Effective Science Teaching for English Language Learners (ESTELL): Measuring Pre-service Teacher Practices

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Introduction

The primary goal of science education reform is to improve student learning of science and make rigorous science content and high expectations accessible to all students, including students from groups whose achievement has traditionally lagged behind that of majority culture students (American Association for the Advancement of Science [AAAS], 1989, 1993; National Research Council [NRC], 1996). Of particular concern is the rapidly growing population of students who do not speak English as a first language (NSTA, 2010). After two decades of "science for all' reforms significant achievement gaps still persist between Anglo European students and students who are linguistic minorities (Buxton, 2006; Lee & Luyxk, 2007; Lynch, 2001; Harding, 2006; NCES, 2006; Rodriguez, 2004). In addition, ELL students 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 K-12 student population continues to expand. In 2000, 68% of ELL were concentrated in six states –California, Texas, New Mexico, New York, Florida and Illinois (Urban Institute, 2005). However the number of ELL students is growing in other parts of the country: Nevada (+354%), Nebraska (+350%) and South Carolina, South Dakota, Georgia, Alabama, Arkansas, and Oregon (+200%). Currently one-third of all ELL in the United States attend California schools, of those 85% are Spanish speakers and the remaining 15% speak one of over 50 different languages (Gandara, Maxwell-Jolly, & Driscoll, 2005). Improving the teaching and learning of ELL is of national significance and of critical importance in California, the context for this study.

Recent research has revealed, however, that the majority of teachers in California do not feel well prepared to teach ELL (CSU Office of the Chancellor, 2007; Gandara, Maxwell-Jolly, & Driscoll, 2005). In 2007, a survey of teacher education program graduates from the California State University system, which prepares 60% of California teachers, found that over 70% of them do not feel prepared to teacher English Language Learners (ELL) (CSU Office of the Chancellor, 2008). A comparable situation holds for teachers currently working in California K-12 schools, who report that they have received little to no training to help them meet the needs of English learners (Gandara, Maxwell-Jolly, & Driscoll, 2005). One of their most significant concerns of teachers in the Gandara et al study was their lack of knowledge and skills in integrating subject matter teaching with English language development. This is not surprising given that most teacher education programs do not explicitly teach novices to teach subject matter to ELL. Courses on subject matter teaching typically give little attention to the importance of valuing and incorporating the language and cultural experience of the students being served (Ball, 2000; Bryan & Atwater, 2002; Dalton, 1998; Fradd & Lee, 1995; Godley, Sweetland, Wheeler, Minnici & Carpenter, 2006; Sleeter, 2007; Stoddart, 1993; Stoddart, Solis, Tolbert & Bravo, 2010; Zeichner, 2003). Issues relating to cultural and linguistic diversity, when taught, are often presented in separate courses that often focus on social conditions not pedagogy (Met, 1994; Zeichner, 2003).

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. The NSF funded *Effective Science Teaching for English Language Learners* (ESTELL) research project described in this paper engaged science methods faculty at three institutions of teacher education in restructuring the science methods courses and student teaching experiences to use an experiential learning approach to explicitly model an approach to science teaching based on ESTELL pedagogy.
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Theoretical and Empirical Framework

The general a priori foundation for ESTELL is socio-cultural theory (Bakhtin, 1981; Moll, 1990; Rogoff, 1990, 1995; Rogoff & Wertsch, 1984; Tharp, 1997; Tharp & Gallimore, 1988; Vygotsky, 1978; Wertsch, 1985, 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, 1994; Lemke, 2001; Rosebery, Warren, & Conant, 1992; Tharp & Gallimore, 1988; Warren & Rosebery, 1995, 1996). The authors of this proposal have drawn on empirical research on sociocultural pedagogy to develop a model of science education for ELL: ESTELL (Effective Science Teaching for English Language Learners). ESTELL 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; Stoddart, 1999; 2005; Stoddart, Pinal, Latzke & Canaday, 2002; Stoddart, Abrams, Canaday, & Gasper, 2000); the social and cultural contextualization of instruction (Aikenhead, 2006; Bouillion & Gomez, 2001; Brown, Ash, Rutherford, Nakagawa, Gordon, & Campione, 1993; Buxton, 2006; Calabrese Barton & Zacharia, 2003; Edwards & Eisenhart, 2005; Hammond, 2001; Lee and Fradd, 1998; Lee & Luykx, 2006; Stoddart, 2005; 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 learning

Many ELL 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, 1988, 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, 1992; Stoddart et al., 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, 1992). Integrating science and literacy instruction synergistically promotes the development of English language, science literacy, and scientific understandings.

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 (Stoddart et al, 2002). This is a synergistic approach to teaching and learning where language and literacy development is contextualized in scientific inquiry projects that promote understanding through collaborative work and discourse between teachers and students.

Cultural and social contextualization

ELL students, however, 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; 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; Stoddart, 2005; Warren, Ballenger, Ogonowski, Rosebery, & Hudicourt-Barnes, 2001).

ESTELL instructional practices

Building on the research on effective teaching for ELL, the integration of science, language and literacy research and the research on sociocultural pedagogy by CREDE and others, the ESTELL project has incorporated five instructional practices that have been demonstrated to have the potential to improve the teaching and learning of science to linguistic minority students,

- 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.

In the ESTELL project is integrating these practices into pre-service science teacher education and investigating the impact on student teachers' knowledge, beliefs and practice. This paper focuses on the analysis of student teachers' instructional practice in their student teaching practicum in the first year of the implementation of the intervention.

Method

The ESTELL project is an NSF DR K-12 Discovery Research Development project. It includes science education faculty and researchers from three state university teacher education programs and one research university in California. The three teacher education programs were chosen for two reasons: (1) each program prepares novice teachers to work in regions of great cultural, linguistic and economic diversity and low educational attainment and each has a strong focus on preparing teachers to be responsive to student diversity; and (2) all three institutions have one year post-baccalaureate elementary teacher education programs with the same requirements and coursework. In the first year of the project (2008-09) an experimental science methods course was developed based on the ESTELL pedagogy. In Year 2: First Implementation (2009-10), the science methods course was taught by four science methods instructors during the Fall Quarter. Using a quasi experimental design, data on the student teachers in three of the experimental ESTELL science methods courses and a comparison group of control student teachers in 'business as usual' science methods courses was collected. The data included a pre-post program survey of teacher knowledge and beliefs and an observation of teaching practice during the student teaching practicum. This paper focuses on the observation of teaching practice. In 2009-10, the data collected at the third site was incomplete and could not be included in this analysis. Fidelity of implementation observations were also conducted in the experimental science methods courses. This paper presents the results of classroom observations conducted on the control and experimental group CLAD and BCLAD novice teachers and the associated fidelity of implementation instructor scores and two of the three institutions. The DAISI (Dialogic Activity in Science Instruction Rubric) was used for both the student teacher and science methods instructor observations.

ESTELL Teacher Education Intervention

The structure of the ESTELL pre-service teacher education program is based on three principles established by prior research on pre-service teacher preparation: (1) teachers need to learn new instructional approaches through the pedagogy they are being prepared to teach (Ball & McDiarmid, 1990; Hewson & Hewson, 1988; Stoddart, 1993a; Stoddart, Connell, Stofflet & Peck, 1993; Stofflett & Stoddart, 1994; Veal & Makinster, 1999); (2) The teaching of science content and subject matter methods should be integrated with knowledge about the language and culture of the students being served (Dalton, 1998; Fradd & Lee, 1995; Met, 1994; Rodriguez & Kitchen, 2005; Stoddart, 1993a; Zeichner, 2003).; (3) Coherence needs to be established between the different components of the teacher education program – coursework, practicum and supervision (Stoddart, 1993b; Wilson, Floden & Ferrini-Mundy, 2001). These principles were incorporated into the: (a) ESTELL science teaching methods course; and (b) the teaching practicum.

ESTELL Science Methods Course

The ESTELL science methods course was created collaboratively by four science methods instructors who work at the three participating state university campuses during the 2008-09 development phase of the project. The CLAD instructors included an Anglo-European, female first year Assistant Professor, an experienced female Professor originally from India 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 instruxctors 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 ESTELL framework. Each of the instructors committed to teach the course in the two phases of implementation in 2009-10, 2010-11.

The science methods course focused on engaging student teachers in a personal learning experience of science methods instruction through ESTELL 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 ESTELL 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 all of the ESTELL categories, but we highlighted one or two of the categories per unit to make it easier for student teachers to engage with the ESTELL framework. The course matrix is presented in Table X and includes the selection of key, standards-based, grade appropriate science content knowledge and corresponding pedagogical strategies

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 will be assessed through standardized observations of science methods course, practicum 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.

Professional Development

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

Classroom Observation Rubric

DAISI (Dialogic Activity in Science Instruction Rubric)

The DAISI was used as an outcome measure to assess novice teachers' use of ESTELL in their student teaching practicum. It was also used in the science teaching methods courses to assess the fidelity of implementation of ESTELL. The DAISI provides quantitative measures of the quality of teachers' classroom enactments of ESTELL Pedagogy (Stoddart, Solis, Bravo & Tolbert, 2007). 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 (Stoddart, et al., 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.

Table 1. DAISI Observer 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

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. A Cronbach's alpha was calculated on each of the six subscales and found all to be above the 0.7 threshold.

Sample

The ethnic demographics of CLAD and BCL
AD pre-service teacher observation sample participants is as follows: 51% White, 35% Latino, 9% Asian, 5% Other. The gender make-up was predominantly female (84%) and the dominant age range was between 20 to 30 years of age (93%). All are seeking credentials that will allow them to teach in K-8 settings.

Results

This analysis is based on observations of student teachers who participated in six science methods courses and the associated student teaching practicum—two CLAD Experimental and two CLAD control courses and in 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. Teacher candidates were observed once during their student-teaching practicum. Each observation was scored on a scale of 0-3 along the ESTELL instructional practices. 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 a instructional practice. Overall disaggregated mean scores by instructional practice area indicate uneven implementation of the ESTELL instructional practices. Mean scores by instructional practice range between .48-1.59.

BCLAD Analysis

A one-way ANOVA was conducted to compare differences on five EDAISI Domains between the BCLAD ESTELL pre-service teachers and the BCLAD control group. There was a statistically significant positive difference between the ESTELL pre-service teacher DAISI implementation means compared to the control group on two (Collaborative Inquiry and Science Talk) of the five EDAISI Domains measured by the observation protocol. There was a positive statistically significant difference in the means for Collaborative Inquiry between the ESTELL 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 ESTELL BCLAD pre-service teachers (M=1.51, SD=0.36) and the IES control group (M=1.12, SD=0.44) observation (ANOVA, $F(1, 21) = 5.47$, $p < .05$). The mean scores of the BCLAD ESTELL group were above the scores of the BCLAD control group on all ESTELL categories.

Table 2. DAISI Observation Scores for ESTELL 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	

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 ESTELL 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 low level of the introductory category on all ESTELL 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 EDAISI observation protocol scores between the ESTELL experimental group and the control conditions. Comparisons were made for CLAD Instructor 1 and CLAD instructor 2 who teach at two different participating institutions. See Table 4 below.

Table 3. DAISI Observation Scores for ESTELL CLAD 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	Instructor	1.364**	.512	16	F(2,63) = 5.36, p <

Reasoning	1				.01
	Instructor 2	1.342**	.397	19	
	Control	1.019	.344	29	

The results indicate that there are statistically significant differences on the EDAISI instructional practices scores between the two ESTELL experimental groups (Instructor 1 and Instructor 2) and the control group. The differences were on three of the five EDAISI 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 EDAISI 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, our analysis revealed that student teachers in both ESTELL 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 shows the DAISI mean scores for each ESTELL domain for the BCLAD and CLAD instructors and the student teachers in their courses. The instructor scores are for the first time each had taught the ESTELL 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 novice teachers. With BLCAD and CLAD 1 instructors generally at full implementation and novice teachers at the introductory level.

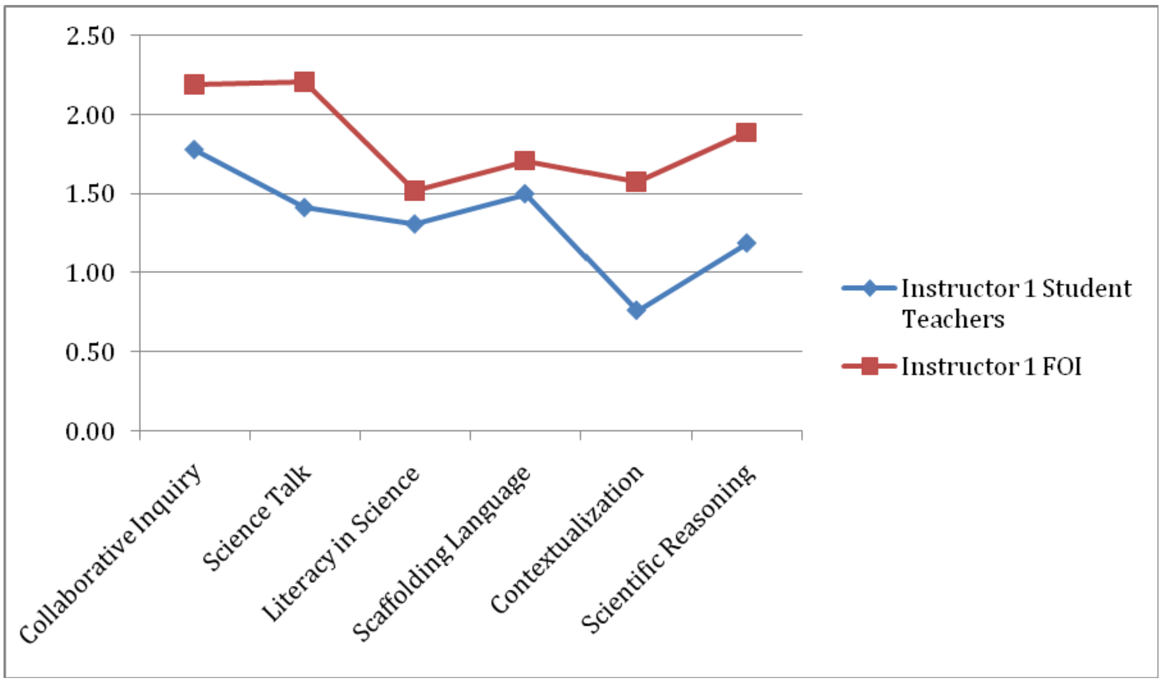
Table 4. DAISI Mean Scores of Experimental Teacher Candidates & Fidelity of Implementation of Method Course Instructors: First Implementation

	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

The small student teacher observation sample size in the first stage of implementation precluded doing a correlational analysis between instructor and student teachers DAISI scores. However, as Figures 1, 2 and 3 show there is some degree of association between instructor FOI scores and student scores, i.e. in the majority of cases the instructor's strength of implementation is mirrored by the student teacher group's strength of implementation.

As Figure 1 shows, in the BCLAD group there is a strong pattern of association between instructor and student teacher scores on Collaborative Inquiry, Literacy in Science, Scaffolding Language and Scientific Reasoning.

Figure 1. BCLAD: Instructor FOI and student teacher DAISI scores



Figures 2 and 3 show the relationship between student 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. See Figure 2. 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. Student scores in the Scaffolding Language, Contextualization and Scientific Reasoning domains are almost equivalent to the instructor scores – at the introductory level.

Figure 2. CLAD 1 Instructor FOI scores and student teacher DAISI scores

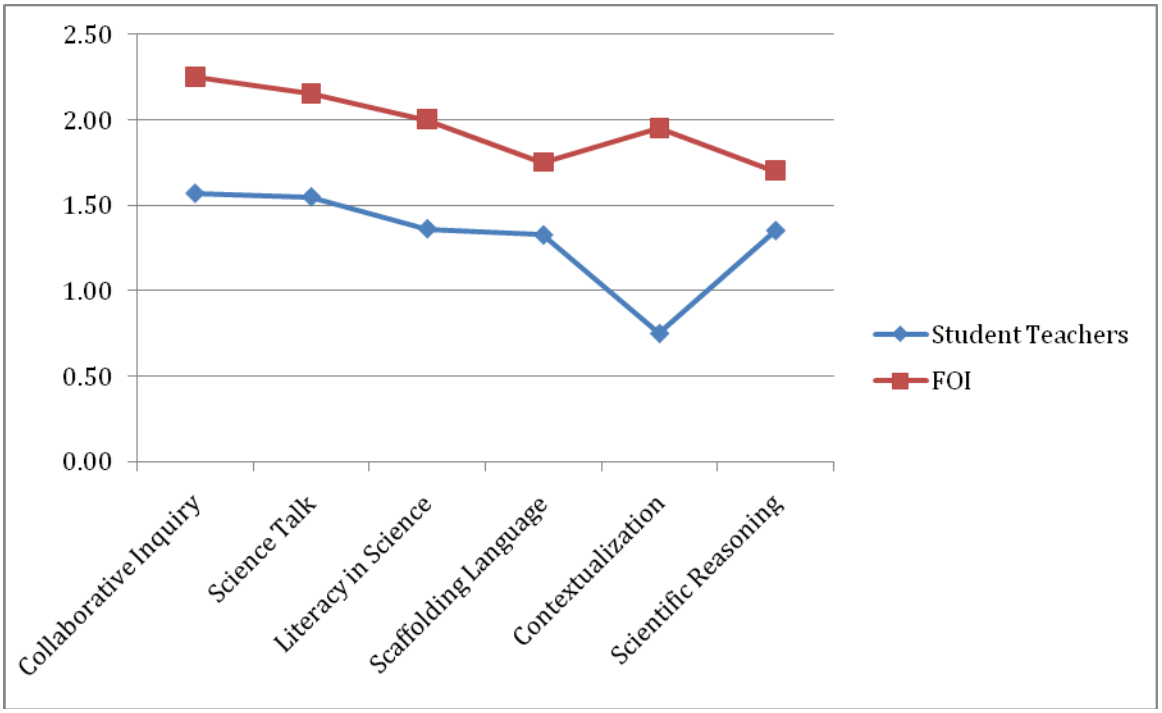
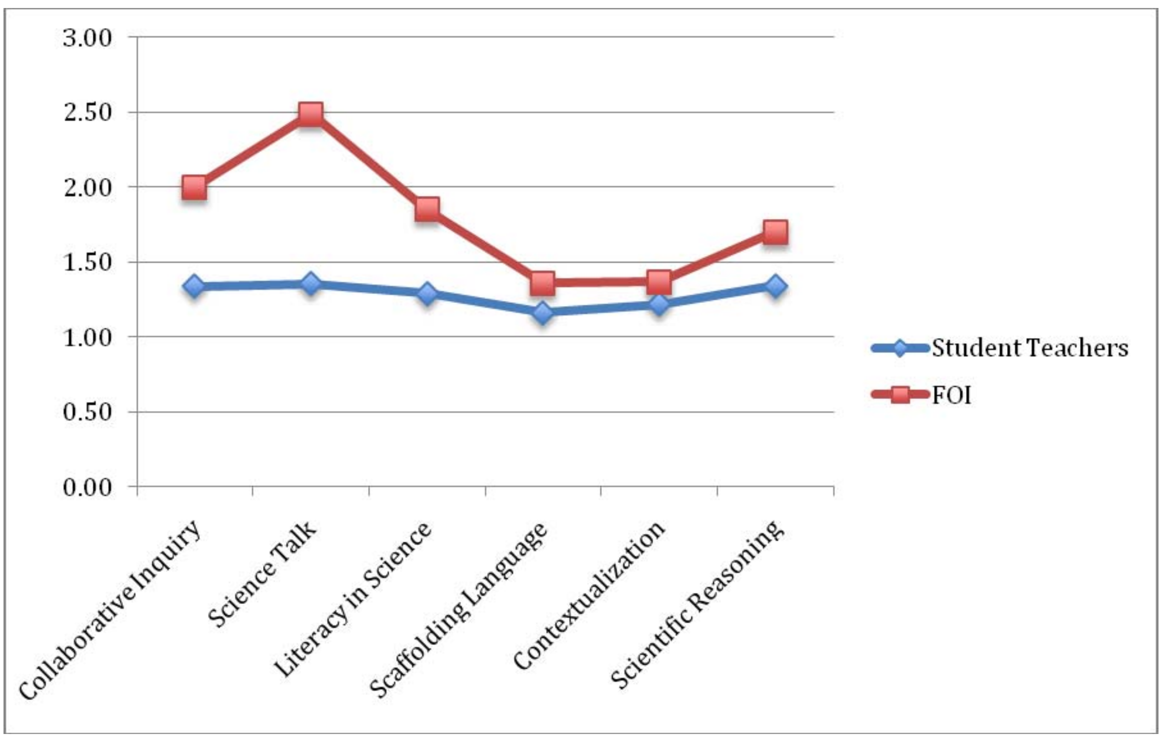


Figure 3. CLAD 2 Instructor FOI score and student teacher DAISI Scores



Discussion

Results from the first year of implementation of the intervention suggest that the intervention is having a positive impact on ESTELL student-teachers in how they teach science during their student-teaching practicum. These differences are present even when we account for expected differences arising from bilingual and non-bilingual credential programs. Compared to control bilingual credential (BCLAD) student-teachers, ESTELL bilingual credential (BCLAD) student-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; ESTELL student-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 teacher use of science discourse patterns for ESTELL student-teachers. While still at the introducing levels of implementation of effective pedagogy, ESTELL student-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. ESTELL bilingual 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 student-teachers found significant differences between ESTELL and non-ESTELL CLAD participants in the study as well in other ESTELL domains in the area of promoting scientific reasoning and inquiry and also, contextualizing science activity. In the area of scientific reasoning both cohorts of ESTELL student-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. ESTELL student-teachers (from instructor 1) were 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 ESTELL CLAD student-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 ESTELL science methods course shows that the implementation of the treatment with the teacher education courses parallel those of their students in the practicum by ESTELL domain. Naturally, instructors have much higher scores in the use of the ESTELL pedagogy, while some notable contextual differences exist.

These results reported in this paper are for the first year of the implementation of the ESTELL intervention. Further analysis will include mixed methods analysis of teacher practices, attitudes, and knowledge of both year 1 and year 2 of implementation of the study. The data include teacher transcribed interviews for each observation and transcripts of method course sessions. Lastly, case study analysis of first year teachers and student achievement of their students will provide further context to the effects of ESTELL pre-service experiences.

Classroom observation measures, such as those used in this study, are complicated by their focus on measuring difficult to define social constructs (Borman and Kimball 2005; Luykx and Lee 2007) including effective pedagogy, teacher quality, student achievement, and the relationship between these areas. Our examination of pre-service science teaching practices, however, moves forward thinking on previous conceptualizations of responsive science pedagogy. Our 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. 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, our 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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