Contribution of Practice

# PERSPECTIVES FROM A STEM EVENT: INCREASING STEM KNOWLEDGE, LITERACY PRACTICES, AND BILINGUAL LANGUAGE USE FOR STUDENT TEACHERS AT PUERTO EDUCATIVO

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**Abstract**

*This paper discusses the learning experiences of an educational STEM event named Puerto Educativo from the perspectives of a science educator, a literacy educator, and a Spanish-speaking student teacher. The discussion details how the STEM event at Puerto Educativo was theorized, its positive implications, and the use of this service-learning event in the community. The perspectives discussed by the educators indicate bilingual instruction accompanying STEM service-learning demonstrations help build positive science identities and create collaborative learning spaces for student teachers in border regions.*

Keywords: STEM, literacy, bilingual instruction, student teachers

Early intervention in STEM (science, technology, engineering, mathematics) experiences can diminish disparities caused by race in STEM achievement. Interventions that have significant long-term effects include supplemental instruction, bridge programs, meta-cognitive study strategies, tutoring, and promoting social networks of peers among STEM majors (Chang et al., 2014). Science teachers, especially student teachers in education preparation programs, who use these types of interventions, are more effective at encouraging STEM careers. Student teachers can face a variety of challenges as a result of their own experiences. Negative experiences, especially for new teachers, can alienate them from science. New teachers are less likely to be successful in teaching through scientific inquiry, especially if they lack experience (Davis et al., 2006). Students that identify as Latino\a or African American show less STEM persistence (Chang et al., 2014). Minority students who do not see people of similar backgrounds working in STEM can lose interest in science. Culturally responsive teaching methods can facilitate interest and connect students to the culture of science. One method of connecting the language of science to a student's background is to develop their scientific identity (Anderson & Ward, 2013).

Texas border school districts report higher proportions of English Language Learners (ELLs), economically disadvantaged students, bilingual students, limited English proficiency (LEP), and at-risk students; also, border regions typically employ a higher number of Hispanic teachers (Sloat et al., 2007). Gender disparities exist in STEM careers as well. Women are less likely to enter STEM fields because their interest in science and math is lower than their white, black, and Hispanic male counterparts (Cunningham et al., 2015). In combination, these factors can exacerbate STEM disparities, particularly for k-12 schools in border regions. One way to lessen STEM disparities is to better prepare science and mathematics


ISSN: 2474-3976 online

teachers in teacher preparation programs. The purpose of this paper is to articulate potential strategies to elicit interest in STEM with student teachers through the use of collaborative/community-based STEM learning events and study the use of cognates in the academic language of STEM learning events. Three educators will offer their perspectives on the use of the STEM toolbox, a bilingual strategy that incorporates academic and Spanish cognates, the everyday experiences of students with STEM tools, and learning activities that support STEM-DED demonstrations. The perspectives offered are from the observations of two teacher educators and one bilingual student teacher. All three educators worked together to coordinate the STEM discrepant event demonstrations (STEM-DEDs) and activities during a service-learning experience on the U.S-Mexico border named Puerto Educativo.

## Literature Review

The following literature review will explore disparities in STEM fields and/or strategies and interventions that can better prepare student teachers. A study in West Texas disputes the claims of low enrollment of Hispanic students in STEM fields. They studied a paradox that occurred at their own institution. The researchers wanted to know what contributed to the increase in enrollment at an institution in the Texas Panhandle region and how this growth could be supported in the future (Hunt et al., 2014).

The focus of the study was to determine which specific elements contributed to the rise in STEM majors, their choice of institution, and whether or not there was a gender disparity between male and female Hispanic students. Emerging themes indicate students like learning communities connected to STEM fields- either through study groups for specific classes and professional groups, or groups created through scholarship programs (Hunt et al., 2014). Female and minority students could benefit from learning experiences that encourage a collaborative environment.

Certain fields in STEM are more encouraged for females than others. Emphasis is placed on nurturing fields – like biology, teaching, and nursing as opposed to more the physical science fields. This is evidenced by the stereotype threat: comments based on gender or ethnicity and/or actions by classroom teachers and students (Davis et al., 2006). A study conducted in West Texas focused on nine female graduate students enrolled in a science education course for student teachers involving electrical circuits. These researchers postulate that "cultural mediation helped students go form new concepts or modify existing or spontaneous concepts," and when students worked together, they "viewed themselves as groups of scientists who are engaging in the scientific process and promoting positive dispositions" (Davis et al., 2006, p.57). These researchers believe that a strong relationship to content, creating a community of learners, and connecting content to individual students' everyday experience positively influences student attitudes towards science (Davis et al., 2006). This study points to the strong possibility that including a community-based dynamic, where students are cooperatively engaging in inquiry and see themselves as scientists, supports an increase in interest in STEM.

For bilingual student teachers, a dual language context can increase knowledge of science content and academic language development. Student teachers that are shown learning approaches and strategies that integrate science understanding can help students formulate their scientific identities (Garza et al., 2014). In another study conducted in the South Texas region, student teachers were exposed to a dual language education workshop at a park. Student teachers worked in bilingual pairs, that is, one bilingual and one monolingual speaker, which helped them develop cultural understanding. The teacher educators in this study used a multi-sensory environment where children were exposed to a nature walk and music to develop scientific ideas. Another strategy used was to use Spanish cognates during content instruction so students could relate new terminology with prior terminology. These strategies helped to develop student science identity and to challenge the student teachers' pedagogical approaches to learning (Garza et al., 2014). Accessing science curriculum and STEM curriculum can be difficult for non-English speakers.

Similar results are found in communities along the U.S-Mexico border. Diaz & Bussert-Webb (2017) analyzed how student teachers incorporated funds of knowledge as "third space" spaces other than home or school, otherwise known as an informal learning space. This is a space wherein school and home discourses integrate science and mathematics for youth. Student teachers in this study

completed pre and post reflections on two lesson plans, a questionnaire, and focus group instruction. Several major themes emerged from their analysis: hands-on inquiry experiences assisted teachers in connecting the children's everyday experiences to scientific tasks such as asking questions, gathering data, and considering evidence (Diaz & Bussert-Webb, 2017).

In consideration of these studies, this article outlines a pilot service-learning event involving a collaborative informal learning space where student teachers were encouraged to use bilingual instruction. Student teachers developed STEM-DEDs with peers in an informal public learning space, Puerto Educativo. This event employed a service-learning model to help student teachers to work reciprocally to engage children and parents in inquiry while integrating content for Spanish language instruction as well. This service-learning experience utilizes the DEAL (Describe, Examine, and Articulate Learning) model of critical reflection. The steps to this approach include examining the experience in light of the learning goals, articulating the learning, and articulating goals for future learning and/or refining learning (Ash & Clayton, 2009, p. 28). The DEAL model was utilized to inform teachers and to reflect on the learning process for the STEM-DED presentations.

## Methods/Design of Service-Learning Event

Puerto Educativo is an indoor space in an open-air mall located on the border in South Texas. It features a public inclusive educational space for elementary-aged children. Puerto Educativo primarily encourages literacy-oriented activities. This space began as an initiative with a local university and has been extended to events of different disciplines. This location was used to implement the service-learning event with STEM-DEDs. Elementary science student teachers from a local University volunteered to participate as demonstrators. Twenty-five student teachers taught children of various age groups discrepant events that involved STEM-based education. The elementary science student teachers displayed their STEM-DEDs on a table with two or three student teachers per table. Children and parents who came to the event were welcomed and encouraged to participate. The student teachers were also encouraged to implement a STEM toolbox, a collection of paper manipulatives, in the context of the STEM-DED instruction. The STEM-DEDs are inquiry-based learning discrepant events that involve an unexpected outcome. Student teachers are asked to integrate STEM instruction into their discrepant events. Because children, parents, and other adults varied in their fluency and preference of the Spanish language, student teachers who were fluent in Spanish were given the option to use dual language instruction as they presented their STEM-DEDs. This service-learning experience was designed to help student teachers teach science and mathematics content associated with the discrepant events and the STEM toolbox, practice questioning techniques, and integrate basic process skills. Basic process skills and questioning techniques included: measuring, estimating, observing, safety, inference, classifying, predicting, utilizing mathematics applications of data in charts, questioning techniques, and explaining content and concepts used (Goldston & Downey, 2012).

The STEM-DEDs are discrepant events that were modified by the student teachers to include mathematics and science concepts. Students were also encouraged to engineer different situations for the discrepant events and to use technology, either in the form of scientific instruments as technology or everyday technology to facilitate the discrepant events. The STEM toolbox is a paper envelope or foldable filled with different informal and formal scientific instruments and images. Some of these instruments included differing size paper rulers, a magnifying glass, Ziploc bags, a spoon, a plastic pipette, and non-standard units of measurement such as different colored lengths of yarn. The toolboxes contained both English and Spanish names on the images of science equipment. Student teachers were required to integrate the STEM toolbox as needed in the STEM-DED. A second and separate activity was presented by one student teacher. During this activity, children learned about the STEM toolbox in dual language instruction and how to use the scientific instruments in the toolbox. The STEM-DEDS were practiced and peer-critiqued prior to the demonstrations.

This study is a preliminary pilot study to determine the effectiveness of the STEM-DEDs in conjunction with a STEM toolbox and dual-language instruction. The teacher educators targeted three primary categories to analyze: effectiveness of the STEM-DEDs in terms of content and pedagogy, the effectiveness of the STEM toolbox with dual

language instruction, and the integration of literacy strategies. These strategies were studied through observational notes for their impact on dual language instruction and the possible impact on student science identity. Three different perspectives on the STEM-DED event will be discussed. The first perspective, from a science educator, will share an analysis of the effectiveness of the STEM-DEDs and the STEM toolbox as it relates to teaching pedagogy. The second perspective, from a literacy educator, will share analysis and observations of the STEM toolbox teaching event and dual-language instruction through a literacy lens as it relates to science identity. The last perspective offered in this paper is from a bilingual student teacher who facilitated the STEM toolbox teaching event. She will discuss her teaching experience using the STEM toolbox and dual-language instruction and the possibility of using dual-language instruction in the future.

## The Perspective of the Science Educator: STEM-DEDs and the STEM Toolbox

As a part of this service-learning experience, student teachers improved their teaching techniques by conducting STEM-DEDs in groups that employed a service-learning model. From observational notes taken, students felt confident about three specific aspects of teaching: the discussion of the content and discrepant event, working with peers, and use of the STEM toolbox. Student teachers exhibited confidence when presenting the STEM-DEDs. The groups that practiced the STEM-DEDS more often knew how to move fluidly into different extensions of the discrepant events. The observational notes indicate these student teachers were eager to show the math and science discrepant events, to ask questions, and to engage students in more challenging situations. These groups relied on their members to provide support and did not struggle to integrate the STEM toolbox. Even though student teachers felt confidant using conversational Spanish in a public space, they were challenged to use Spanish cognates while teaching discrepant events. It was also observed that student teachers were more confidant working in pairs or groups of three but struggled with explaining content vocabulary effectively in both languages. Garza et al. (2014) provide some insight about conducting science events for dual language speakers. These researchers suggest student teachers are more confidant with science when they have bilingual pairs, that , when students are grouped as one monolingual speaker with one dual language speaker. Also, Garza et al. (2014) suggest students be exposed to content vocabulary and cognates before the lesson/teaching event. In these demonstrations, student teachers who did not review content area vocabulary and Spanish cognates before implementing the STEM-DEDs were less confidant making connections between scientific vocabulary and their Spanish cognates. Another concern was the use of the STEM toolbox in the STEM-DEDs. Since the STEM toolbox had both Spanish and English labeling, student teachers may have felt pressured to explain the Spanish equivalent and relate that to the larger STEM-DED explanation. Children were given STEM toolboxes to take home; however, because student teachers were more focused on presenting the STEM-DEDs, children may not have understood the importance of utilizing the STEM toolbox items in everyday life. Thus, from this observational analysis of 12 presentation groups, there is evidence to suggest science identity and motivation for student teachers increased. However, the connection to the Spanish scientific terms and use of Spanish and English throughout the lesson was less apparent. The next educator will give insight into the literacy aspect of bilingual instruction and its connection to the STEM events at Puerto Educativo.

## The Perspective of the Literacy Educator: Literacy Connections and the STEM Toolbox

A connection between language and literacy is evident. Reading and writing or literacy skills develop during the child's first eight years. Oral language skills must be developed first, followed by reading and writing. Writing is the skill that takes the longest to develop. Writing requires formal educational and academic support for many years after a language is acquired (Cummins, 2000). Literacy must be fully developed in the first language for it to transfer to a second language, assuming that the native language is based on the Roman alphabet, like Spanish. With a language that uses non-Roman characters, this transfer will not be as automatic, but children will understand that the printed word has meaning and is a form of oral communication in symbols to be deciphered. However, if literacy is not fully developed in one's native language, then the process of literacy development will be

more complex and may take longer than expected (Cummins, 2000).

Educators recognize that knowing words is critical for students' success academically. In addition, students who are successful and high achieving have a rich vocabulary and know many more words than students who are not as academically successful (Tompkins, 2016). According to some researchers, the vocabulary of the lowest-achieving high school seniors is the same as the vocabulary of high achieving third graders (Beck et al., 2013). Variations of children's word knowledge tend to connect with the socioeconomic class of the family and are evident from when the child enters kindergarten and first grade (Tompkins, 2016). Researchers have seen that children who come from lower SES have lower word knowledge than the higher socioeconomic status (SES) children. In fact, Beck and her colleagues (2013) demonstrated that the higher SES children know twice as many words as the lower SES children (Tompkins, 2016).

Additionally, Beck et al. (2013) also found that children who come from higher SES families have a vocabulary that is amplified by having more vocabulary-rich experiences with their families. Similarly, children who come from higher SES backgrounds who are read to daily, go to the library more often and have books at home that they can enjoy. Families who have a higher SES also use words that are more advanced when they are speaking to their children. Children who have less vocabulary have a very hard time catching up with those who have more word knowledge. This happens because high achievers learn more and acquire words faster than those who are low achievers (Tompkins, 2016). Children who come from high SES families accomplish acquiring 3000 to 4000 words a year as compared to low SES children who learn at a slower pace (Tompkins, 2016). When they graduate from high school, the high SES students have a vocabulary of 50,000 plus words (Tompkins, 2016).

Having stated all this, the children that came to Puerto Educativo were of a mixed SES, and most were bilingual. Children who are bilingual have knowledge of words in both languages. Put together, they may have a large, combined vocabulary bank, but when each language is measured separately, it may be less. Theories of bilingualism state that competent bilinguals form some of the same cognitive and neural bases to aid vocabulary knowledge in their languages, meaning both of their languages (Hernandez & Li, 2007; Kroll, 2015 as cited in Ka et al., 2016). The STEM toolbox, which has vocabulary in both languages, becomes crucial for children and plays a role in connecting families to the Puerto Educativo event. Furthermore, researchers state that Latino\a native language allows children to be part of the cultural environment and experience traditions; this is a significant factor in their identity and this, in turn, provides an avenue for them to be able to develop resiliency which helps them to become academically successful (Stevenson et al., 2019). The resiliency developed through interacting in their native language and community helps them to build relationships, which in turn provides a support system. This support system then enables the students to be able to conquer obstacles that they may encounter following their interest in STEM (Stevenson et al., 2019).

In addition to learning content vocabulary, the children also gained knowledge of the content vocabulary in their native language. STEM vocabulary can be difficult for bilingual speakers and especially difficult for ELL learners. Teachers need to use multiple strategies to be sure that comprehension is being established in the lesson. Even monolingual students need to practice content vocabulary, as it may be foreign to them, and if not comprehended, may hinder understanding of concepts taught in the lesson.

The event that I observed with the STEM toolbox demonstrated enrichment of content vocabulary in Spanish and English benefited the student, parents, and teacher in multiple ways. Sometimes the students did not know the word in English, then the Spanish was very helpful and vice-versa. Children who are only familiar with conversational Spanish were also learning the content vocabulary in Spanish, which meant they were learning academic Spanish. This also worked in the other way; sometimes, children did not know English but understood Spanish. The student teachers gave both languages equal time and pre-taught the vocabulary before beginning the activity. With all this happening, children had important discussions in English and Spanish and were exposed to the spelling of words in both languages. Families participated more when the student teachers spoke Spanish. Thus, a strong rapport was built between the students, family, and teacher.

A science education class and a literacy class for student teachers have many avenues for the integration of language and literacy. Word walls in both Spanish and English can be useful, as can having student teachers create their own Spanish–English Dictionary of STEM words. In the future, I would like to see more integration of the literacy class with the STEM class and more fieldwork that allows student teachers to practice Spanish and English teaching skills. These types of informal learning experiences create community-based enrichment activities which benefit many members of the community, especially lower SES families.

### The Perspective of a Bilingual Preservice Teacher

As a bilingual teacher, it is my duty to investigate new strategies that will benefit my students. In collaboration with professors at the university, the Puerto Educativo event was very successful. Through very didactic and hands-on instruction, children were able to grasp new knowledge in a very different and innovative way. The main tool in this project was the STEM toolbox: a toolbox created so children understand that science is everywhere. This toolbox is made from items that can be found at home for educational purposes. This way, children can practice their background knowledge about science. At the Puerto Educativo event, participants freely walked around to observe the STEM-DEDs presented by other future educators. This created an opportunity to focus on the laboratory tools being used at these demonstrations. It was a perfect moment to talk about the lab tools and incorporate the cognates of the names of these tools in Spanish.

As a Spanish speaker, science terminology can be very hard to understand. Therefore, we decided to incorporate visuals, the STEM toolbox, and whiteboards, to better explain the names of these tools and how they are used in the STEM-DEDs. Elementary students at this event were eager to learn the pronunciation of the tools in Spanish and English. As the instruction was presented to the participants, they began to talk about their past experiences in the laboratory. A third grader mentioned that an experiment was conducted in her science class. These types of activities are authentic and are much more meaningful for children as compared to a worksheet that they fill out after listening to a lesson about magnets, for example. During the explanation, a child mentioned the connection between “microscope” and “microscopio”. This was a teachable moment to introduce the meaning of cognates and how useful it is when you know the meaning of a word in your native language. This can also be easily connected to a language arts lesson since the root words in science terminology are sometimes the key to understanding the meaning of the word. For this activity, the children were presented with a picture and were asked to match it to the corresponding instrument in the STEM toolbox. Then they were challenged to figure out the name of the instrument. If they didn’t know the proper name of the instrument, they were asked if they knew its use. Using their background knowledge, they made an educated guess, and then the student teachers explained the name and the instrument’s proper usage. This was a fun activity for the students because they liked learning different pronunciations of the tools they just saw used in the STEM-DEDs showcase. It is very important to awaken their interest in science at an early age to surpass any stereotype in the STEM field. This strategy of dual language instruction will be used with my future students. The purpose is to encourage students to envision themselves as scientists and to further their education outside the classroom.

## Conclusions

Collectively, from this pilot study, we suggest the following strategies can increase student teacher interest in STEM:

1. Building content knowledge by pre-teaching cognates and Spanish academic vocabulary before the STEM activity to children as well as student teachers. This helped increase rapport with the children, families, and student teachers.

2. The use of the STEM toolbox activity to challenge children’s understanding and pronunciations of the tools in conjunction with the STEM-DEDs showcase, and

3. The use of collaborative groups to increase student teacher motivation, and Spanish academic vocabulary, and content vocabulary.

Literature suggests student teacher identity can increase with a multisensory environment which encourages the development of scientific ideas. Also, Spanish cognates used during instruction, especially with the use of bilingual pairs, help student teachers develop a cultural understanding (Garza et al., 2014). Other research also suggests when student teachers work together to create a community of learners, they develop positive attitudes towards science (Davis et al., 2006). The Puerto Educativo space served as a "third space" where children and student teachers alike felt comfortable making mistakes, and discourses of mathematics and science at home and school were discussed. Diaz and Bussert-Webb (2017) suggest hands-on inquiry experiences can encourage children to ask questions, look at evidence, and gather data. This was encouraged with the STEM-DEDs in the Puerto Educativo informal learning space.

The perspectives of these educators detail the use of bilingual instruction and literacy strategies that make STEM-DEDs more accessible for bilingual Spanish speakers. This event suggests where bilingualism is encouraged, more parents and children are likely to participate, and science identity can be increased for the student teachers. The student teachers in this article felt more confidant after using bilingual instruction to supplement her science activity. Student teachers used conversational Spanish when they encountered a child who needed Spanish language instruction. This was especially important in the addition of the formal science terms in Spanish to children's vocabulary.

A second lesson taken from the event is that student teachers need more understanding of science and math cognates before instruction. As a future concern, it would be more fitting to integrate literacy strategies in conjunction with the STEM-DEDs, the STEM toolbox, and specific peer critique before student teachers present publicly. It would also help to continue having student teachers work collaboratively in bilingual pairs to encourage the use of Spanish throughout the STEM-DEDs. It is also important to note the researchers did not assume all student teachers would use both languages. Bilingual student teachers were encouraged to use both languages throughout the STEM-DED as they saw fit. In these ways, STEM and literacy activities may aid lower SES children in acquiring word knowledge and STEM concepts.

Similar informal learning activities could be provided to children on a regular basis in hopes of increasing STEM-based vocabulary and concepts. These types of informal learning experiences need to start early and continue throughout elementary years on a regular basis. The library is also a wonderful place for children to check out books that easily lend themselves to STEM concepts and can be acquired readily in children's literature. Places, such as the local library, could offer free workshops for parents to demonstrate how to help their children. Other possibilities for this project are to extend the STEM-DEDs to an after-school family math and science night where members of the community can also encourage the use of bilingual instruction. Language and literacy are intimately related to a child's culture. We hope that this article can provide insight into how we encourage children from Spanish-speaking households into STEM careers and reduce the disparities that exist for STEM.

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