Pre-Service Teacher Efficacy and Practices with Responsive Science Pedagogy for English Learners

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Abstract

This paper presents results from a research effort that gauged pre-service teachers' efficacy about effective pedagogy for English learners during science. Similarly, we present findings of the observations made during these teacher candidate's clinical teaching experiences to see the degree of use of these practices during the time when they taught science. A pre and post-survey was administered at the onset and again at the completion of their teacher education program to gauge their dispositions toward the integration of English learner pedagogy and science teaching. During the second phase of their clinical teaching experience, observers visited these candidates at their teaching placements and observed the candidates teaching a science lesson, using a researcher-created observational protocol. Findings suggest pre-service teachers do not make considerable gains in efficacy to teach science to English language learners and results from observations suggest minimal implementation of these practices as they teach science to English learners. Such findings suggest a need for the integration of English learner pedagogy into science methods courses in teacher education.

Introduction

Closing the achievement gap in our nation will require educators to address the needs of the rapidly growing number of English language learners (ELLs) in the United States' school age population. Once considered a regional concern of gateway states, such as Arizona, California, Texas, Florida, and New York, embracing the needs of linguistic minority students has become a national concern, as record growth of ELLs sweeps through an increasing number of states in the South, Midwest, and Northwest (National Clearinghouse for English Language Acquisition; 2007). North Carolina, for example has seen a 500% increase in the ELL population from 1993-2003, while states like Nevada, Nebraska, Georgia and Indiana all had more than 200% increase during the same time period (Batalova, Fix, & Murray, 2005).

Along with being the fastest growing, ELLs are also among the most academically vulnerable students in schools today (Wong-Fillmore & Snow, 2002). Science achievement in particular, ELLs score significantly lower than their native English speaking peers. The 2005 National Assessment of Educational Progress data shows only 28% of fourth grade ELLs scored at or above basic level, while more than double that number (71%) of native English speakers reached this achievement level (NAEP, 2005). Moreover, this achievement gap between native speakers of English and English language learners is persistent. The average science scores of eighth and twelfth-graders identified as being ELLs were not significantly different in 2005 than in previous assessment years (1996 & 2000) where scores constituted a 48 scale score difference between native speakers of English and ELLs over the ten year period (NAEP, 2005). In order to meet the needs of these students, teachers must have the ability to recognize and address the language demands of academic content area instruction, including those in science (NCES, 1999). There is a great deal of evidence to suggest that teachers who develop these abilities can enact pedagogical practices in science that are academically fruitful for English language learners (Lee & Fradd, 1998; Klentchy & Molina-De La Torre, 2003; Stoddart et. al, 1999). This study contributes to this growing body of research by addressing the following questions:

- What are pre-service teacher's dispositions toward implementing effective ELL pedagogy during science?

- Do (and if so to what degree) pre-service teachers implement effective ELL pedagogy during the science teaching they do during their clinical experience?

Literature Review

Teacher Development & Responsive Pedagogy

The improvement of teacher quality is again a national priority (Gardner, 1983; Paige, 2004) but a goal that requires understanding of the multiple and difficult to define forces and their accompanying characteristics influencing teaching and learning (Borman & Kimball, 2005). The scope of this study relates to this renewed challenge in so far as it centers on the development of new teachers and their preparation to teach science to culturally diverse students who primarily only have access to English at school. However, there is a broad field of research focused on supporting and preparing new teachers to work in culturally diverse settings (Artiles & McClafferty, 1998; Banks & Banks, 2004; Nieto, 1999; Sleeter, & Cornbleth, 2011). This work has contributed to productive re-thinking about the role of teachers in the classroom problematizing their traditional "banking knowledge" role (Freire, 1986). Culturally responsive teaching in effect pushes the boundaries of teaching to accomplish critical cultural work by validating students' experiences, recognizing the whole child not just the official curriculum, empowering students to act on their knowledge, and envisioning teaching with the potential to become socially transformative (Gay, 2000; Ladson-Billings, 1992).

A more discrete, growing area of research directly addresses the language learning dimensions of teaching in culturally diverse classrooms with English Language Learners or what has been termed "linguistically responsive teacher education" (Lucas, Villegas, & Freedson-Gonzalez, 2008). All new teachers, but especially those teaching ELL students, need preparation on effective language teaching practices grounded in second-language acquisition theory (Wong-Fillmore & Snow, 2002). While there is no unified approach or consensus in the field (Cummins, 2002, 2009; Genesee, Lindholm-

Leary, Saunders, & Christian, 2005; Krashen, 1999; Valdés, 2004) on teaching ELL students, there exists a real need for theory and research-driven teacher preparation in this area. Yet, there is some agreement on over-arching second-language learning processes that require a substantive understanding of how language is learned and how non-native English language learners develop a second language and academic English. For example, there is recognition that ELL students benefit more from explicit attention to language forms and functions especially as they relate to disciplinary discourses (Schleppegrell, & Colombi, 2002; Spycher, 2009). Children acquiring a second language benefit from scaffolding and differentiation of polysemous words such as words like "predict" and "observe" as they relate to science inquiry or English narrative analysis. For new teachers this means that they need to attend to and anticipate possible questions ELL students may confront as they teach a particular subject-area and unpack these words and their multiple language forms (e.g. observe, observation, observatory, etc.) that provide additional language context for students. Promoting meaningful social interaction where students practice using both oral and written, grade-level language functions is another second-language acquisition process that is accepted as one that greatly benefits the development of academic English for ELL students (Coleman, Goldenberg, 2010; Collier, 1992; Cummins, 2002; Thomas & Collier 2003). These and other language processes (Lucas et al, 2008) need to be central components of teacher education programs preparing teachers to teach diverse ELL students and can not be implemented through peripheral, ad-hoc exposure in teacher education methods courses. Moreover, there is some evidence that suggests that this process has the potential to be a bi-directional process where teacher candidates' knowledge about their students is enhanced through situated engagement with their local communities (Garcia, Arias, Harris Murri, & Serna, 2010).

Science-Language Integration: Encouraging Results

In traditional science programs, ELLs face the dual role of acquiring content knowledge and language, without due instructional time devoted to the language needed to accomplish expected science tasks (Stoddart, Pinal, Latzke, & Canaday, 2002). Without the proper scaffolds, the cognitive load of dealing with the academic language demands of science often compromises ELLs' science understanding (Lee & Luykx, 2004). These language demands can include understanding and making sense of investigation procedures (Carr, Sexton & Lagunoff, 2006), explaining processes (Lee, & Fradd, 1998), participation in (and understanding the rules of) discussions (Dobb, 2004), acquiring specialized science vocabulary (Chamot, O'Malley, 1994), gathering information from science books (Fathman & Crowther, 2005), as well as writing observations and expository texts (Amaral, Garrison & Klentschy, 2002).

A series of research studies, using both qualitative and quantitative methods, has demonstrated that ELLs in classrooms where language and content are both addressed, make considerable gains in content knowledge and language proficiency (Stoddart, 2002; Klentschy & Molina-De La Torre, 2003; Amaral, Garrison & Klentschy, 2002; Moje, Collazo, Carrillo & Marx, 2001; Lee & Fradd 1998; Bravo & Garcia 2004).

Working primarily with fourth and sixth grade students, Amaral, Garrison and Klentschy (2002) studied the effects of instruction that allowed students to conduct first-hand science investigations and keep a science journal to distill science activities and develop writing proficiency. The instructional focus on hands-on science activities and authentic purpose to sharpen their writing skills offered by science (Yore, Holliday & Alvermann, 1994), led to significant gains by ELLs in both science knowledge and literacy abilities. Each subsequent year (4 years total) students remained in this intervention, resulted in significant gains in science achievement. Using results from the states' science assessment, these researchers note mean result increases for both fourth and sixth grade ELLs. Interestingly, across both grade levels, less proficient ELLs made similar gains in science knowledge, as did more proficient speakers of English, including native speakers of English.

Students also showed gains in writing proficiency. With the use of a district writing assessments, the researchers also present increases in passing rate of this district exam. The longer ELLs remained in the science and writing intervention, the stronger the gains. Instructional attention to the genre of science writing was provided, essential as many students in primary grades are more familiar with narrative than expository writing (Duke, Bennett-Armistead, 2003). Bravo and Garcia (2004) in gauging the science writing abilities of fourth grade ELLs found a substantial number of students "narrativizing" science reports (e.g., including setting, focusing on individuals that conducted the investigation instead of investigation procedures) at the baseline data point, and later, after instruction on the structure of a science report, using a more expository frame.

Stoddart, Canaday, Clinton, Erai, Gasper, Latzke, Pinal & Ponce (1999) focused their research energies on studying the benefits of integrated language and science instruction on ELLs' science knowledge and vocabulary development. After experiencing science instruction that was infused with opportunities to hear and practice using key science vocabulary, ELLs in grades first through fifth posted significant increases in their use of complex science vocabulary (e.g., species, fossil, habitat). ELLs also posted significant gains in accuracy of scientific propositions, as measured by concept maps that each student constructed. Related and robust research on vocabulary learning in science supports the need to target key science concepts with instruction (Cervetti, Pearson, Bravo, & Barber 2006). While science exposes students to a large corpus of challenging and often abstract words, science also presents students with multiple, multi-modal, thematically-related and contextualized experiences with target words, all of which increase student opportunities to build active control of generative academic language (Bravo & Cervetti, 2009).

Successful approaches to science teaching that have ELLs in mind, address the language demands of science by infusing existing science programs with practices that amplify the language of science without watering down the content. Such tools as visual representations (e.g., word maps, concept maps) (Carr, Sexton & Lagunoff, 2006; Bravo & Garcia, 2004), inclusion of supplementary materials (books, maps, illustrations) (Echevarria, Vogt, & Short, 2006; Amaral et. al, 2002;), and pre-teaching science vocabulary (Chamot & O'Malley, 1994; Stoddart et. al., 1999) are common suggested language accommodations that scaffold ELLs' science experiences. The research cited above shows positive science and language outcomes for ELLs in integrated curriculum when these practices take place.

While there is reason to believe that carefully crafted science instruction can have particular benefits for their development of academic language, we also believed that additional supports might be needed in order obviate some of the linguistic obstacles that English language learners face in science. Addressing these linguistic obstacles in science should be a focus of teacher training and this paper looks to address the degree to which these are currently a focus of instruction in science methods courses.

Methods

While the larger study design is quasi-experimental in nature, this initial data collected from pre-service teachers involved pre-service teachers that were moving through their teaching credential program without an intervention. Hence pre/post survey data was gathered and a single observation was done during their science teaching that takes place during their clinical teaching experience.

Participants. The ethnic demographics of participants is as follows: 60% White, 12% Latino, 14% Asian, 12% mixed race. The gender make-up was predominantly female (88%) and the dominant age range was between 20 to 30 years of age (80%). All are seeking credentials that will allow them to teach in K-8 settings. A total of 105 pre-service teachers participated in this baseline data collection from the three research sites. Table 1 below illustrates this demographic information.

Table 1. **ESTELL Participant Demographics.**

		2008-09 Cohort		2009-10 Cohort	
		n	%	N	%
Race/Ethnicity					
	White	143	61.6	112	59.9
	Latino	28	12.1	30	16.0
	Asian	33	14.2	25	13.4
	Mixed	28	12.1	20	10.7
	Total	232	100.0	187	100.0
Gender					
	Female	205	88.4	159	85.5
	Male	27	11.6	27	14.5
	Total	232	100	187	100
Age Group					
	20-25	134	57.8	99	52.9
	26-30	57	24.6	42	22.5
	31-35	14	6.0	13	7.0
	35+	27	11.6	33	17.6
	Total	232	100.0	187	100.0
Undergraduate Major					

Soc. Science	77	33.6	63	34.1
Education	54	23.6	50	27.0
Science & Engineering	7	3.1	4	2.2
Professional Degree	10	4.4	15	8.1
Other	81	35.4	53	28.6
Total	232	100.0	185	100.0

Sites. The study took place in three Universities that issue K-8 teaching credentials. The three sites were very similar in composition. All were on the semester system and were relatively about the same size (20-30 tenured tenure track faculty) and all issued bilingual as well as Cross Cultural Language and Academic Development (CLAD) credentials.

Instruments. Two data sources were collected to trace the development of pre-service teacher dispositions toward integration of ELL pedagogy into science and enacted practices of the treatment pedagogy during their field placement.

Survey. With respect to the survey, the reliability of each domain was examined using a classical test analysis approach that assessed the quality and distinctiveness of the six effective pedagogical scales (n = 147). In the table below we provide results of this analysis

Table 2. Survey Reliability Analysis of the ESTELL Instructional practices (n=147).

	Number of Items	**Cronbach's Alpha**
1. Facilitating Collaborative Inquiry	5	0.67
2. Promoting Science Talk	7	0.74
3. Contextualization	4	0.77
4. Language & Literacy in Science	9	0.80
5. Promoting Scientific Reasoning	6	0.58

Negative and positively phrased questions in the survey included:

- *Discussions about science investigations can take away from the doing of science.*
- *English learners need to be proficient in English language, reading and writing before they are taught science.*
- *Teacher should try to use as many language modalities (e.g., reading, writing, listening, speaking) as possible to make science understandings accessible to English learners.*

Observation Protocol. The ESTELL Dialogic Activity in Science Instruction (EDAISI) is a classroom observation instrument developed to capture the range of teaching practices and behaviors in the classroom related to science and ELL pedagogy integration. The observation protocol was developed by a set of collaborators across fields of science education, literacy development, second-language acquisition, and linguistic anthropology. The central theoretical perspective builds from work developed by Stoddart (2002) on science-language integration and Tharp's (2004) Vygotskian principles for promoting dialogic and effective pedagogy.

The observation scheme includes ethnographic notes, ratings of teacher use of the ESTELL domains, science observation and a "debrief" that further contextualizes the observation. The ethnographic notes include a map of the classroom setting, documenting the unfolding of the lesson, including visuals or grouping organizations used during the lesson. The ratings of the ESTELL domains during the lesson are done with a rubric scaled on a range from Not Present (score-0), Introducing (score 1), Implementing (2) to Elaborating (score-3). The scaling of these items mirrors those utilized by another CREDE observational instrument (Doherty, Hilberg, Epaloose, & Tharp, 2002). Observers rate each ESTELL domain across this scale every fifteen minutes. The observation "debrief" poses teachers a set of questions that further explains what the goals were for the lesson, how familiar students were with the content being taught, as well as the teacher sense of efficacy with the science subject matter.

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.

Table 3. Reliability Analysis of the ESTELL Observations (n=147).

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

Analysis. The analysis presented here is that of the control group. A one-way within subjects (or repeated measures) ANOVA was conducted to compare differences in the five ESTELL Pedagogy Domains between the Pre- and Post-ESTELL survey administrations and to examine the practicum observations. A similar analysis was conducted to analyze differences of implementation of the ESTELL pedagogy using the observation instrument scores (EDAISI)

Results.

Survey. There was a statistically significant negative difference in the means for several domains. Results of dispositions toward the instructional practices are presented in the table below.

Table 4. **Survey Baseline Control Cohort Pre and Post ESTELL Instructional practice Descriptive Statistics**

	Pre-Survey		Post-Survey			
	Mean	Std. Dev.	Mean	Std. Dev.	One-way ANOVA	P-val.
Facilitating Collaborative Inquiry	3.216	.281	3.140	.333	F(1, 134)= 4.70*	0.032
Promoting Science Talk	3.217	.255	3.207	.291	F(1, 134)= .122	0.727
Contextualization	3.472	.405	3.258	.432	F(1, 134)= 21.34***	0.001
Language & Literacy in Science	3.163	.275	3.106	.303	F(1, 134)= 3.10	0.081
Promoting Scientific Reasoning	3.419	.360	3.139	.384	F(1, 134)= 45.95***	0.001

* p < .05; ** p < .01; *** p < .001.

Table 4 also shows that there was a statistically significant negative difference between the pre-survey and post-survey means on three of the five ESTELL Instructional Practices – Facilitating Collaborative Inquiry (p >.05), Contextualization (p> .0001), and Promoting Scientific Reasoning p > .001). Teacher candidates' agreement with ESTELL instructional practices diminished between the onset and end of their traditional (non-ESTELL) teacher education program.

The means for Facilitating Collaborative Inquiry scale was 3.22 on the pre-survey and 3.14 on the post survey. There was a statistically significant difference in the means for Facilitating Collaborative Inquiry between the Pre-Survey (M=3.22, SD=0.3) and the post-survey (M=3.14, SD=0.35) administration (ANOVA, F (1, 134) = 4.70, p = .032). On the other hand, the means for the Promoting Science Talk instructional practice were 3.22 on the pre-survey and 3.21 on the post-survey. The means for Promoting Science Talk were similar and therefore not statistically significant (ANOVA, F (1, 134) = 0.122, p = .727). The Contextualization scale had a mean of 3.47 on the pre-survey and 3.26 on the post-survey. The means of Contextualization also showed a statistically significant difference between the pre-survey (M=3.47, SD=0.41) and the post-survey (M=3.26, SD=0.43) administration (ANOVA, F (1, 134) = 21.34, p < .001). Similar to the Promoting Science Talk instructional practice, the Literacy in Science scale had a mean of 3.16 on the pre-survey and 3.11 on the post-survey, this difference in means however was not statistically significant (ANOVA, F (1, 134) = 3.10, p < .081). Finally, the Promoting Scientific Reasoning scale had a mean of 3.42 on the pre-test and 3.12 on the post-test, a difference that was statistically significant (ANOVA, F (1, 134) = 45.95, p <

.001). There was no statistically significant change between pre-survey and post-survey results on two ESTELL instructional practices including Language and Literacy in Science and Promoting Science Talk.

Observations. Teacher candidates were observed once during their student-teaching phase. 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. 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. Results were as follows:

Table 5. Pre-Service Observation Scores for the Baseline Cohort.

	Mean	Std Dev	Min	Max
1.Facilitating Collaborative Inquiry	1.5924	.40251	.67	2.50
2.Promoting Science Talk	1.3735	.49980	.17	2.50
3a.Literacy in Science	1.1561	.45078	.50	2.50
3b.Scaffolding & Language Development	1.3508	.44795	.50	2.50
4.Contextualization	.4894	.40850	.00	1.75
5. Promoting Scientific Reasoning & Inquiry	1.2977	.59053	.00	2.50

With the exception of two instructional practice areas (Facilitative Collaborative Inquiry and Contextualizing Science Activity), teacher candidates implemented all other four ESTELL Instructional practices at the introductory level (ranging from 1.15-1.37). An overall basic or introductory implementation of the ESTELL Instructional practices suggests that teacher candidates were:

- using but not explaining science discourse patterns to students while giving limited to no follow-up to student contributions (Promoting Science Talk)
- 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)

Facilitating Collaborative Inquiry achieved the highest mean score of 1.59. This instructional practice area measured the level of student-teacher and student-student collaboration and shared scientific authority during science teaching. A score of 1.59 indicates that baseline teacher candidates promoted *minimal* to *some* student-student interaction within at least one kind of collaborative learning structure while still mostly promoting scientific authority as a close enterprise not able to be challenged by students and the teacher.

Contextualizing science activity received the lowest mean score of .48. 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 .48 indicates that baseline teacher candidates rarely provided nor elicited examples from student experiences in the teaching of science objectives; students might have also offered those examples but in such cases, these contributions were not used or overlooked as a potential science resources.

Discussion

Survey findings suggest little change from pre to post survey administration on the part of the control participants with regard to knowledge about the ELL pedagogy that would make science more accessible to ELLs. Teacher candidates' level of agreement with the ELL pedagogy hovered near neutral levels at pre-administration of the survey, suggesting there was much room to grow in this domain. Yet, current models of teacher education programs focus on methods and theory-based courses separately. In the case of learning about ELLs and their particular needs, this is done separate from methods courses like science. Such an approach leaves teacher candidates with the role of understanding how ELL pedagogy applies to content areas. Results from this study, suggest that this may not be the most efficacious approach.

With regard to the observation results, teacher candidates implemented this pedagogy at a rudimentary level. This would be expected, given their neutral levels of understanding of the pedagogy as reported in the survey results section above and the novice nature of the teacher candidates. Yet, it was clear that finding ways to make connections between the science activities and the experiences students come to the classroom with, whether regarding the local/ecological or home/community, was above all the most difficult for student teachers to implement. This mirrors similar findings from others (Lee, 2004; Moje, Collazo, Carrillo & Marx, 2001). In the development of EDAISI, we consider the concept of instructional and cultural congruence because it addresses effective science learning conditions of diverse student directly. According to Luykx and Lee (2007), a *cultural congruence framework* can be used by teachers to align science instruction within classroom communities that may have distinct ways of seeing the world and their place in relation to the natural world. This approach is found to be very effective. 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.

These findings, while troubling due to the wide research-base for the efficacy of integrating science and language, illustrates a critical need on the part of teacher education programs to bring coherence to methods and ELL pedagogy..

Conclusion

Elementary teachers face the formidable challenge of engaging an increasingly linguistically diverse population of students in learning about the full array of academic disciplines. The challenge is particularly significant in science, a discipline in which few ELLs are reaching grade level proficiency. Yet, science can be a rich and authentic context in which ELLs can sharpen their academic language proficiency while building their science knowledge, *if* language accommodations are made. These accommodations include an instructional focus on the language and literacy needed to complete the science tasks ELLs are asked to participate in and understand. This paper contributes to the understanding that teachers entering the profession require additional attention in how to make science more accessible to this growing and academically vulnerable student population.

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