Restructuring pre-service teacher education to respond to increasing student diversity

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ABSTRACT

Several pressing issues call for institutions charged with the responsibility to educate prospective teachers to rethink their model of teacher preparation to better address the educational needs of English Language Learners (ELLs). It is projected that by 2025 one in four students in the U.S. will be from homes where a language other than English is spoken (NCES, 2006). For at least thirty years, the achievement of ELLs has lagged behind that of native English speakers in science and literacy (Buxton, 2006; Lee & Luyxk, 2006; NCES, 2006). In 2010 report, the National Academy of Science identified improving the preparation of teachers to teach science to ELLs as a national priority that would increase the successful participation of underrepresented minorities in STEM careers and degree programs (NAS, 2010).

This paper describe the findings of a research and development project that involved science education faculty at three universities in developing and implementing an experimental science teacher education program to prepare pre-service teachers to use research-based instructional strategies in science teaching to improve the science learning of ELLs. A quasi-experimental study was used to examine the impact of the experimental program on 85 student teachers' instructional practice and compared with the practice of 50 student teachers who participated in the control "business as usual" program. The results showed that experimental group student teachers implemented significantly more ELL-responsive practices while they taught science during their clinical practices than control group student teachers.

Keywords: Teacher education, science education, cultural and linguistic diversity, teacher practices, observation rubric

INTRODUCTION

After two decades of "science for all" reforms significant achievement gaps still persist between Anglo European students and English language learners (ELLs) (Buxton, 2006; Lee & Luyxk, 2007; Lynch, 2001; Harding, 2006; NCES, 2006; Rodriguez, 2004). ELLs score significantly lower than their native English-speaking peers in science. Data from the National Assessment of Educational Progress show only 17% of eighth grade ELLs scored at or above basic level in science, while well over double that number (68%) of native English speakers did so (NAEP, 2011). Moreover, this achievement gap between native speakers of English and ELLs is persistent. The average science scores of eighth and twelfth-grade ELLs were not significantly different in 2011 than in previous assessment years (2009 & 2005) where scores constituted a 48 scale score difference between native speakers of English and ELLs (NAEP, 2011).

In addition, ELLs are significantly less likely than their Anglo counterparts to pursue advanced degrees in science (CPST, 2007) or to perceive science as relevant to their lives outside of school (Aikenhead, 2001, 2006; Atwater, Wiggins & Gardner, 1995; Buxton, 2006; Calabrese Barton, 2003; Hammond, 2001; Lemke, 1990; Lynch, 2001; Rodriguez, 1997, 2004; Stanley & Brickhouse, 2001). This is a serious educational problem for the U.S. as the ELL student population continues to expand. In 2000, 68% of ELLs were concentrated in six states – California, Texas, New Mexico, New York, Florida and Illinois (Urban Institute, 2005). However the number of ELLs is growing in other parts of the country: Nevada (+354%), Nebraska (+350%) and South Carolina, South Dakota, Georgia, Alabama, Arkansas, and Oregon (+200%) (Batalova, Fix & Murray, 2007).

The research reported in this paper focuses on the preparation of pre-service elementary teachers to teach science to English Language Learners by integrating language and literacy development and science discourse into contextualized science instruction.

Theoretical and Empirical Framework

The conceptual foundation for this research is socio-cultural theory (Bakhtin, 1981; Moll, 1990; Rogoff, 1990, 1995; Rogoff & Wertsch, 1984; Tharp, 1997; Tharp & Gallimore, 1988; Vygotsky, 1978; Wertsch, 1991) the efficacy of which has been established through a series of empirical studies that demonstrate that student learning is enhanced when it occurs in contexts that are culturally, linguistically, and cognitively meaningful and relevant to students (Au, 1980; Deyhle & Swisher, 1997; Doherty & Pinal, 2002; Estrada & Inmhoff, 2001; Heath, 1983; Hilberg, Tharp & Degeest, 2000; Lee and Fradd, 1998; Ladson-Billings, 1995; Lemke, 2001; Rosebery, Warren, & Conant, 1992; Tharp & Gallimore, 1988; Warren & Rosebery, 1995, 1996). The framework draws on several bodies of prior research: the integration of inquiry science, language and literacy practices (Baker & Saul, 1994; Casteel & Isom, 1994; Lee and Fradd, 1998; Lee & Luykx, 2007; Lee, Maertin-Rivera, Penfield, LeRoy & Secada, 2008; Rodriguez & Bethel, 1983; Rosebery, Warren, and Conant, 1992; Author One, 1999; 2005; Author One, Pinal, Latzke, & Canaday, 2002; Author, One, Pinal, & Latzke, 2000; Author One, Author Three, Tolbert, & Author Two, 2010; Author One, Author Two, Author Three, & Author Four, 2012); the social and cultural contextualization of instruction (Aikenhead, 2006; Author One, 2005; Bouillion & Gomez, 2001;Brown, Ash, Rutherford, Nakagawa, Gordon, & Campione, 1997; Buxton, 2006; Calabrese Barton & Zacharia, 2003; Edwards & Eisenhart, 2005; Hammond, 2001; Lee and Fradd, 1998; Lee & Luykx, 2006; Warren, Ballenger, Ogonowski, Rosebery, &

Hudicourt-Barnes, 2001); and the research on sociocultural pedagogy conducted by researchers at the Center for Research on Education Diversity and Excellence (CREDE).

Integrating language, literacy and science

Many ELLs do not have access to rigorous instruction in academic subjects and are often relegated to remedial instructional programs focusing on the acquisition of basic literacy skills and facts aimed at improving student English-proficiency levels instead of teaching high quality content (Garcia, 1993; McGroaty, 1992; Moll, 1992; Pease-Alvarez and Hakuta, 1992; Valdes, 2001). However, a substantial body of research in the English language development literature has demonstrated that the integration of subject matter teaching with language and literacy development can enhance learning in both domains (Cummins, 1981; Genesee, 1987; Lambert & Tucker, 1972; McKeon, 1994; Met, 1994; Swain & Lapkin, 1985). Science lessons are a particularly powerful context for learning language and literacy. In inquiry science, the use of language is contextualized by being related to objects, visual representations and pictures, hands on activities, and experiences with the local environment (Baker & Saul, 1994; Casteel & Isom, 1994; Lee and Fradd, 1998; Rodriguez & Bethel, 1983; Rosebery, Warren and Conant, 1995; Author One, Pinal, Latzke, & Canaday, 2002). By relating language and literacy activities to real life objects, events and activities the words have real meaning for students. In science lessons, students communicate their understanding in a variety of formats, for example, in writing, graphic representations and creating tables and graphs (Lee & Fradd, 1998; Warren, Ogonowski, Ballenger, Rosebery, & Hudicourt-Barnes, 2001). Students also talk about science in science class--describing, hypothesizing, explaining, justifying, arguing, and summarizing--all of which support the development of science understanding and reasoning processes (Rosebery, Warren & Conant, 1995). Integrating science and literacy instruction synergistically promotes the development of English language proficiency, science literacy, and scientific understandings. For example, Lee, Maerten-Rivera, Penfield, LeRoy, & Secada (2008) implemented a five-year project, where ELLs were involved in science activities where the teacher included attention to the language and literacy in science, in particular, instructional supports to promote the understanding of key science concepts by using such visual tools as drawings of experimental setups, and Venn Diagram. Teachers were also encouraged to engage students in a variety of group formations to promote communication. On a researcher-developed science assessment administered before and after a year-long intervention, culturally and linguistically diverse students in the seven treatment classrooms outperformed students in the eight comparison classrooms. The relationship between science learning, language and literacy learning and science discourse, therefore, is reciprocal and synergistic. Through the contextualized use of language in science inquiry students develop and practice complex language forms and functions. Through the use of language functions such as description, explanation and discussion in inquiry science, students enhance their conceptual understanding (Author One, Pinal, Latzke, & Canaday, 2002).

Cultural and Social Contextualization

ELLs, not only face difficulties due to language barriers in schools, but must also cross borders between their home cultures and the school culture (Aikenhead, 2001, 2006). Whereas this transition is not a difficult one for most middle class Anglo students, it can be quite a formidable process for cultural and linguistic minority students. When students' experiences from their lives outside of school are incorporated in instruction, however, the transition between home and school is a much smoother one. Integrating student cultural knowledge, experiences, and interaction patters has been shown to improve the achievement and participation of linguistic minority students in science (Lee & Luykx, 2007; Dalton, 1998; Moll, Amanti, Neff, & Gonzalez 1992; Tharp & Gallimore, 1998). A series of studies have demonstrated that the use of contextualized instructional in diverse science classrooms leads to improved student outcomes, including increased participation and engagement in science, positive differences on standardized learning measures, positive attitudes toward science, and increased consideration of science as a career goal (Aikenhead, 2006; Bouillion & Gomez, 2001; Buxton, 2006; Lee and Fradd, 1998; Warren, Ballenger, Ogonowski, Rosebery, & Hudicourt-Barnes, 2001).

Author Two, & Garcia, (2004), for example infused 3rd grade science curriculum with opportunities for home/school connections, as well as offered teachers professional development to leverage students' home language and culture to better understand the science concepts under study, and found 3rd grade ELLs' science writing to improve significantly from pre to post test. Students' science understandings of states of matter also improved significantly. In a follow up qualitative study (Author One, 2005), note teachers' ability to bend the science curriculum to fit within students' cultural experiences, especially with personal understandings of such terms as "solid" as compared to the scientific understanding.

Supporting teachers in providing effective content-area instruction for ELLs will require ongoing professional development. This paper reports the results of a study examining the impact of an intervention that integrated effective pedagogy for ELLs in science education then gauged its impact on pre-service teachers' practice.

METHODS

Study Overview

The study analyzed changes in two groups of novice teacher's science instructional practice with ELLs after they participated in either an experimental ELL-focused teacher education program or a control "business as usual program". The experimental group received coursework and coaching in five effective instructional practices for ELL drawn from the literature discussed above:

- Integrating science, language and literacy development: In science lessons students also can communicate their understanding in a variety of formats, for example, in writing, orally, drawing and creating tables and graphs
- Engaging students in science talk: In science lessons, students also talk about science--describing, hypothesizing, explaining, justifying, arguing, and summarizing--all of which support the development of science understanding and reasoning processes
- Contextualized science instruction: In inquiry science the use of language is contextualized by being related to objects, visual representation and pictures, hands on activities, and experiences with the local environment. By relating language and literacy activities to real life objects, events and activities the words have real meaning for students

- Collaborative inquiry in science learning: In science lessons students work on group projects in learning communities through inclusive and collaborative student engagement
- Developing scientific understanding: In science lessons students learn to use the scientific method to hypothesize, collect data, analyze and reach justified conclusions.

Student teachers in the control teacher education program participated in a general science teaching methods and practicum. Pre-service teachers in both the Cross-Cultural, Language & Academic Development (CLAD) and the Bilingual Cross-Cross-Cultural, Language & Academic Development (BCLAD) certification programs were involved in both control and experimental groups.

The Intervention

Student teachers in the experimental program participated in a: (a) re-structured ELLs-focused science methods course and; (b) student teaching placement teaching practicum in a classroom where the master teacher had received professional development in addressing the needs of ELLs during science.

Experimental Science Methods Course

The experimental science methods course was created collaboratively by four science methods instructors, who work at the three participating state university campuses during the development phase of the project. The CLAD instructors included an Anglo-European, female first year Assistant Professor, an experienced female Professor originally from the Philippines and a university lecturer and experienced elementary and middle school (Anglo, female) teacher who is often hired to teach the science methods course at that campus (data from this CLAD section are not included in this analysis). There was one CLAD instructor at each campus. Each of the CLAD instructors is at a different campus. The BCLAD instructor is a Latino, senior professor in cross-cultural and bilingual education. The instructors had six face-to-face meetings and six phone conferences, as well as multiple correspondences via e-mail, in order to develop a common science methods course using the research framework.

The science methods course focused on engaging student teachers in a personal learning experience of science methods instruction through the research-based pedagogy which modeled the integration of science content with language and literacy, the use of science discourse and contextualized science instruction, collaborative inquiry and scientific reason. The primary vehicle for the treatment science methods instruction was the use of five California Science Standards-based, units (with corresponding lesson plans and activities). These units were: Biodiversity, Skulls and Teeth, Earth, Sun & Moon, Electricity and Arthropods. Each unit was designed to illustrate the five approaches to addressing the needs of ELLs in science, but one or two of the categories per unit were highlighted to make it easier for student teachers to engage with the framework.

Professional Development

Master teachers who mentored the experimental group pre-service teachers participated in a two day professional development workshop that focused on introduction to the pedagogy components, review of lessons plans which modeled the five pedagogical components, mentoring resources that incorporate these components, an observation guide, and a variety of articles on being effective mentors for student teachers and effective teachers of science for English Language Learners.

Setting

Sites include three California teacher education programs of comparable size and teacher education focus. All three sites focus on preparing pre-service teachers for Bilingual and Cross-Cultural, Language and Academic Language credentials. These credentials allow students to teach in kindergarten through eighth grade settings. Each teacher education program graduates approximately 200 students from their respective credential fields (e.g., BCLAD, CLAD).

Participants

Over half of the participating pre-service teachers were white (51%), Latino pre-service teachers comprised 9% of the sample, with 5% Asian and 4% multiracial participants. In addition, over 77% of the participants' ages ranged between 20 to 30 years of age. The gender makeup of the sample was 81% female, and 19% male.

In addition, 60% of the participating teachers were enrolled in a Cross-Cultural Language and Academic Development (CLAD) program and 40% in a Bilingual Cross-Cultural Language and Academic Development (BCLAD) program. Notably, only 2 participants majored in a science related field, while the majority (81%) majored in Education, Humanities, Liberal Studies, and Social Science.

Classroom Observation Rubric

The DAISI (Dialogic Activity in Science Instruction Rubric) was used as an outcome measure to assess novice teachers' use of the ELL pedagogy in their student teaching practicum. It was also used in the science teaching methods courses to assess the fidelity of implementation of the pedagogy among the faculty. The DAISI provides quantitative measures of the quality of teachers' classroom enactments of the ELL Pedagogy (Author One, Author Two & Author Three, Tolbert, & McKinney de Royston, 2009). Each observation yields a set of 5 scores, one score for each for LL, C, CI, IC, and CT. Each sub-theme is scored on a four-point scale: not observed (0), introducing (1), implementing (2), elaborating (3). These levels of implementation are based on the literature on the development of teacher expertise in science language integration (Author One, Pinal, Latzke, & Canaday, 2002). The following examples are drawn from the Language and Literacy categories. At Level 1: Present, the teacher incorporates both science and language activities in the lesson, but these activities are not integrated. For example, the teacher may teach science vocabulary before he/she does a science activity. At Level 2: Implementing, science and language activities are integrated; however, one activity is dominant. For example, a teacher uses a narrative story on a science topic. At Level 3: Elaborating, the teacher fully integrates science and language activities. For example, the teacher engages in an instructional conversation with a group of students as they conduct a science investigation.

Cronbach's alpha was calculated on each of the six subscales and found all to be above the acceptable range of 0.7, as indicated in Table 1 (Appendix). All observers were trained and calibrated on the observation scheme and reached above an 87% agreement on each of the ESTELL domains. Video of science teaching was used for the training.

Fidelity of Implementation

In research on an instructional or curriculum intervention it is important to consider fidelity of implementation i.e., how well an innovation is being implemented in comparison with the original program design. In studies where there is failure to implement the program as planned, there is potential to conclude erroneously that observed findings can be attributed to the conceptual or methodological underpinnings of a particular intervention, rather than the fact that it was not delivered as intended (Dane and Schneider, 1998; Dusenbury, Brannigan, Falco & Hansen, 2003; Lee, Penfield & Maerten-Rivera, 2009; Lynch & O'Donnell, 2005). Studying fidelity of implementation can explain *why* innovations succeed and fail. It also provides important information on feasibility of the intervention. Standardized observation schedules represent the most rigorous measurement of FOI (Fullan & Pomfret, 1977; Ruiz-Primo, 2006). The fidelity of the implementation of the teacher education program was assessed through standardized observations of science methods course, and student supervision using the DAISI (Dialogic Activity in Science Instruction Rubric) described below through live observations of science methods instruction and student supervision.

Data Analysis

To analyze the data, an analysis of covariance (ANCOVA) was used to account for differences on the post-test controlling for pre-test performance between the intervention and control condition participants. This covariate adjustment technique represents the amount of change on the post-assessment measures while accounting for each participant's pre-test score. With the pre-test scores controlled for in the model, any differences detected in this analysis reflect assessment performance beyond what is already measured on the pretest.

RESULTS

This analysis is based on observations of student teachers that participated in six science methods courses and the associated student teaching practicum—two CLAD Experimental and two CLAD control courses and a BCLAD experimental and one BCLAD control. The CLAD control and experimental were drawn from the 2009-10 admissions groups within each institution. As the BCLAD experimental group instructor is the only science education BCLAD instructor group at the institution the BCLAD control group was drawn from the other participating institution. Pre service teachers were observed once during their student-teaching practicum. The scoring scale relates to the potential implementation of effective science teaching practices for ELLs. Each one of the six instructional practices was scored every fifteen-minutes during the course of an entire science lesson ranging on average from 40-60 minutes. A score of 0 denote the absence of a particular instructional practice. A score of 1 denotes an introductory or basic implementation of a instructional practice. A score of 2 denotes full implementation of the instructional practice. A score of 3 denotes full and elaborated implementation of an instructional practice. Overall disaggregated mean scores by instructional practice area indicate uneven implementation of the ELL instructional practices. Mean scores by instructional practice ranged between .48-1.59.

BCLAD Analysis

A one-way ANOVA was conducted to compare differences on five DAISI Domains between the BCLAD experimental pre-service teachers and the BCLAD control group. There was a statistically significant positive difference between the experimental pre-service teacher DAISI implementation means compared to the control group on two (Collaborative Inquiry and Science Talk) of the five DAISI Domains measured by the observation protocol. There was a positive statistically significant difference in the means for Collaborative Inquiry between the experimental BCLAD pre-service teachers ($M=1.84$, $SD=0.26$) and the control ($M= 1.47$, $SD=0.53$) observations (ANOVA, $F(1, 21) = 4.74$, $p < .05$). The means for Science Talk also showed a positive statistically significant difference between the experimental BCLAD pre-service teachers ($M=1.51$, $SD=0.36$) and the control group ($M=1.12$, $SD=0.44$) observation (ANOVA, $F(1, 21) = 5.47$, $p < .05$). The mean scores of the BCLAD experimental group were above the scores of the BCLAD control group on all ELL pedagogical instructional strategies, as indicated in Table 2 (Appendix).

BCLAD experimental group pre-service teachers implementation of Collaborative Inquiry and Science Talk was at a high introductory level moving towards full implementation. All other experimental group instructional practices were at the introductory level (ranging from .70-1.38). An overall basic or introductory implementation of the ESTELL Instructional practices suggests that teacher candidates were:

- offering some basic science literacy tasks with no explicit instruction on science tools or supplanting science activities with literacy tasks while providing limited instruction on key vocabulary (Literacy in Science)
- providing implicit instruction on English Language structures with minimal modified scaffolding for ELLs (Scaffolding and Language Development
- listing prior student science knowledge while leading all phases of the inquiry process (Promoting Scientific Reasoning & Inquiry)

The BCLAD control group scored at the introductory level on all ELL instructional support domains.

For both groups, Contextualizing science activity received the lowest mean score of (.49.control, .70 experimental. This instructional practice area measured the level of inclusion and incorporation of student home, community, and local physical/geographic resources in the teaching of science. A score of .49 indicates that baseline teacher candidates rarely provided nor elicited examples from student experiences in the teaching of science objectives.

CLAD Analysis

A One-Way ANOVA analysis was conducted to test the differences in means on the DAISI observation protocol scores between the experimental group and the control conditions. Comparisons were made for CLAD Instructor 1 and CLAD instructor 2 who teach at two different participating institutions and differences between these conditions are indicated in Table 3 (Appendix). The results indicate that there are statistically significant differences on the DAISI instructional practices scores between the two experimental groups (Instructor 1 and Instructor 2) and the control group. The differences were on three of the five DAISI sub-domains—Collaborative Inquiry, Contextualization and Science reasoning. The means on Collaborative Inquiry for the student teachers in the Control group (mean = 1.8) were higher compared to the means for student teachers in each of the two treatment courses (Instructor 1 mean = 1.58, and Instructor 2 mean = 1.33), and these differences were statistically significant ($F(2,63) = 6.54$, $p < .01$). On the Contextualization sub-domain, the DAISI scores for student teachers that were taught by Instructor 2 were higher (mean = 1.12) compared to both, student teachers that took the treatment course with Instructor 2 and the control group, and these differences were also statistically significant ($F(2,63) = 25.81$, $p < .001$). Lastly, the analysis revealed that student teachers in both treatment groups scored higher (Instructor 1 means=1.36, and Instructor 2 means = 1.34) on the Scientific Reasoning sub-domain than the control group student teachers (mean = 1.01), and these differences were also statistically significant ($F(2,63) = 5.36$, $p < .01$).

Comparison of Science Methods Instructor Scores and Pre-service Teacher Scores

Table 4 (Appendix) shows the DAISI mean scores for each DAISI sub-domain for the BCLAD and CLAD instructors and the pre service teachers in their courses. The instructor scores are for the first time each had taught the experimental course. As the table shows the BCLAD and CLAD 1 instructor both scored at, or close to, full fidelity of implementation (FOI) implementation of the instructional practice in each domain (level 2). The CLAD 2 instructor had a high level of implementation for Science Talk and almost reached full implementation in Literacy in Science but scored lower in all the other domains. The instructors' overall fidelity of implementation is higher than the pre service teachers. BCLAD and CLAD 1 instructors generally were teaching at a full implementation and pre service teachers at the introductory level, as indicated in Table 4 (Appendix). The small pre service teacher observation sample size in the first stage of implementation precluded doing a correlational analysis between instructor and pre service teachers' DAISI scores. However, as Figures 1, 2 and 3 show there is some degree of association between instructor FOI scores and pre service teacher scores, i.e. in the majority of cases the instructor's strength of implementation is mirrored by the pre service teacher group's strength of implementation.

As Figure 1 shows, in the BCLAD group there is a strong pattern of association between instructor and pre service teacher scores on Collaborative Inquiry, Literacy in Science, Scaffolding Language and Scientific Reasoning, as indicated in Figure 1 (Appendix).

Figures 2 and 3 below show the relationship between pre service teacher DAISI scores and instructior scores in Instuctor 1 and 2's courses. In the CLAD instructor 1 courses, there is a clear association between the Instructor FOI scores on Collaborative Inquiry, Science Talk, Collaborative Inquiry, Literacy in Science, Scaffolding Language and Scientific Reasoning and a discrepancy on contextualization, as indicated in Figure 2 (Appendix).

As Figure 3 shows, for CLAD instructor 2, there is an association between the Instructor FOI scores on Collaborative Inquiry, Collaborative Inquiry, Literacy in Science, Scaffolding Language, Contextualization and Scientific Reasoning. Pre service teacher scores in the Scaffolding Language, Contextualization and Scientific Reasoning domains are almost equivalent to the instructor scores at the introductory level, as indicated in Figure 3 (Appendix).

Results indicate that treatment group pre service teachers outperform pre service teachers in the control group in using science pedagogy that takes into consideration both 1) the language demands of science learning and 2) students' socio-cultural and linguistic resources.

DISCUSSION

Results from the first year of implementation of the intervention suggest that the experimental program is having a positive impact on treatment pre service teachers science instruction during their student-teaching practicum. These differences are present even when account for expected differences arising from bilingual and non-bilingual credential programs. Compared to control bilingual credential (BCLAD) pre service teachers, treatment bilingual credential (BCLAD) pre service teachers use more inclusive and varied science instructional formats that promote greater interaction between teacher and students with more frequent instances of interaction between students; treatment pre service teachers are also more likely to deliver science lessons where science knowledge and authorship is challenged. Moreover, there were significant differences in the area of pre service teacher use of science discourse patterns for treatment pre service teachers. While still at the introducing levels of implementation of effective pedagogy, treatment pre service teachers were more likely to model science discourse patterns like showing way of providing evidence, making scientific explanations, or even proposing methods for conducting inquiry activities than control bilingual student-teachers. Treatment bilingual pre service teachers were also more likely to use the kind of investigatory and epistemic types of questions and commentary that are highly restricted for ELLs in classrooms where yes and no, closed type of questions dominate classroom talk.

Moreover, an analysis of non-bilingual CLAD credential pre service teachers found significant differences between treatment and control CLAD participants in the study as well in other ELL instructional scaffolding domains, specifically in the area of promoting scientific reasoning and inquiry and also, contextualizing science activity. In the area of scientific reasoning both cohorts of treatment pre service teachers (for both Instructor 1 and Instructor 2) were more likely to science lessons to key content objectives and provide some feedback to children on how they were conducting inquiry activities than control participants. Treatment pre service teachers (from instructor 1) scored significantly higher in contextualizing science activity, which includes both inclusion of person-home-community activities and local-physical experiences in the teaching of science. This finding means that these treatment CLAD pre service teachers are providing some examples from the local contexts and also at least acknowledging students' contributions or questions as resources for teaching the science lesson. Also, an analysis of the fidelity of implementation of the treatment science methods course shows that the implementation of the treatment with the teacher education courses, parallel those of their students in the practicum by ELL instructional support domain. Naturally, instructors have much higher scores in the use of the pedagogy, while some notable contextual differences exist.

CONCLUSION

Classroom observation measures, such as those used in this study, are complicated by their focus on measuring difficult to define social constructs (Borman & Kimball, 2005; Luykx & Lee, 2007) including effective pedagogy, teacher quality, student achievement, and the relationship between these areas. The examination of pre-service science teaching practices, however, moves forward thinking on previous conceptualizations of responsive science pedagogy. Analysis of the intersection of culture and language locates student cultural experiences within personal, home, community knowledge over that of presumed student ethnic identity mediators. That is, prototypical science practices (e.g. inquiry, questioning, discourse patterns of reasoning, etc.), student cultural knowledge (e.g., codes, alternative science concepts) and teachers moves to intersect these elements require explicit attention for promoting more effective science learning contexts in diverse classrooms, particularly those where ELLs reside. Elementary science education in diverse student contexts remains a major challenge for teachers despite some advances in professional development (Johnson & Marx, 2009; Lee, Lewis, Adamson, et al 2008). Yet, the research findings demonstrate the development of more effective science teaching practices can begin already with novice teachers. Elementary teachers face an important challenge in the teaching of science in diverse contexts that requires that they acquire and master potentially new academic repertoires that will enable them to better serve an ever-increasing culturally and linguistically diverse student population.

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APPENDIX

Table 1. DAISI Reliability Analysis (n=147).

	Number of Observations	Cronbach's Alpha
1. Facilitating Collaborative Inquiry	112	0.782
2. Promoting Science Talk	110	0.771
3. Contextualization	113	0.729
4. Literacy in Science	115	0.791
5. Scaffolding Development of Language	113	0.804
6. Promoting Scientific Reasoning	110	0.832

Table 2. DAISI Observation Scores for ELL Pedagogy BCLAD pre-service teachers compared to a BCLAD control cohort.

DAISI Subscale	Instructor	Mean	Std. Deviation	One-Way ANOVA
Collaborative Inquiry	Control	1.47	.53	F (1,21) = 4.74, p < .05
	BCLAD	1.84*	.26	
Science Talk	Control	1.12	.44	F (1,21) = 5.47, p < .05
	BCLAD	1.51*	.36	
Literacy in Science	Control	1.11	.64	F (1,21) = 1.41
	BCLAD	1.38	.44	
Contextualization	Control	.49	.26	F (1,21) = 1.38
	BCLAD	.70	.55	
Scientific Reasoning	Control	1.18	.42	F (1,21) = 0.52
	BCLAD	1.32	.53	

Table 3. DAISI Observation Scores for CLAD Experimental pre-service teachers compared to a CLAD control cohort.

DAISI SubDomain	Instructor	Mean	Std. Dev.	N	One-Way ANOVA
Collaborative Inquiry	Instructor 1	1.586	.338	16	F (2,63) = 6.54, p < .01
	Instructor 2	1.338	.437	19	
	Control	1.800**	.511	29	
Science Talk	Instructor 1	1.508	.456	16	
	Instructor 2	1.355	.335	19	
	Control	1.461	.485	29	
Literacy in Science	Instructor 1	1.177	.441	16	
	Instructor 2	1.289	.329	19	
	Control	1.421	.508	29	
Contextualization	Instructor 1	.521	.442	16	F (2,63) = 25.81, p< .001
	Instructor 2	1.219***	.362	19	
	Control	.538	.277	29	
Scientific Reasoning	Instructor 1	1.364**	.512	16	F (2,63) = 5.36, p < .01
	Instructor 2	1.342**	.397	19	
	Control	1.019	.344	29	

Table 4. DAISI Mean Scores of Experimental Pre Service teacher & Fidelity of Implementation of Method Course Instructors: First Implementation

	BCLAD Figure 1		CLAD 1 Figure 2		CLAD 2 Figure 3	
	EDAISI	FOI	EDAISI	FOI	EDAISI	FOI
Collaborative Inquiry	1.78	2.19	1.57	2.25	1.34	2.00
Science Talk	1.41	2.21	1.55	2.15	1.36	2.49
Literacy in Science	1.31	1.52	1.36	2.00	1.29	1.85
Scaffolding Language	1.50	1.71	1.33	1.75	1.16	1.36
Contextualization	0.76	1.58	0.75	1.95	1.22	1.37
Scientific Reasoning	1.19	1.89	1.35	1.70	1.34	1.70

Figure 1. BCLAD Instructor and Pre Service Teacher DAISI Scores

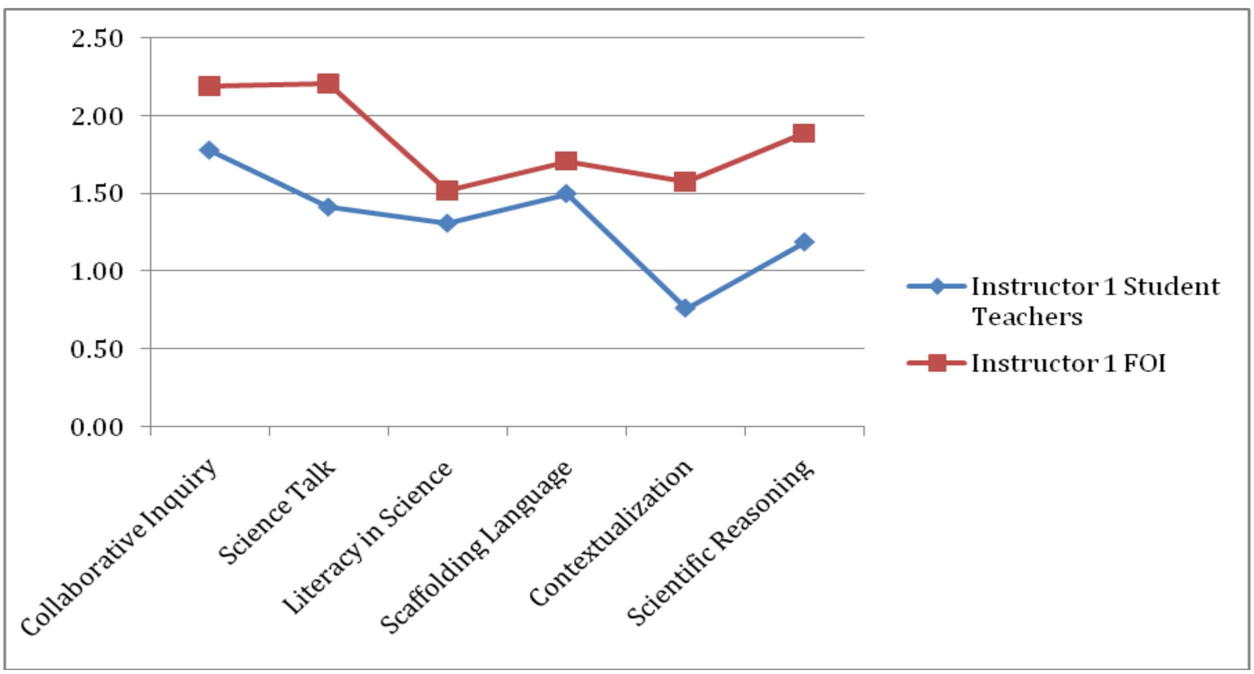

Figure 2. CLAD 1 Instructor FOI scores and Pre Service Teacher DAISI scores

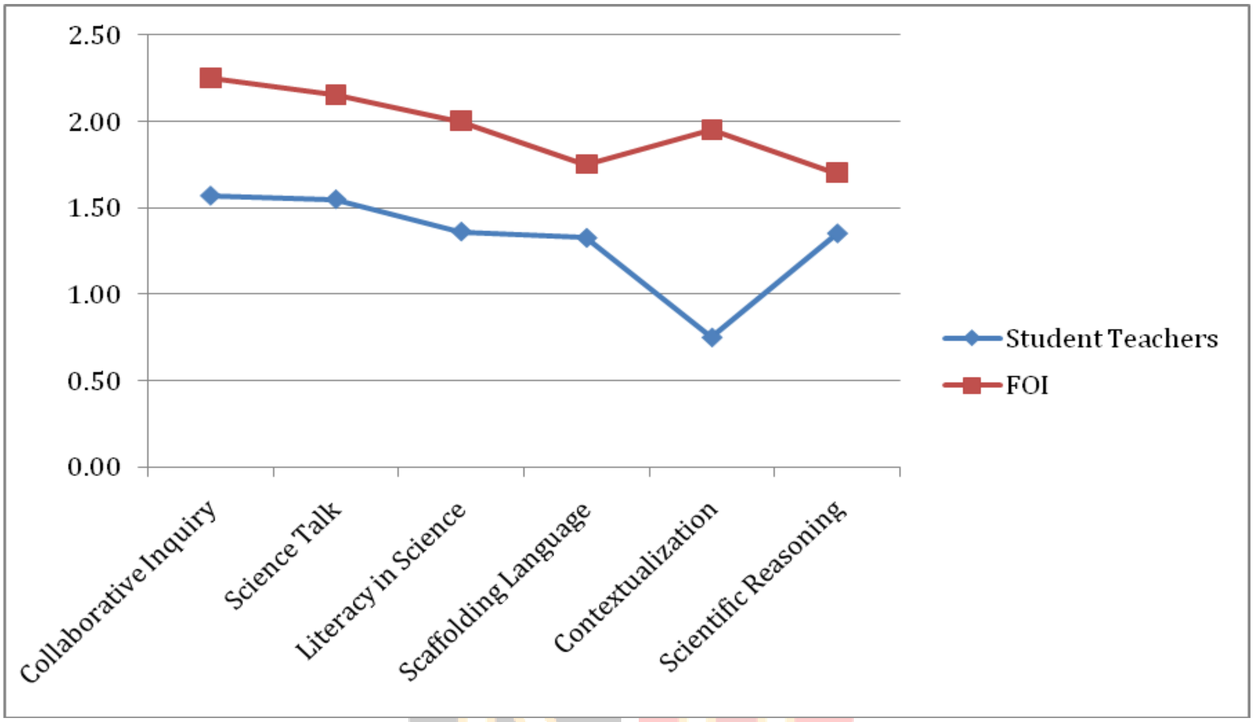

Figure 3. CLAD 2 Instructor FOI score and Pre Service teacher DAISI Scores