded with teachers learning as students through the process of inquiry. The concepts of "engage, explore and explain" guided teacher observations of the key structures, behavior, and habitat of goldfish and guppies in individual tanks. Facilitators responded to teacher queries with additional queries or questions (for example, "*How do you know that? I wonder why?*") in lieu of a readily available conceptual response. Through the creation of teacher dissonance, dialogue, and documentation of visual observations (Loucks-Horsley, Love, Stiles, Mundry and Hewson, 2003), teachers were gradually disseminated with concepts, ideas and facts on the structures, habitat, and basic needs of goldfish and guppies.

To fossilize the inquiry process, teachers explained their observations, compared and contrasted their understandings of guppies and goldfish structures and habitat within the "explain and confirm" sequence. Teacher learning was then advanced to understand how the integrated resources (e.g. read fact and fictional story books on fish care, draw and name parts of fish, and cut and create models of fish for kinesthetic learning) supported

[3] This study has used "Inquiry-science" and "Science-inquiry" interchangeably to apply the use of inquiry-based approaches to science instruction for the PD.



Adapted from the National Research Council 2000 Inquiry and the National Science Education Standards. Washington D.C.: National Academy Press

teacher and student understandings that can transfer beyond the textbook content. This was made evident by participants engaging as learners in the creation of the resources and then reflecting on how the resources support the teaching of the science content and process skills. Finally, facilitators discussed and responded to teacher questions of how the adaptive inquiry-based science instruction differed from text-based science instruction (Prince & Felder, 2007).

Teachers Reflect on Day One and Create Habitats for Land and Aquatic Snails

On **day two**, teachers reflected on the first-day activities by engaging in lessons as learners and then developed a list of activities that could support all learners. The teachers were introduced to Animals 2x2 from the FOSS curriculum guide promoting the observation of two animals with very similar and some dissimilar structures, habitat and behaviors. Both land and aquatic snails were introduced and supported with discussions about structures, behaviors, and basic needs of snails. Teachers were provided the opportunity to learn how to maintain land snails in the classroom. They created a "Teacher Wall" addressing the explanations for essential inquiry-science elements underpinning the lessons and meeting the kindergarten science standards.

Teachers Apply Inquiry-Science through Peer Teaching Experience on Earthworms and Night Crawlers

On **day three**, after reflecting on the previous day, the participants continued to develop their understanding of what inquiry science would look like with student instruction and the skills needed to facilitate it. Through collaboration, teachers identified places within the lessons where they could engage in the features of inquiry science. Facilitators initiated discussions about the iterative nature of the Inquiry Science Map, and the techniques needed to collect evidence for long-term investigations. Teachers engaged in discussions and explored additional science books and technology resources to enrich their instruction. They identified places in a lesson unit where additional conceptual information would be beneficial for the teacher's science content knowledge and for students to take science beyond the classroom parameters.

A major milestone of the third day of the PD was experiencing the nature of inquiry-science through its conceptual understanding and application. Teachers independently taught a unit on earthworms and night crawlers to fellow teacher participants using the five steps of the inquiry science cycle. Later, the teachers constructed the "Teacher Wall" that included explanations for the rationale underpinning the lessons.

Model of the "Think Aloud" Strategy for Science Experiment

On **day four**, teachers demonstrated knowledge of isopods' structures, behaviors, and the way they use those structures to meet their basic needs and survival. Teachers identified places within the instructional materials where they could get additional information to support inquiry science teaching and learning. The facilitators constructed and modeled an interactive "Think Aloud" strategy demonstrating a science experiment to guide teachers to conduct their own investigation (ex; "To Act like a Scientist"), collect data, analyze and interpret data to validate their findings based on evidence. Teachers used the "Think Aloud" strategy to design their own collaborative experiment and discussed the cyclical nature of the 5 steps to inquiry-science.

Processes of Inquiry Science and Implementation-Calendar for School Year

On **day five** teachers focused on the process of asking and answering questions related to the facilitation of student-directed investigations. Discussions described how analyzing animals support students in learning about science content and the work of scientists. Teachers were given collaborative time to develop an implementation calendar aligned with individual school schedules. Finally, the participants evaluated the institute by responding to the post-PD questionnaire. A summary of the 5-day activities is shown below.

Summary of Activities During the Five Days of An Inquiry-Based Science PD

- Participants observed and compared two animals (goldfish/guppies, land/aquatic snails, etc.) in their natural environment to explore animal structures and behavior.
- Facilitators posed questions instead of providing answers "How do you know that?" (HDYKT) and "I Wonder Why?".
- Created a "Gots and Needs" bulletin each day to assess what was learned and what needed to be addressed.
- On day 1 the "gots" were less and "needs" were more. Over the next 4 days, "gots" gradually increased and "needs" reduced.
- On days 1 and 2, participants were adult learners of inquiry-based science immersion units.
- Prepared "Teacher Walls" addressing the explanations for essential inquiry-based science elements underpinning the lessons.
- Continuously monitored that the California Kindergarten Science Content Standards and Framework were met.
- On day 3 participants engaged in collaborative preparation and presentation of inquiry science.
- On day 4 participants designed an interactive "Think Aloud" science experiment called "To Act Like a Scientist" and used the 5-step cyclical nature of inquiry science.
- Diverse learner teaching strategies were presented to meet all learner needs.
- Addressed integrated resources for conceptual understanding (fact/fictional text, animal artifacts, etc.).
- After day 1, each day began with reflective analysis of the previous day's activities.
- Finally, before concluding on day 5, each participant prepared an Implementation Calendar for the School Year.

Survey Questionnaire

This study measures the impact of a five-day PD intervention on teachers' perceptions on implementing a new science curriculum using the inquiry-based science instruction. Separate pre-PD (at the start of day one) and post-PD (at the end of day five) surveys were conducted. The survey was in the form of a questionnaire with 11 items[4] and participants were asked to respond on a Likert scale that ranged from 0 (*unrelated*) to 1 (*not accurate of me*) to 7 (*very accurate of me*). The 11 items cover four clusters of teacher perceptions.

[4] A SCALE survey entitled July 2007 QED Institute Teacher-Participant Survey was prepared by Evaluation & Development Associates, Pasadena, CA and is different from that used in this study. The SCALE survey extended over 5 pages and included sections on meeting the Institute's goals, comfort level in implementing unit's lessons, general reactions, and general comments. For example, it had 29 questions assessing knowledge and skills alone.

Professional Development Survey

Cluster 1: Confidence Level Responses
1.I have confidence/knowledge to use the FOSS Animals science curriculum units. 2.I know what science inquiry learning is about. 3.I know what science immersion is about. 4.I am motivated to use FOSS science investigation units for inquiry learning.
Cluster 2: Concerns and Issues Responses
5.I am concerned in having enough time to teach a new content and its curriculum units each day. 6.I am concerned about how science inquiry and immersion units affect student learning. 7.I would like to know what resources are available when I teach from the FOSS science curriculum.
Cluster 3: Learning Assessment, Diverse Learners and Scientific Belief Responses
8.I would want to know how to assess student learning of science. 9.I would like to know the effect of using science inquiry and immersion units for diverse learners. 10.I am concerned about students' scientific beliefs at home and the science units to be taught at school.
Cluster 4: Collaborative-Work Response
11.I would like to collaborate with other teachers in the district to maximize the effects of science inquiry.

Items 1-4 measure how teachers perceive their levels of confidence in implementing a science curriculum. All four items are positive reflections of teacher perceptions. Answering a 6 or 7 on a Likert scale would indicate teachers have a high level of confidence entering the new curriculum instruction. Items 5-7 measure participants' anxiety levels and their concerns. While all participants may have confidence or knowledge to teach an inquiry-science curriculum, these items seek to understand what concerns they may have in implementing this new instructional method. These items began with "I am concerned" and "I would like to know" statements. They contrast the "I have the confidence" and "I know" statements used in items 1-4. Expressing any anxiety would help the PD facilitators address issues and provide resources to reduce stress.

The next set of 3 items address learning assessment and how to measure student learning of science (item 8), how to teach diverse learners (item 9), and, the presence and challenge of meshing scientific beliefs at school, at home and in the community (item 10). Finally, item 11 highlights teachers' willingness to collaborate with other teachers to help maximize the district's efforts in the implementation of an inquiry-science curriculum.

Analysis of Results

Forty-two teachers attended the 5-day PD and responded to the survey. For each item, sample means and standard errors are computed for both pre-PD and post-PD responses. The difference between the post-pre means and a correlated groups (difference of means paired-samples) t-statistic is presented. The Pearson r correlation coefficient is also included. For the t-test of n=42, the degrees of freedom (df) are 41, and the 1-tail t critical is 1.68. Only 1-tail tests are discussed as it is hypothesized that the PD intervention will improve teacher perceptions and are one-way directional. The results are discussed cluster-wise in Tables 1-4.

TABLE 1

Cluster 1: Confidence Level

Paired-Samples (Correlated Groups) t Tests

	Descriptive Statistics		Post-Pre Statistics		Paired Test (Difference of Means)		
	Mean	Std Error	Mean	Std Error	t-stat	Prob(T<=t)	Pearson r
1. I have the confidence/knowledge to use the FOSS Animals science curriculum units.							
Pre	2.14	0.27					
Post	6.02	0.14					
Difference			3.88	0.30	12.88	0.000	0.03
2. I know what science inquiry learning is about.							
Pre	2.57	0.27					
Post	6.14	0.18					
Difference			3.57	0.36	9.99	0.000	-0.26
3. I know what science immersion learning is about.							
Pre	3.29	0.32					
Post	6.05	0.18					
Difference			2.76	0.38	7.25	0.000	-0.07
4. I am motivated to use FOSS science investigation units for inquiry learning.							
Pre	5.64	0.24					
Post	6.52	0.11					
Difference			0.88	0.26	3.39	0.001	0.08

For the t-test of n=42, the degrees of freedom (df) are 41, the 1-tail t critical is 1.68

Item 1 compared the confidence and knowledge level that each teacher had in order to use the FOSS Animals 2x2 science curriculum units. Before the PD, the teachers had a mean level of 2.14 with a standard error (s.e. hereafter) of 0.27. The post-PD mean rose to 6.02 with a reduced s.e. of 0.14. The difference of means test had a t statistic of 12.88 which is statistically significant at the .01 level, suggesting that teachers' confidence and their knowledge to use the science units had increased following the PD.

The Pearson r is insignificant at 0.03 suggesting no relationship between pre- and post-PD confidence levels.

Item 2 compared the knowledge teachers have of what science inquiry learning is about. Teachers had a pre-PD mean of 2.57 (s.e. of 0.27) and a post-PD mean of 6.14 (with a drop in s.e. to 0.18). The mean difference t-statistic of 9.99 is statistically significant at the .01 level. The Pearson r at -0.26 suggests that there was an adjustment towards the mean. Teachers with high pre-PD knowledge of science inquiry were reducing their surety on what it was after the PD. While teachers with a low acceptance of what science inquiry is about felt more comfortable with their knowledge of science inquiry after the PD.

Item 3 compared what teachers knew about science immersion learning. The pre-PD mean of 3.29 (s.e. of 0.32) rises to a post-PD mean of 6.05 (s.e. fell to 0.18). The difference of means t statistic at 7.25 is statistically significant at the 0.01 level, suggesting that teachers knew more about what is science immersion learning after the PD. The Pearson r was -0.07 and is not significant.

Item 4 asks teachers how well they are motivated to use FOSS science investigation units for inquiry learning. It must be noted that all the teachers have been selected by the district to teach the FOSS science curriculum. There is an inherent tilt towards either science teaching, or these teachers want to maximize their learning (during this 5-day PD) on how to teach FOSS. The pre-PD mean of 5.64 (s.e. of 0.24) shows the sample is highly motivated to use FOSS units for inquiry learning. The post-PD mean rises to 6.52 (s.e. drops to 0.11) and the t-statistic of 3.39 is statistically significant at the 0.01 level. The Pearson r of 0.08 shows no significant correlation between pre-PD and post-PD motivation.

TABLE 2

Cluster 2: Concerns and Issues

Paired-Samples (Correlated Groups) t Tests

	Descriptive Statistics		Post-Pre Statistics		Paired Test (Difference of Means)		
	Mean	Std Error	Mean	Std Error	t-stat	Prob(T<=t)	Pearson r
5. I am concerned in having enough time to teach a new content and its curriculum units each day.							
Pre	4.90	0.29					
Post	3.64	0.28					
Difference			-1.26	0.31	-4.09	0.000	0.41
6. I am concerned about how science inquiry and immersion units affect student learning.							
Pre	4.12	0.33					
Post	2.71	0.33					
Difference			-1.40	0.41	-3.46	0.001	0.25
7. I would like to know what resources are available when I teach from the FOSS science curriculum.							
Pre	5.86	0.24					
Post	3.88	0.34					
Difference			-1.98	0.35	-5.65	0.000	0.30

For the t-test of n=42, the degrees of freedom (df) are 41, the 1-tail t critical is 1.68

The first concern addressed was whether teachers have enough time to teach a new content and its curriculum units each day. The pre-PD mean of 4.90 fell to a post-PD mean of 3.64. Both had a similar s.e. of around 0.29. The t statistic for the difference of means was -4.09, and this is statistically significant at the 0.01 level, suggesting that teachers' concerns had significantly reduced following the PD. However, of interest, is the high Pearson r of 0.41. While the PD has reduced teachers' concerns, the drop is still related to the same teachers before and after the PD. So teachers who entered the PD with a high concern, exited from the PD still having a high concern. While those who entered the PD with a low level of concern exited from the PD with an even lower level of concern.

Item 6 evaluates teachers' concerns about how science inquiry and immersion units affect student learning. Here the focus is on the pedagogy of student learning through a new method that relies on science inquiry and science immersion. The pre-PD mean was 4.12, and the post-PD mean was 2.71. Both had an identical s.e. of 0.33. The t statistic for the difference of means was -3.46 and this is significant at the 0.01 level. This suggests that the PD did reduce teachers' concerns on how science inquiry and immersion units affect student learning. There was a moderate Pearson r of 0.25 linking teachers' concerns to their prior feelings even after the PD.

Item 7 focused on what resources are available when teaching from the FOSS science curriculum. Teachers had a high pre-PD mean of 5.86 (s.e. of 0.24) which dropped to a post-PD mean of 3.88 (s.e. of 0.34). The test statistic for the difference of means had a high t statistic of -5.65 which is statistically significant at the 0.01 level. This suggests that teachers' anxieties were addressed by the PD and they now had a better feel for what resources are available when teaching from the FOSS science curriculum. Similar to items 5 and 6, the Pearson r is a moderate 0.30 suggesting that the same high-anxiety teachers stay highly anxious after the PD, albeit at lower levels.

TABLE 3

Cluster 3: Learning Assessment, Diverse Learners, Scientific Beliefs

Paired-Samples (Correlated Groups) t Tests

	Descriptive Statistics		Post-Pre Statistics		Paired Test (Difference of Means)		
	Mean	Std Error	Mean	Std Error	t-stat	Prob(T<=t)	Pearson r
8. I would want to know how to assess student learning of science.							
Pre	5.95	0.19					
Post	3.40	0.31					
Difference			-2.55	0.36	-7.15	0.000	0.04
9. I would like to know the effect of using science inquiry and immersion units for diverse learners.							
Pre	5.36	0.30					
Post	3.69	0.35					
Difference			-1.67	0.40	-4.14	0.000	0.23
10. I am concerned about students' scientific beliefs at home and the science units to be taught at school.							
Pre	4.02	0.32					
Post	2.79	0.30					
Difference			-1.24	0.37	-3.31	0.001	0.28

For the t-test of n=42, the degrees of freedom (df) are 41, the 1-tail t critical is 1.68

Item 8 allowed teachers to enter more broadly into the skill of assessing student learning of science. How to assess and evaluate student performance was an important learning-tool provided during the 5-day PD. Inquiry-based science learning differs from text-based instruction and the ability to measure (assess) student performance must be objectively recorded. The pre-PD mean of 5.95 (s.e. of 0.19) drops to a post-PD mean of 3.40 (but the s.e. rose to 0.31). This suggests that while the need to learn student assessment in science learning was satisfied by the PD; the variation in teachers' perspectives on how to assess students increased. Testing for difference of means in the correlated groups test shows a t statistic of -7.15, which is statistically significant at the 0.01 level. This query had a Pearson r of 0.04 suggesting that there was no relationship between what teachers wanted to know about student assessment before or after the PD.

Diverse learners and the effect of using science inquiry and immersion units were addressed in item 9. A high pre-PD mean of 5.36 (s.e. of 0.30) drops to a post-PD mean of 3.69 (s.e. of 0.35). The mean difference t-statistic of -4.14 is statistically significant at the 0.01 level, suggesting that teachers were more comfortable after the PD as to how using science inquiry and immersion units will affect diversity learners. The Pearson r is a moderate 0.23, and shows teacher anxiety stays even after the PD.

Students' scientific beliefs at home and the science units to be taught at school were focused here. Teachers had a pre-PD mean of 4.02 (s.e. of 0.32) which dropped to a post-PD mean of 2.79 (s.e. of 0.30). The difference of means t statistic of -3.31 is statistically significant at the 0.01 level. The PD helped reduce anxiety as to home beliefs and what is taught at school. Again, a moderate Pearson r of 0.28 shows teachers entering with a high anxiety are also the high-anxiety teachers after the PD. The evidence suggests that there may be a sub-set of teachers repeatedly expressing their anxieties even though the items in the survey (items 5-7, 9 and 10) are distinct and separate. Still, the test results for each of these items signify that the PD had successfully addressed each issue and helped reduce teachers' concerns and anxiety levels.

TABLE 4

Cluster 4: Collaborative Work

Paired-Samples (Correlated Groups) t Tests

	Descriptive Statistics		Post-Pre Statistics		Paired Test (Difference of Means)		
	Mean	Std Error	Mean	Std Error	t-stat	Prob(T<=t)	Pearson r
11. I would like to collaborate with other teachers in the district to maximize the effects of science inquiry and immersion units.							
Pre	5.21	0.27					
Post	5.26	0.27					
Difference			0.05	0.29	0.17	0.430	0.43

For the t-test of n=42, the degrees of freedom (df) are 41, the 1-tail t critical is 1.68

The last query asked if teachers would like to collaborate with other teachers in the district to maximize the effects of science inquiry and immersion units. Both the pre- and post-PD means were high at 5.21 and 5.26 respectively. Both had a similar s.e. of 0.27. The test statistic at 0.17 is not statistically significant. Teachers' opinions on collaboration were not changed by the five day PD. This is the only query that did not show any change following the PD. However, the Pearson r is high at 0.43 suggesting that teachers who are highly motivated to collaborate before they started the PD stay as highly motivated to collaborate after the PD.

Three and Six Month Interval PDs with Classroom Experience

After the 5-day PD concluded, K-teachers were encouraged to apply the inquiry science teaching approach in their respective classrooms at the commencement of the academic year. Two additional follow-up 1-day PDs were conducted in November 2007 and February 2008 at three and sixth month intervals and were voluntary with no financial incentives. The first 1-day PD was organized for teachers to receive assistance to help implement the new science curriculum. Teacher initiated queries to embed inquiry science processes were answered for effective instruction and learning. Peer-teacher interactions led to problem-solving instructional logistics and constructive input of teaching support.

The second 1-day PD extended teacher collaboration through the review of student science activities and classroom science artifacts. Eleven teachers attended this second PD and responded to the same 11 item survey questionnaire with a Likert scale from 0-7. The survey questionnaire items were similar to the items in the pre- and post- 5-day PD. However, items 5-11 were re-stated as confirmatory positive statements. These items were not stated as concerns and needs but more towards measuring teacher confidence and knowledge from their classroom instructional implementation and experiences.

TABLE 5

The 1-Day Return PD Survey Results

		Mean	Std Error
	Cluster 1: Confidence Level Responses		
1.	I have the confidence/knowledge that I need to use the FOSS Animals 2x2 science curriculum units.	6.00	0.30
2.	I know what science inquiry learning is about.	5.82	0.30
3.	I know what science immersion learning is about.	5.64	0.36
4.	I am motivated to use FOSS science investigation units for inquiry learning	6.36	0.31
	Cluster 2: Concerns and Issues Responses		
5.	I know how to manage enough time to teach a new content and its curriculum units each day.	4.82	0.44
6.	I know how science inquiry and immersion units affect student learning.	5.91	0.25
7.	I know what resources are available when I teach from the FOSS science curriculum.	6.27	0.19
	Cluster 3: Learning Assessment, Diverse Learners and Scientific Belief Responses		
8.	I know how to assess student learning of science.	6.00	0.30
9.	I know and can see the effect of using science inquiry and immersion units for diverse learners.	6.09	0.25
10.	I am aware of students' scientific beliefs at home and the science units to be taught at school.	5.36	0.33
	Cluster 4: Collaborative-Work Response		
11.	I collaborated with other teachers in the district to maximize the effects of science inquiry and immersion units	6.00	0.30

For item 1, teacher confidence in implementing the FOSS curriculum was at a mean of 6.00 (s.e. of 0.30). Items 2 and 3 confirmed teacher confidence of inquiry and immersion learning with means of 5.82 (s.e. of 0.30) and 5.64 (s.e. of 0.36) respectively. Item 4 had a high mean of 6.36 (s.e. of 0.31) thus showing a strong motivation to use FOSS investigation units for inquiry learning.

Items 5-7 all showed increased means. Item 5 had a mean of 4.82 (s.e. of 0.44) thus confirming teachers were able to organize time to teach new science content each day. Item 6 with a mean of 5.91 (s.e. of 0.25) showed teachers have increased their awareness of how the inquiry approach of teaching affected student learning. Item 7's mean at 6.27 (s.e. of 0.19) suggests that teachers have found the appropriate use of resources to enrich the teaching of FOSS units.

Item 8 with a mean of 6.00 (s.e. of 0.30) confirmed teachers are confident with their ability to assess student learning of science. Item 9 with a mean of 6.09 (s.e. of 0.25) confirms that teachers see the effectiveness of inquiry science learning for diverse learners. Item 10 with a mean of 5.36 (s.e. of 0.33) showed an increase in teacher confidence to differentiate between student home beliefs and inquiry science teaching.

And finally, item 11 with a mean of 6.00 (s.e. of 0.30) showed a greater collaboration among teachers than what was measured during the 5-day PD (post-PD mean was 5.25). This is very encouraging. It shows how LAUSD science teachers in the kindergarten classes are willing to work towards the district's objectives for a successful implementation of the new FOSS inquiry science immersion curriculum.

Overall, the return one-day PD survey results show a remarkable level of increased knowledge and confidence among teachers in implementing the inquiry-science teaching. Teacher responses indicated teacher sharing, dialogue, and support of peers with resources and instructional activities within a professional learning community for the promotion of science learning among kindergarten children. While the small number of 11 respondents may not provide robust results, this follow-up PD was intended to help teachers who voluntarily attended.

Conclusions and Implications

Looking at items 1 to 4, the statistical results indicate that the 5 day PD was significant in improving the confidence levels of participating teachers. Item 1 has the largest test statistic of 12.88. Teachers entered the PD with a low 2.14 level of confidence, but completed the PD with a high level of confidence measured at 6.02. Also, in all 4 items the standard error nearly halves. The PD has successfully dropped teachers' anxieties and raised their confidence in preparing them to use the FOSS units in inquiry science learning. Similar statistical significance is documented for 6 of the 7 concerns and challenges that teachers may face in implementing the new science curriculum. To summarize the research's findings:

* The results show a five day PD and additional follow-up PD days can significantly alter teachers' confidence and concerns that teachers would encounter when beginning a new science curriculum within the confines of its pedagogy.
* The PD successfully helped reduce perceived doubts and provided enough information to ease the task of locating and using resources for the FOSS science units.

* The PD helped drop anxiety levels even though high-anxious teachers stay high-anxious, albeit at a lower level.
* The PD helped address many issues present in introducing a new curriculum. The survey measured awareness of the following issues:
    - What constitutes science inquiry-learning;
    - What is involved in science immersion-learning;
    - How to assess student learning from science immersion;
    - How to respond to diversity learners in science immersion;
    - How do home beliefs connect with science immersion teaching.

In conclusion, one cannot ignore the teaching experience and initiative the forty-two teacher participants brought to the PD to make it a success. The wide range of 1-36 years of K-4 teaching and the initiative to teach science in the classroom already existent among the teachers was remarkable. It provided a fertile terrain for positive growth in inquiry-science pedagogy provided during the PD intervention. It is the high level of dedication that drives teachers to reach their potential and be willing to take the opportunity to life-long learning, especially among teachers who have been teaching for 20-36 years. In the 5-day and 1-day PDs, both the novice and veteran teachers took the time, the risk, and ownership of their learning by collaborating and sharing teaching experiences and artifacts to enhance their students' scientific literacy.

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