The Water Lab Curriculum for Teaching Science to Young English Language Learners

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Abstract

This article describes a science curriculum model for preschool English language learners (ELLs) based on an integration of Socioconstructivistic theory, content-based instruction, and the Ethnic Educator approach. The curriculum model is implemented through a Water Lab project that shows learning progress in science concepts and first-and-second-language (L1 and L2) skills as compared to educational standards. This curriculum contributes to the literature by teaching science content through: (1) a conceptual approach stimulating higher-order thinking strategies, (2) inquiry-based and problem-solving pedagogical strategies, (3) students’ prior cultural and L1 knowledge, and (4) active learning and the social participation of students in learning communities.
The Water Lab Curriculum for Teaching Science to Young English Language Learners

This article describes the development and implementation of a science curriculum for preschool English language learners (ELLs). The curriculum model developed is based on an integration of Socioconstructivistic theory (Dimitriadis & Kamberelis, 2006; Vygotsky, 1962), content-based instruction (Echevarria, Voght, & Short, 2008; Mohan, 1990; Short, 1993), and the Ethnic Educator approach (Gonzalez, 2009; Gonzalez, Yawkey, & Minaya-Rowe, 2006) providing a much needed conceptual approach for teaching science to young ELLs. This curriculum model integrates theoretical components stemming from these three approaches as it: (1) uses a conceptual approach for learning as it stimulates preschoolers to develop higher-order thinking strategies and conceptual knowledge in science; (2) uses an inquiry-based pedagogical strategy for teaching science content through a problem-solving approach of scientific inquiry; (3) integrates science content knowledge with the students’ prior cultural and L1 knowledge, and their personal histories; and (4) uses active learning and the social participation of students in learning communities in the classroom.

The development of a science curriculum that integrates contemporary pedagogy for young ELLs is very much needed because of the significant demographic shifts that US public schools are undergoing today and in the decades to come. The preschool classroom in which this curriculum model was implemented as a pilot was situated in a preschool center at a large research university in the Midwest, which served as a regional laboratory and demonstration facility. This preschool classroom exemplified the multilingual and multicultural backgrounds of students illustrated by the 2007 US Census data, in which the main teacher and first author of this paper needed to integrate content area teaching (in this case science) with English-as-second-language (ESL) learning for 40% of her students. According to 2007 US Census data,
25% of early childhood students (in preschool through Grade 3) in US public schools are from minority backgrounds (with 20% for Grades 4-12). Projections of this Census data state that by the year 2023, 62% of US public school students will be minorities, with 30% of them coming from a Hispanic background. The 2010 U.S. Census data with its report, *2010 Census Shows America’s Diversity* further supports the projections from the 2007 data. According to the report, the “Hispanic population increased by 15.2 million between 2000 and 2010 and accounted for more than half of the total U.S. population increase of 27.3 million. Between 2000 and 2010, the Hispanic population grew by 43 percent, or four times the nation's 9.7 percent growth rate.” (U.S. Census Bureau, 2010, “Hispanic Population Growth,” para. 1).

Unfortunately, many of the children from this growing population attending U.S. schools by the year 2023 will be considered at-risk of underachievement and dropping-out of school and of coming from poverty stricken households (Berstein & Edwards, 2008). Contributing to this underachievement problem is the lack of integrated ESL and content-knowledge curriculums and pedagogy, as ELLs miss out on academic knowledge across content areas when they are pulled out for non-integrated ESL teaching. Even if they were left out in the mainstream classroom, ELLs cannot learn content knowledge at grade level because of teachers’ unpreparedness to integrate ESL teaching and content-based instruction. As stated by the National Council of La Raza (2011), “Because ELLs are learning a new language at the same time as they are learning content in the curriculum, they face multiple challenges to school success.” Thus, an integrated curriculum, like the one presented in this paper, can help connect ESL and content-area instruction, which can be implemented collaboratively between mainstream and ESL teachers or ideally in full-day ESL and bilingual classrooms (Buxton, Lee, & Shantau, 2008).
The sections included in this paper are: (1) the curriculum model supported by a theoretical framework, (2) the implementation of the curriculum model through six units with activities and students’ quotes, (3) evaluation of the implementation of the curriculum, and (4) conclusions and educational implications for young ELLs.

The Curriculum Model

The curriculum model developed integrates a Socioconstructivist framework with content-based instruction and the Ethnic Educator approach. Four learning components supported by Socioconstructivist theory are used: (1) the students’ background knowledge and personal histories, (2) cultural artifacts, (3) the students’ social interactions with peers and teachers in the form of learning communities, and (4) the zone of proximal development (Dimitriadis & Kamberelis, 2006; Gonzalez et al., 2006). All students’ personal histories include both internal factors, such as developmental level, and external factors, such as the language spoken at home that interact to create background knowledge. Teachers need to tap into every student’s background knowledge as a strong foundation to construct new knowledge. Then, when teachers take ELLs’ previous cultural and personal histories and prior background knowledge into account for planning the curriculum, it is more likely that they can achieve academic success.

Cultural artifacts refer to the “tools” that students have access to in their home environments, communities, and general culture. While concrete objects such as books and computers are often recognized as cultural artifacts, Vygotsky stated that language was the most important cultural artifact because, “As a whole, language is used to navigate social situations,
develop concepts, and regulate thinking” (cited in Dimitriadis & Kamberelis, 2006, p. 195). This concept of cultural artifacts is related to the third and fourth components impacting learning, which are students’ social interactions with others and the zone of proximal development. Students need to develop relationships with peers and role models because it is by working together that they receive the benefits of scaffolding. Typically, language is used to develop social relationships with peers and role models, and it becomes more difficult when students and teachers do not share a common language. Therefore, teachers following a Socioconstructivistic curriculum create a classroom environment and plan activities where social interaction is encouraged and supported in the form of learning communities. Social interaction with native-English speaking peers will increase opportunities for L2 development in relation to content areas, such as science (Pray & Mondhardt, 2009; Tabors, 1997). In addition students also belong to other social communities, external to the classroom, including speakers of their L1 and related cultural components that also need to be integrated in the curriculum. Finally, the zone of proximal development is the “space” in which students can learn individually and with the help of more capable peers or role models, such as teachers. The curriculum proposed integrates these four components of learning stemming from a Socioconstructivistic framework with content-based instruction for the case of ELLs learning science.

The integration of these two theoretical frameworks into a curriculum model results in a conceptual approach for learning supported by the Ethnic Educator approach: to stimulate students to construct general concepts that can be applied across content areas and grade levels, as well as specific science content knowledge (Gonzalez et al., 2006). General concepts refer to higher-level thinking and learning strategies that are used at cognitive, metacognitive or metalinguistic levels (e.g., learning how to use memory as a conceptual tool for learning, or
learning how to use positive transfer of knowledge in the native language and culture to ESL situations). Specific content area knowledge, such as facts and information, is approached with a long-term and in-depth focus. The curriculum units throughout the school year (and even across school years) need to cover in-depth and fewer topics in a particular content area, as part of a thematic curriculum. The connections of topics and themes make available for students multiple applications of concepts related to factual knowledge that stimulate their development of general thinking and learning skills. Children’s “theories” or general concepts will need to be revised and so the curriculum needs to offer thematic coherence for making in-depth explorations over an extended “developmental period of time” (Gonzalez et al., 2006). As students spend time engaged in in-depth exploration of a topic through hands-on experiences, they will begin to develop more abstract, theoretical knowledge. Moreover, as students practice their thinking skills, they will begin to develop metacognition, metalanguage, and metalearning that will prove to be critical to succeed in American schools.

The curriculum model proposes using inquiry-based instruction as a central pedagogical strategy that integrates the Socioconstructivist and content-based instruction paradigms for science education for young ELLs. Since language and pre-literacy skills development needs to be about content areas, the science curriculum model proposed provides ELLs with authentic opportunities to use L1 and L2 within meaningful activities, and to learn the problem-solving approach of scientific inquiry (Conezio & French, 2002; Fleer, 2009; French, 1996; Gallas, 1995). Inquiry-based instruction is closely tied in with the principles of active learning where, students learn content, develop conceptual knowledge, and acquire language though a discovery-oriented approach (Fern, Anstrom, & Silcox, 1995; Nelson, 1996).
For young children, science is finding out about their everyday world surrounding them. Meaningful science learning starts with children’s intrinsic motivation to discover and explain their world, and their learning makes progress because of teachers’ encouragements. Then, following an Ethnic Educator’s perspective (Gonzalez et al., 2006), the curriculum model views teachers’ roles as facilitators of children’s interests, who guide them through meaningful hands-on problem-solving activities using a variety of media for exploring new science concepts. Teachers need to encourage young children to develop their own questions about how the world works in the form of “theories,” and then to investigate them within the classroom learning community. In addition, teachers need to model the “attitude of a scientist” by canalizing the children’s curiosity and their “theories” into learning “how to learn about science” (metacognition and metalearning) through practicing prediction, hypothesizing, experimenting, and communicating theories and ideas with a community of learners (Conezio & French, 2002; French, 1996).

Moreover, the discussion of science concepts provides young children with authentic social situations to think and talk about problem-solving and scientific inquiry. By thinking about their science ideas, children can develop mental representations or “theories” and translate them into verbal representations or articulations of verbal forms. Thus, science instruction becomes a process on inquiry-based education involving theorizing, hands-on meaningful activities, social interaction, resulting in concept construction through content-based instruction for L1 and L2 development in ELLs. Open-ended science activities can involve multiage groups of children at a wide-range of developmental levels. Teachers can then observe and respond to children’s individual strengths and educational needs; and children can support each other’s attempts to develop concepts by using peer modeling and support (Conezio & French, 2002).
While inquiry-based education has long been known to be beneficial to young children (Abruscato, 2004), it has also been found to make science more accessible to ELLs. For instance, a study conducted by Settlage, Madsen, and Rustad (2005) revealed that ELLs were less intimidated by science when the inquiry method was implemented because it created a “shared experience” in which young children could participate in science activities and talk about their experiences with each other. By sharing a common experience and having opportunities to use language to discuss their learning with peers, ELLs are able to increase their learning of scientific concepts (Dimitriadis & Kamberelis, 2006). They need to model the articulation of these experiences and concepts for the development of language and pre-literacy skills. Learning how to communicate ideas fosters language skill development in young children as well as social interaction (Chaille & Britain, 1997; Gallas, 1995).

Furthermore, inquiry-based instruction is a useful pedagogical strategy to implement content-based instruction because it integrates language instruction with academic content. In turn, the use of language as a method of instruction is also in tune with Socioconstructivistic learning components, including that the most important cultural tool for learning and for academic success is language. With content-based instruction, ELLs are given access to L2 for articulating concepts across content areas, including science. ELLs also learn when and how to use this language, so that they may listen, speak, read and write like scientists (Fang, & Shleppegrell, 2008). To achieve this goal, ELLs are provided with multiple and meaningful learning experiences in which to use and practice their language in the context of specific content areas, such as science (Gibbons, 2002). Considering the fact that Cognitive Academic Language Proficiency (CALP) can take five to seven years to develop (Brown, 2007), it is important for ELLs to, not only receive instruction and practice the English language, but that they also not
miss out on content knowledge. Many students become “at risk” for academic failure because they are not provided with access to content knowledge in the mainstream classroom, as they have not yet mastered the English language used as a cultural tool or vehicle to teach. When ELLs are pulled out of the classroom to receive ESL instruction, they also miss opportunities to engage in collaborative work with mainstream English-speaking students. They are denied opportunities to build relationships with their peers and learning from their peers, which is another important learning component according to Socioconstructivistic theory. That is the rationale behind the effectiveness of inquiry-based learning, as it allows ELLs to remain in the mainstream classroom and thus receive the same content-instruction as mainstream English-speaking peers, and also receive opportunities to work with peers through the use of language as a cultural tool for learning.

Thus, the curriculum model proposed integrates Socioconstructivistic and conceptual approaches for learning with inquiry-based and content-based pedagogical strategies for effectively teaching science to young ELLs. The curriculum model was implemented in the form of a Water Lab unit.

**The Implementation of the Water Lab Curriculum**

The Water Lab curriculum consisted of a long-term, in-depth investigation of the physical properties of water through a variety of media. The children decided that they wanted to name the sensory table The Water Lab because as a child explained, “A lab is a place where you do work and you got a job to do!” The Water Lab curriculum was implemented as a pilot for a preschool full-day class at a university preschool center in a large research University in the Midwest, that serves as a regional laboratory and demonstration center. The selected class had
10 children enrolled whose ages ranged from 3-to-5-and-a-half-years old, with equal number of girls and boys. The children came from mixed socioeconomic backgrounds, since some qualified for Head Start funding, others were paying reduced tuition as their parents were international students on campus, and still others came from middle-income households and paid full tuition. For the majority of the children, it was their first experience with formal schooling. Four of the children were ELLs. Two children still primarily spoke their native language, one was at the intermediate phase of second language development, and the fourth was fully bilingual. Although all of the children participated in the Water Lab curriculum pilot, this paper focuses on describing the learning experience of the ELLs.

The teachers implementing the curriculum worked at the preschool center and were certified in early childhood education. The first author of this article worked full-time in this preschool center and she was an assistant teacher for the selected classroom. While implementing the curriculum, she was completing her master studies in teaching English as a second language. Her undergraduate degree was in early childhood education and she had also taken some courses in Spanish at the college level. Based on her formal studies of Spanish she was able to memorize some useful phrases in Spanish for communicating with the children in her classroom. She would actively try to improve her communicating command in Spanish by asking parents and staff members to write down useful phrases for her, which he would memorize. She considered it important to communicate with her students in their native-language in order to make them more comfortable and safe in her classroom, and to show respect for their culture.

The Water Lab was implemented within a period of eight months (from October through May) to allow the necessary developmental time for children to explore a topic through a coherent curriculum. The materials consisted of the sensory table, sink, and the equipment
necessary for each unit in the curriculum. The curriculum was implemented thorough six units centered on the following topics: mixing and pouring, colors, bubbles, snow, sink and float, and fountains. The theme of the curriculum was the exploration of water in its various forms and through a variety of media. We explain below how each unit was developed and what materials were used, and then we discuss the science concepts and language skills learned by the children.

**First Unit: Mixing and Pouring**

The Water Lab began in October when the children were learning about the signs of fall. Cornmeal was placed in the sensory table. One day, some of the children working in dramatic play decided that they wanted to make soup. They put the cornmeal in pots and pans and mixed it with water. During this activity the children became interested in mixing and pouring. In order to support the children’s investigations, teachers made available a variety of materials.

During the first month of the Water Lab, the children explored how they could make the water move by using different tools. Each day the sensory table was filled with water. The children were provided with spoons, cups, pitchers, bowls, measuring cups, funnels, and plastic test tubes. As the water table became more popular, a second sensory table was added to the Water Lab so all of the children could work together simultaneously.

While working with pouring, the children began to learn how they could make the water move by using the different instruments. They learned that pouring the water from different containers without a lid caused the water to fall into the table, but that the water would not come out if they used the lid on the containers. One child further explored this event by placing a finger in a test tube to keep the water from spilling out. Another child placed an empty cup upside down on top of a full cup and then flipped both of them to make the water move into the empty cup. They figured out what tools they needed to use to make the water go into certain
containers. As they experimented with moving the water to different containers, they began to notice cause and effect. For example, one child noticed that when the water from the sink faucet hit the spoon it made a circle. The child said, “Lauren! Look! It makes a circle!” The child then recorded this observation by drawing a picture of multiple circles.

Along with developing scientific knowledge about the physical properties and movement of water, the ELLs began to develop Basic Interpersonal Communicative Skills (BICS) while working at the Water Lab. They talked about their interests and experiences at home. They also used language to negotiate turn taking and sharing the materials while building social relationships with peers and teachers. They began to use phrases such as “That’s mine,” “I want it,” and “Give me that.” They also began to develop CALP or academic language associated with water concepts. They used words such as up, down, circle, splash, dump, and drip. Some children were even able to define these words. For instance, one ELL stated, “Drip means a little water comes out, but dump means a lot!” The children were able to develop ideas and “theories” based on their hands-on experiences, and to translate them into concepts with the use of language in an active manner. Children could also apply meaningfully the new concepts for learning science content and develop BICS and CALP in their L2.

**Second Unit: Colors**

The next unit in the curriculum was an exploration of colors. The unit was created when the children found bottles of watercolor and began to pour them into the sensory tables. They became interested in how the colors mixed together. To support their interest, teachers added the water colors to the cart that held the children’s materials. The materials from the pouring unit were still available. To help preserve the paint, small bottles were provided. The children were instructed to pour a few drops into the bottles and then fill them with water.
While the children experimented, they observed the changes in color. They observed that more paint made the colors darker and more water made them lighter. Scientifically, they were observing changes in a material when it is combined with other materials. They were using a discovery-oriented approach to form science concepts. They also noticed that while they could add paint to the water, they were unable to take the paint back out. The children experienced a very basic level of chemistry concepts as they were developing their “theories” about how colors were formed and learning how to make predictions.

The children continued to work together and to develop BICS in English as they interacted socially in their learning communities formed of mainstream children and other ESL peers. The active participation in the learning communities motivated the ELLs, who had started the school year in the silent stage of L2 acquisition, to start talking about the colors in their L1 and L2. During this discussion, they began to use code-mixing and code-switching. For example, one child said, “Lauren! Mira! (Look!) Purple! Is purple!” Another child said, “Mira! Mira! Pink!” When the teacher asked, “How did you get pink?” the child replied, “Water.” The teacher said, “You put water in the bottle?” and the child replied, “Si!” The children in the intermediate and advanced stages of ESL learning began to use more complex language. For instance, one child was able to compare the color of the water to fire. The child said, “I made paint that looks like fire!” This child showed ability to use metacognitive and metalinguistic skills applied to science content. The children could develop higher-level thinking and learning strategies because they were using their prior knowledge and their L1 and L2 as cultural tools to articulate their experiences, ideas, and “theories” about color. The interaction of children at different developmental levels of conceptual learning and language proficiency supported all children’s progress, and helped their teachers to observe their strengths and educational needs.
Learning had become an active and meaningful process for these young children, who were following their personal interests and using their cultural and linguistic background knowledge as a foundation for conceptual learning in science. Thus, the active participation in a community of science learning through the Water Lab experiences were contributing to the children’s social development and L1 and L2 learning.

**Third Unit: Bubbles**

When the watercolor bottles that the children used to pour the paint became empty, the children tried to wash them with soap. They poured the soapy water into the tables and began to investigate how they could create bubbles in the water. To help the children with their exploration, they were given eggbeaters, whisks, slotted spoons, and brushes. The paint was removed, but the children still had access to the tools they used during the previous units. As they worked they learned about what type of movement and which tools could create bubbles in the water. They also investigated their ideas and “theories” about what would happen if they poured water on top of the bubbles. In addition to discovering that bubbles were created when soap was added to the empty watercolor bottles, they noticed that placing the bottles in the water created bubbles as well.

In addition to exploring the scientific properties of the bubbles, the ELLs continued to learn new language to articulate their ideas and “theories” and communicate them to their peers and teachers. They started to use phrases such as, “I am winning”, “I need more”, “Give me it” and “No, stop.” They also began to discuss the scientific concepts that they were learning to continue their explorations of concepts further with the help of peers. The children’s participation in hands-on activities encouraged them to make meaningful observations and questions, and to continue their explorations within the classroom learning community. For
instance, a child who made bubbles by pushing a bottle into the water said, “Listen! It makes a big noise. Look—the’s a bubble. The bubble splashes everywhere and makes noise. The teeny-weeny bubbles are going up there!” Their “theories” went through many constant revisions and teachers allowed extended periods of time for children to discuss their ideas. For instance, during group time, the teacher asked the children what happened when they poured water on top of the bubbles. The ELLs provided several responses including: “It melts,” “I think you get more bubbles,” “More bubbles by bringing in the water in like that,” “I put white and then there were bubbles,” “I put soap in the water and that is why there are more bubbles,” “Pop, pop, pop,” and “Out, out, out.” Moreover, the ELLs also provided non-verbal responses. For example, one child pointed up to represent how the bubbles floated on top of the water. Another child pushed her hands together to make a popping sound. A few children began to write and use representational forms to make pictures of the bubbles. These examples illustrate how discussions of science concepts and participation in hands-on activities provided children with authentic experiences to translate their ideas and “theories” (of a non-verbal representational form) into meaningful actions and ultimately into articulations in L1 and L2 (verbal representations). This is an illustration of how science is not an activity per se, but an inquiry-based approach to doing an activity that involves theorizing, hands-on investigation, and discussion. That is how the Water Lab curriculum used inquiry-based instruction to integrate content-based instruction of science with the development of L1 and L2 skills.

**Fourth Unit: Snow**

During the winter quarter, the city experienced a large snowstorm. School was closed for several days due to the weather. When the children came back to school, they were very interested in the snow. So, teachers decided to follow the children’s curiosity for science
concepts as reflected by their daily-life experiences with the world. For some of the ELLs it was the first time they had ever seen snow. Because the temperature was too cold to take the children outside for more than ten minutes at a time, snow was put in the sensory table. The children were also given scoops, spoons, cups, bowls, and molds so they could press shapes into the snow. The snow was also taken to the special activity table where the children put watercolors into the snow using eyedroppers. While the children played with the snow they were able to explore its’ physical properties. They observed how the snow changed over an extended period of time: it melted into liquid water. One child described the snow as, “It got dead because it melted.” When they used the molds they noticed that the snow turned into the shape of the mold, but when they used the molds with water, the shape disappeared when they removed the mold.

The children began to use vocabulary associated with snow and with winter such as snow, ice, cold, melt, icicle, etc. They talked about their observations with the teachers and with each other. Some of the ELLs shared their observations during group time, as they stated: “Snow! Snow! Snow! I cold! Snow cold!,” “It melting. It got no more white,” and “It’s water!” The children needed to compare and shared their observations with those of their peers, and by doing so they were learning how to articulate their ideas, “theories,” and observations into words. As a result, children were using L2 as a tool to learn together as a community of learners how to form science concepts. The beauty was that this particular community of learners was formed by children of different ages, at different developmental levels, and from different socioeconomic, and cultural and linguistic backgrounds. So, language learning for ELLs was supported by learning about science content, allowing for more complex L1 and L2 use in authentic situations. Thus, the problem-solving approach of inquiry-based learning was
supporting ELLs to learn their L2 more effectively and at higher conceptual levels (supporting not only BICS, but also CALPS).

**Fifth Unit: Sink and Float**

The next unit was on sinking and floating. It was developed after an ELL put a milk cap into the water and said, “Look! It’s floating in the water.” The materials from the pouring unit were made available to the children. In addition to these materials were plastic balls and glass marbles of the same size, so that the children would focus on the concepts of weight and size in relation to sinking and floating activities. As the children played with the balls and marbles they began to differentiate between the properties that made them sink and float. They learned that when objects are the same size and one is heavier, the heavier ones will be more likely to sink and the lighter ones will be more likely to float. Although the children did not discuss the weight of the objects, they did talk about what materials the balls and marbles were made of. One ELL said, “Those float because they plastic. Those sink because they glass.”

The ELLs began to use language associated with direction to talk about the balls and the marbles. One ELL called her teacher over and said, “Mira, Lauren! Mira! Is down!” When she said this, she pointed to the glass marbles at the bottom of the table. Then she said, “Look, Lauren, is up.” She then pointed to the plastic balls floating at the top of the water. The child’s actions and the verbal explanations in L1 and L2 that she used showed that she was making observations, and exploring and experimenting with the concepts of sinking and floating. Even though, she had not yet developed the necessary language to fully articulate her experiences with “correct” grammar and syntax, the actions of this ELL showed her ability for representing complex ideas and forming non-verbal concepts in science. Teachers could assess the strengths and educational needs of ELLs by observing their learning progress through extended periods of
time and also through non-verbal and verbal behaviors. Teachers’ observations showed that the ELLs’ ability to form concepts and express their knowledge through actions (non-verbal behaviors and gestures) was at a much higher developmental level than their progress in L1 and L2 skills.

**Sixth Unit: Fountains**

The final unit involved fountains. The investigation began when a small fountain was placed in the classroom. On top of the fountain was a ball that spun around. The children became interested in the fountain and wanted to know what made the ball move. The fountain was taken apart so that the children could see all the pieces. They observed that there was a tube and a pump that made the water come up and out of the fountain to make the ball move. The children then asked for materials so they could build their own fountains. To support the children’s interest teachers made available plastic pipes and tubes. Bowls, cups, and pitchers were still available to the children. Eventually, the children brought the pots, pans, and teapots from the dramatic play area to the Water Lab. The teachers permitted this, because it allowed the children to create more complex fountains to further experiment with how to make water move.

While creating the fountains there were several scientific and mathematical principles that the children had to consider. They had to think about the shapes of the different tubes and pipes and whether or not they would connect to each other. They had to think about symmetry and balance so their fountains would not topple over. They had to consider how to make the water move where they wanted it to go. One ELL became extremely frustrated because he wanted the water to go up the tube and over to the other side. After several days of working and experimenting, he filled a pipe with water and used force to spray the water out of the top. As this example shows, the children’s fountains started out simple but then became more complex.
All the ELLs began to use much more complex language. When they were asked by their teacher to explain the fountains they were constructing, one child at a beginner’s ESL stage said, “I made the water go round and round” and “The ball moves.” Another child at an intermediate ESL level said, “The water is going up the tube, then here comes the water and it rolls!” Another child at an advanced ESL level was able to compare his fountain to a shower, showing metacognitive skills. He said, “The shower looks like a fountain, there’s a tube in the wall.” Thus, allowing extra developmental time and exploring various topics of how water moves across a coherent thematic curriculum, allowed ELLs to make constant revisions and in-depth explorations of science concepts and to use L1 and L2 learning as a tool for thinking and communicating at higher conceptual levels. What was nice to see was that ELLs at different developmental and language learning levels could benefit from participating in the same hands-on activities, and make them personally meaningful and conducive for language and science learning. Both teachers and children had learned how to support each other as a community of learners, and as a result ELLs had also developed L1 and L2 skills necessary for meaningful social interactions.

**Evaluation of the Implementation of the Water Lab Curriculum**

The curriculum was evaluated through its effectiveness on the children’s development of conceptual knowledge in science and L1 and L2 language skills across units. The children’s knowledge and skills were evaluated through classroom observations and portfolios. The observations were collected in the form of anecdotal records throughout the school year and were completed at least once a week, so that the teachers could evaluate the children’s learning progress across the curriculum units. Some of the collected quotes in the anecdotal records are
used in this article as examples of children’s performance across curriculum units. Both verbal and non-verbal behaviors were included in the anecdotal records to provide a more accurate representation of the ELLs’ thinking and learning processes. The portfolios consisted of samples of children’s learning in science and L1 and L2 skills including pictures of children’s behaviors, samples of children’s writings and drawings as evidence of verbal and non-verbal representations of concepts learned in science and L1 and L2 skills developed. During the course of the school year, teachers took a total of 234 photos of the children while they worked in the Water Lab as evidence of the teachers’ observations and to be included as part of the children’s portfolios.

In addition, in order to help the children develop learning strategies, the teacher made documentation panels of each curriculum unit and placed them in the classroom. Each panel contained the title of the unit and carefully selected photos, drawings, writing, and quotes from the children. The children were encouraged to discuss the panels during group time, and while participating in the Water Lab, as teachers prompted them to look at and talk about the panels. As a result, the children began to learn more language for articulating their ideas and “theories” while experimenting at the Water Lab. Children learned how to talk about their non-verbal mental processes and could share their ideas, questions, observations, experimentations, hypotheses, predictions, comparisons, and experiences. While the ELLs developed a significant amount of oral language throughout the school year, they produced less number of non-verbal representations (such as writings or drawings) than their mainstream peers. This is true even for the children in the intermediate and advanced stages of ESL acquisition.

Conclusions and Educational Implications
The demographics of this country are changing. Every year the number of students who do not speak English as their native language continues to increase. Eventually, all teachers will have ELLs alongside their native English-speaking students. Every teacher will need to have knowledge of how to teach science to culturally and linguistically diverse students. Unfortunately, many teachers feel unprepared for this task as they have not received training to teach ELLs. Additionally, teachers are now facing an era of high-stakes testing and accountability through national and state standards. Teaching science to ELLs in an era where literacy, mathematics, and test-taking skills are the focus is often seen as a daunting task. The Water Lab curriculum offers an instructional model to teach abstract scientific concepts to both mainstream students and ELLs, while developing together science content knowledge and L1 and L2 skills, as well as social skills through participation in a community of learners. By teaching science to both native English-speaking students and ELLs in the mainstream preschool classroom, they will be able to work, learn, and succeed together.

Looking back on the year, it appears that the Water Lab curriculum was successful as attested by children’s learning in two main developmental areas: conceptual learning and social development. The first area refers to conceptual learning in science with subsequent development of L1 and L2 skills. Because the Water Lab lasted for eight months, the children were given repeated opportunities to engage in hands-on activities, resulting in conceptual learning as shown in the quotes presented above across curriculum units. They were able to move past their experiences at the Water Lab and apply the new conceptual knowledge in science in a more general way, such as language learning and ability to observe and explore. Conceptual learning in science content and in L1 and L2 could happen in young ELLs because the Water Lab followed a thematic and topical approach throughout curriculum units that
followed the children’s intrinsic curiosity and interests in their everyday life experiences. In fact, the children created the topics represented in the curriculum units. The second area refers to social development and participation in a community of learners. Observations showed that every single child in the classroom participated in the Water Lab on multiple occasions. However, an analysis of the observations records revealed that the ELLs spent more time at the Water Lab than most of their English-speaking peers. The Water Lab was of interest to ELLs because they were intrinsically motivated to learn from personal experiences within the context of meaningful activities and social interactions with peers and teachers. Because all of the children were interested in the topics exploring their own world, they were able to work together and learn from each other. The ELLs began to develop friendships with their English-speaking peers. Because of these developing friendships, the children were able to work together within a community of learners and learn science concepts and L1 and L2 skills from each other.

In addition, the Water Lab proved to be effective in terms of meeting academic content standards mandated by the state for preschoolers, and Head Start program performance standards (2005) and national TESOL standards (2006) designed specifically for young ELLs. Although in preschool, educators are not required to “test” the children, there are Early Learning Content Standards from state Departments of Education that need to be met. Although the Water Lab consisted of exploring a single theme, by the end of the school year, the children participating in the curriculum were evaluated by their teachers as meeting almost every state standard in the physical sciences, science and technology, scientific inquiry, and scientific ways of knowing; as well as a few standards for earth space sciences for early childhood. In terms of the National TESOL standards, the Water Lab met all of the English communication Standards and Goals for Pre-K-Grade 3.
References


Teachers of English to Speakers of Other Languages (TESOL, 2006). *Pre-K-12 English language proficiency standards.* TESOL, Washington, D.C.
