Talking Science in an ESL Pre-K: Theory-building with Realia

What is realia and theory-building? Read on to find both a definition and strategies to employ in your classroom.

On a sunny Texas morning a prekindergarten class serving a diverse group of students, including those who are learning English as a second language (a pre-K ESL class), has left the glossy floors and artificial light of its classroom to explore in the dappled sunlight beneath a leafy tree. This public elementary school class has just finished listening to their teacher read a colorfully illustrated book titled *Leaves*. Following the directions of their teacher, they leave the circle and dart about the grassy space in groups of two, collecting specimens in plastic baggies, eyeing them with magnifying glasses, describing the features of each to one another. One student holds up an interesting leaf to show his teacher. The teacher says, “Hey, look at this! This one has tiny hairs on it. It’s a furry leaf!” He turns back to the 4-year-old who found it. “You make sure you tell us about this when we’re talking about them together, OK?” The boy nods vigorously, and they all turn simultaneously to see what other leafy marvels grow beyond the confines of the school’s walls.

Conversations and Realia

Ongoing research focuses on integrated instruction to promote science and literacy learning that also includes a focus on multicultural perspectives for ESL early childhood classrooms (Cervetti, Pearson, Bravo, & Barber, 2006). This type of instruction allows students to build on the knowledge that they already have about the world by combining non-fiction books and other texts to explore vocabulary that is specific to science content and processes. But it also includes language support through hands-on activities where students are able to carry on conversations about the real world in their home language with peers and teachers (Bruna & Gomez, 2008; Fathman & Crowther, 2006; González, Moll & Amanti, 2005; Rosebery & Warren, 2008). Integral to these linguistically rich experiences is the use of “realia,” another word for objects found in the real world (Spycher, 2009, p. 366). When a student explores using realia, she is not just being exposed to abstract concepts or text on a page, she is using real-life objects to build understandings of the natural world while she builds vocabulary about it. This can be both a multicultural and scientific event.

As students learn vocabulary words by handling real-life objects, they build theories about how the realia work in the world based on their previous experiences and the deep understandings forged in their home language such as when they wonder:

- why honeycombs might be hexagonal
- what happens to water in the sun
- about the patterns of clouds and erosion (Ballenger, 2008; Cummins & Schecter, 2003)

In inquiry and exploration like this, students are using their emerging cultural and linguistic expertise (learned within their families and out-of-school communities) in combination with the new language and academic knowledge that is being introduced at school (González, et al., 2005; Rosebery & Warren, 2008).

Imagine a pre-K classroom where acorns, pinecones, cicada exoskeletons, flowers, bones, antlers, dirt and all
sorts of other objects are handled and discussed in both the first language of the students as well as a second language. In such a setting vocabulary builds quickly, because teachers provide opportunities for students to engage in meaningful communication with scaffolds bridging first and second languages (Goldenberg, Hick & Lit, 2013).

Researchers focused on the learning of those acquiring a second language have long stated that “English language learners are in stronger positions to learn when they are able to use their first language to support their meaning making in science” (Ballenger, 2008, p. 122), while concurrently being provided support and practice in the “academic register” (Cummins & Schecter, 2003) of a language used in their formal education. Studies focusing specifically on preschool support the conclusion that language instruction in one’s first language contributes to growth in both home language and English skills (see Barnett, Yarosz, Thomas, Jung, & Blanco, 2007; Escamilla & Hopewell, 2010) which is the reason bilingual education is offered.

However, bilingual education is not always an option. In many classrooms there are numerous home languages represented among students, and the teacher may not have knowledge of any of them. In such cases, as is the case in the classroom highlighted for this article, teachers employ ESL strategies to scaffold students’ comprehension and to develop English language proficiency. The use of realia and other visuals are one way to provide ESL students opportunities for meaningful communication in English (Saunders & Goldenberg, 2010). Some researchers highlight the importance of providing engaging and motivating opportunities for students to practice English in relatively low-stress environments (García & Jensen, 2007). Interactive reading and engaging the whole body in learning are two examples of instructional methods that have shown benefits for ELLs’ development of academic vocabulary in English (Goldenberg, Hick, & Lit, 2013). Creating strategic partnerships that pair ELLs with native English speakers is another effective strategy that provides both groups the opportunity to interact and learn from one another (Goldenberg, Hick, & Lit, 2013). When these types of actions and conversations, supported by realia, also include a purposeful “theory-building,” then the academic depth of the activities can be greatly enhanced and the benefits grow, especially in terms of creating a space for both multicultural community-building and deep scientific thinking (Tan & Calabrese Barton, 2007; Mercer & Littleton, 2007). “Theory-building,” in this sense, takes its cues from early childhood pedagogy not specifically designed for ELLs.

Theory-Building

ECE researchers overwhelmingly purport that pedagogical approaches in which students develop lines of questioning and then test for answers to those questions using real-world materials in all of the content areas are optimal for developmentally appropriate practice (Bodrova & Leong, 2004; Drew, Christie, Johnson, Meckley & Nell, 2008; Helm, 2008; Kelman, 1990; Leong & Bodrova, 2012; Nimmo & Hallett, 2008). And there is equal support in the literature that informs learning theory for the very young which focuses on experiential exploration (Barnett & Frede; 2001; Gelman & Brenneman, 2004; Konzal, 2001; Mantzicopoulus, Partrick, & Samarapungavan, 2008; Peterson & French, 2008; Sackes, Flevares, & Trundle, 2010). This type of experiential or inquiry-based learning is often described as "constructivist" (Katz, 1999). In this approach, the students learn through explorations, not by directly being told about or shown the concepts (Fosnot, 1996; Gunstone, 2000). “Constructivist theories of learning stress the importance of learners being engaged in constructing their own knowledge” (Hmelo-Silver, Duncan, & Chinn, 2007).

The act of jointly constructing, critiquing and reconstructing theories in a group setting with real-world, everyday materials and ideas is called “theory-building” (Ochs, Taylor, Rudolph, & Smith, 1992, p. 38). And increasingly the very young have been found to build sophisticated theories when they are able to build them through real-world, experiential knowledge and conversation, without direct corrective guidance by adults or teachers (Gopnik, 2012). Gopnik affirms that even the youngest among us engage in theory-building:

*The new research shows that even very young children are deeply engaged in such profoundly cognitive work as hypothesis testing and causal inference. This work is more cognitively challenging, in fact, than much schoolwork. (Gopnik, 2012, p. 1627)*
In fact, Gopnik calls pedagogy -- the very act of teaching -- a “mixed blessing” (p. 1627). She states that even the youngest children are aware that teachers will often “correct” a student’s theory. In order to save themselves from the embarrassment of being wrong, students will be reluctant to theorize about natural phenomena, thereby limiting the amount of practice they get in theory-building in a group setting.

Gopnik (2012) wonders if, out of respect for the knowledge of their teachers, young students abandon viable hypotheses, narrowing theories that they build for themselves in favor of the “truth” that their beloved teacher “knows.”

Given this unintended consequence of “teacher expertise,” a teacher in a multilingual, multicultural classroom, where varying languages, beliefs and worldviews come together, can take heart. The idea that theory-building among peers in their first languages can create deep understandings about science, math, society, literature and other topics can be a very hopeful idea. The teacher can be less concerned with the “right” scientific concept, and more concerned with promoting rich discussions and providing hands-on opportunities. Consider the musings of astrophysicist, Neil DeGrasse Tyson:

“Children are born inquisitors of their natural world. They turn over rocks. They jump in puddles. They pour water down your back. They do things that you can look at as wreaking havoc in the house, or you can look at as a long series of science experiments. … I think the real problem in the world is the adults. … As a kid, something’s in your hand you let go of it. It falls. You tip a glass. Water spills. You are assembling a rulebook for how nature works in the macroscopic world.” (Tyson & Dawkins, 2010)

For the purposes of this article, we wonder whether younger children should be practicing this very valuable skill in the earliest grades. We also wonder if simply being in a classroom might limit the depth of the theories that can be built. Imagine the hypothetical classroom we mentioned earlier -- the one with the acorns, pinecones, cicada exoskeletons, flowers, bones, antlers, dirt and all sorts of other objects. Now imagine the theory-building, constructivist, integrated, multicultural, linguistically-rich possibilities involved in leaving that classroom, finding those same objects outside, in the natural environment, where one might come across them “naturally.” In this low-stress, learning environment “non-mainstream” students have access to powerful theory-building opportunities, scaffolded by teacher-support in academic English.

**Conversations in the Outdoors**

The movement to get students out of the classroom and into the natural environment is growing fast (Danks, 2010; Louv, 2008). Going outside to learn fits with the ideas above, because the realia that is most “real” is that which is in its natural environment. (Louv, 2008; Lowell, 2008). The physical phenomena that creates the natural environment is a complicated and enmeshed network, which one can see in the sky, the seasons, growing plants, the movement of animals...outside. There is an increasing interest in the “no child left inside” movement (Danks, 2010; Louv, 2008; Lowell, 2008; Parker-Pope, 2009). The call to create green spaces of learning at public schools with students is a compelling one in which integrated learning moves outdoors, and theories about the world are constantly honed through academically supported exploration of realia (Danks, 2010; Nimmo & Hallet, 2008). “Interdisciplinary outdoor lessons lend themselves to blending topics that had previously...
been taught separately” (Danks, 2010, p. 3). Weise (2012) and others purport that quality science instruction needs, at least at times, to be led outside in green spaces and in the context of natural habitats and the physical phenomena of the natural world (Nimmo & Hallett, 2008; Weise, 2012). However, “Often in our modern world, it’s not as easy as simply sending children outside to play” (Diamond, 2009). For many, green outdoor spaces are hard to find.

A Green Gap

Lee and Buxton (2010) note that neither science, nor science instruction, is independent of cultural, linguistic and societal factors (Lee & Fradd, 1998; Moje, Collazo, Carillo, & Marx, 2001). Lee and Buxton note that “Access to rigorous and engaging science teaching that promotes scientific reasoning and argumentation has emerged as a key factor in promoting science learning of all students” (2010, p. 43). However, access to hands-on, green-space instruction demands access to green spaces. “Non-mainstream students tend to have less access to such instruction than their mainstream peers” (p. 43). In this case these “non-mainstream” students are represented in part by students learning English as a second language, a linguistic identity that is tied to race, ethnicity, culture and place (Gruenewald, 2003). A great deal of research surveyed by Lee and Buxton (2010) supports the notion that the scarcity of access to such instruction falls along race and socioeconomic lines, as does the frequency of English being spoken as a first language by students in schools.

Integrated ESL Science Instruction in an ECE Setting

Return to the teacher and the ESL pre-K class in the opening vignette of this article. This busy group of young learners and their teacher are doing their work in an urban elementary school in a large Texas city serving 86% Latino, 10% African American, and 5% White and Asian American students. This is a population that is 79% limited in English proficiency (LEP) and nearly all receive free lunch benefits.

In Texas, as in other parts of the US, the overwhelming majority of residents speak Spanish or English as their first languages (Modern Language Association, 2010). Texas allows for bilingual education, even dual language in many districts (Gómez, Freeman, & Freeman, 2005). The school in the opening vignette has many bilingual pre-K classrooms where the students are expected to be able to converse, explore and interact in their first language with modest (and increasing over time) efforts toward “adding on” a second language (May, 2008). This second language is usually English, but in a growing number of districts Spanish is the added language. In 2010 English was spoken by 65.8% of people over 5 years of age in Texas, and this number has been dropping over the last decade (MLA, 2010). Of the remaining speakers in 2010 (the latest available data), 85.41% spoke Spanish (MLA, 2010). This means there are over 1.1 million speakers who do not speak Spanish or English. This classroom is one of many ESL pre-K classrooms in areas with many Spanish and English first language speakers where the classroom is a “catch all,” containing the students who have higher levels of proficiency...
in English but speak Spanish at home. This classroom also contains students who speak languages other than English or Spanish at a wide range of proficiencies. As is often the case, this “catch-all” ESL classroom is taught by a white, monolingual, English-speaking teacher, certified in ESL (Samson & Collins, 2012).

We wish to be overt about our stance on bilingual and dual language education: We believe that, when available, all students, as well as society, benefit from multilingualism. And in a state like ours, Texas, where one’s language is an indicator of one’s access to education and financial security (Macedo, Gounari, & Dendrinos, 2003), we see dual language education as hopeful toward interrupting this linguistic hierarchy. We are proponents of multilingualism and multiculturalism through dual language education and policy. However, author Tim Kinard is a former teacher in one of these “catch all” ESL classrooms where the LEP of the students is widely varied, and the linguistic resources of the teacher are severely limited. Both Tim Kinard and Jesse Gainer (second author who taught in Spanish/English bilingual classrooms) are interested in pedagogy that opens the curriculum in meaningful ways to the students in “catch-all” ESL classrooms like the one described above.

The STELLAR Project

Informed by this interest, Jesse Gainer has been leading professional development events for the past several years in which ESL teachers are introduced to interdisciplinary approaches to teaching science. The workshops are focused on rich, engaging dialogue, using students’ first languages, academic English, and scientific concepts, while engaging in student-centered, hands-on scientific learning episodes with a specific attention to leaving the classroom and investigating the sciences out-of-doors (Weise, 2012). These efforts have been part of a grant-funded endeavor called the “Science and Technology for English Language Learners Achieving Results” (or STELLAR) Project at Texas University where the grants’ investigators designed outdoor pedagogical development for ESL teachers in Texas. The research that led to this article was begun after a teacher who had attended a STELLAR Project professional development workshop made statements that led the team to be interested in investigating the way he has integrated science and language arts instruction in his pre-kindergarten ESL classroom. After one workshop, the pre-K teacher from the opening vignette told our investigators:

“I teach pre-K, so everything we do is integrated, but what I really like the most of what they did with the integration [of science] is the language arts and the group writing. Because we do group writing every day, but we usually do it with language arts, so now, I saw how they did it, and I can bring in [scientific] diagramming, which I never did with pre-K. But now that I saw how they were able to do it, I can show [them], and I can have the kids do it on their own…..”

Inspired by his comments, Jesse Gainer travelled to the teacher’s school to film him leading an integrated science lesson with his ESL students. After visiting the classroom and witnessing the integrated science instruction, we reflected on the ways in which he has skillfully addressed some of the issues central to teaching science to English language learners.

Return to His Lesson

This pre-K teacher leads a group of students out into a green space adjacent to their classroom and teeming with botanical specimens. There is a covered porch in a fenced area. The plants that grow in this area range from short, leafy hedges to a verdant line of trees. The teacher gathers his students on the concrete slab shaded by a leafy, 15-foot tree. The plant is smallish for a tree, but it towers over the four-year-olds. The sun’s light from its morning angle illuminates the tree’s leaves like a stain-glassed window. Beneath the trees’ glowing leaves, the pre-K teacher opens a book.

“I’ve got this book, and it’s called Leaves. What do you think it’s going to be about?” A chorus erupts: “LEAVES!” “And “What do you think we’re going look at outside?” “LEAVES!” The teacher grins, “Very perceptive.”

“As we read it I want you to listen to the words in this book, because in a few minutes I’m going to have you go look for some leaves, and I want you to describe them using some of the words in this book.”

He guides his students through the shared reading. He then establishes guidelines for successfully engaging in their scientific exploration. He assigns each a partner. Each duo is given a hand lens and a plastic baggie for observing and collecting leaves. He dismisses his students, trusting them to accomplish the task before them, driven by their curiosity. The teacher then follows his students into the botanical diversity available to them beyond the walled borders of...
their classroom. The students dash about the space, chattering to one another as they go. Different dialects are shared. Different languages are used. Exuberance is the timbre of the movements.

“Look! Look!” a student shouts. “This one is HUGE.” “Great word!” her teacher responds.

One student clips a leaf from its stem and shows his teacher a small hole – a perfect tiny circle in the leaf. “How’d that get there?” the teacher asks. The student thinks, head tilted, then says, “Rain?” His teacher responds, with curiosity and without condescension: “You think maybe rain put that hole in the leaf.” The teacher’s tone is very slightly questioning, but at the same time even more affirming. Another student chimes in, “No! A caterpillar!” The teacher restates the second idea, “You think maybe a caterpillar ate it!” he says.

Afterward, the students gather again on the concrete slab, in the light of the leafy cathedral and engage in a shared writing on a dry-erase board, listing words that describe the diverse collection of leaves they’ve harvested, contemplating a wide range of possibilities that encompass what “a leaf can be.” Indeed, at the top of a large pad of paper, their teacher has written, “A Leaf can be…. The teacher takes dictation, “Green, bumpy, big, skinny, hairy, soft, spikey, brownish-red, huge…” “Huge?” He responds, “What does that mean?” “BIG!” responds the chorus. “REALLY big”, adds one voice. He nods, continuing. He adds the descriptive words to the page, reading over them often and being explicit about the inclusiveness of the words. Leaves can be many things.

“They can be eaten!” the boy who found the leaf with the hole asserts. “Indeed.” The list is developmentally appropriate vocabulary for his students. It is also developmentally appropriate to the academic register of English in science for pre-K. Vocabulary is strengthened and grows in this verdant space. As Lee and Buxton (2010) point out, students like the ones in this urban pre-K are less likely to have access to this type of hands-on learning than their more affluent counterparts. This is why we highlight one amazing aspect of this outdoor exploration and shared writing: the green space into which these 4-year-olds tumble is the only green space within city blocks, and it is the tiny green swath of grass and bushes that house the air-conditioning condenser units for this large public school.

**Going Even Further: Possibilities for Theory-building**

We are drawn to this teacher’s creative ability to seek out this seemingly uninviting green space for the exploration of its realia. We are also drawn to the moment where students hypothesize about the hole in the leaf. During the shared writing the boy asserted that leaves could be “eaten.” But, earlier, when he found the holey leaf he told his teacher that “rain” might have made the hole. His teacher responded: “You think maybe rain put that hole in the leaf.” But, another student exclaims, “No! A caterpillar!” Then the teacher states, “You think maybe a caterpillar ate it!”

In this exchange, there is not the slightest hint of condescension in the teacher’s response to the “rain hypothesis.” And when he restates the girl’s position that a caterpillar made the hole, he does not deem one hypothesis “correct” and another “incorrect.” However, when the students reconvene to share their ideas, it is the boy who had previously put forth the rain hypothesis who now offers the descriptive word “eaten.” He has learned. But what has he learned? Did he hear the other student’s idea, and weigh it against his own, deciding that hers works better for him? Or was there a hidden message in the response of his teacher that told him one hypothesis was right, and the other was wrong?

Given our multiple viewings of this short exchange on video, we hear the slightest inflections leaning the student toward the second proposed hypothesis. And upon reflection, we realize that, in our shared decades of leading the learning of the young, we have often created a moment where one hypothesis was deemed “correct” which means that all others are now “incorrect.” But, could there be a new space available in the curriculum where there is room for a celebration of many complex theories?

The teacher did not tell one student she was right and another he was wrong, nor did he have the two debate their positions. He simply restated what they had said. But in analyzing this moment, we realize...
that a decision was quietly made. We have wondered a great deal about the decision the boy made to share another’s hypothesis with the group. We further realize that in our future endeavors, we can create spaces, in moments like these, where we call attention to the fact that two ideas have been put forth. Two theories have been built. We can then help the class support the theories, not proving one wrong, or one right, but proving how deeply everyone is thinking about both ideas.

For instance, the student who thought about rain falling from the sky can be lauded for his understanding:

- of the relative size of rain drops (for the hole was, indeed, about the size of a drop of rain)
- of the relative delicacy of this particular leaf
- that falling from a great height generates velocity, and
- that velocity is a powerful force.

And in terms of the student who posited the “caterpillar hypothesis,” she could be celebrated for her understanding:

- that caterpillars eat leaves
- that a caterpillar wouldn’t necessarily eat the whole thing
- that animals we cannot see are at work when we are not around.

When we first saw the lesson, we assumed a caterpillar ate the leaf, too. But who can say which hypothesis is true? Even if the hole was eaten, it wasn’t necessarily a caterpillar. (Indeed, weeks after watching this video, Jesse Gainer texted Tim Kinard after a heavy rain, stating “It rained last night and made holes in the leaves at my house! I’m … totally serious! [forget] the caterpillar theory!”)

If these viable, testable and debatable elements of the students’ competing hypotheses were lauded in a carefully equal way, then science would be directed away from being a collection of vocabulary words and a collection of facts or “right answers,” toward a complex pursuit of investigation, in which all possible realities are explored and theories are built. We celebrate this teacher for allowing both hypotheses to stand, unchallenged, because we assert that he didn’t intentionally lead students to reject one theory for another, nor did he intentionally stifle the critical thinking of students who were constructing theories based on their observations of nature. However, we recognize that, unintentionally, teachers are always at risk of squelching lines of thought in the pursuit of leading students toward sanctioned forms of knowledge.

Conclusion

We feel it is important to recognize innovative, quality teaching where we have found it. Therefore, we recognize that the pre-K teacher in the opening vignette is providing his students with many of the keys to success in schooling by hands-on practice in the out-of-doors that builds on prior knowledge and exercises home languages. He also practices scientific talk and writing with his students in a green space that these authors would never have thought to utilize.

Further, we believe that by allowing competing hypotheses to stand, this teacher is contributing to a theory-building process that can lead to a creation of vibrant, lauded, nurtured and internally constructed theories about phenomena. We do not feel it is an overstatement to assert that moments like this subtle exchange can contribute to the construction of one’s school identity (Chen, 2009). If we start a student’s academic life by assigning “correct” or “incorrect” to their ideas, we are not contributing to their ability to build theory. Remember, “Children grow into the intellectual life around them” (Vygotsky, 1978, p. 88). If we celebrate theory-building, and offer ample opportunities for practicing this skill, we create the opportunity for students to create a school identity of “thinker.” If we stop teaching correct answers and, instead, teach ECE/ ESL students to learn to value the viability of the theories they build, based on their own experiences, then Tyson’s condemnation of adults as being “the real problem in the world” and Gopnik’s fear that pedagogy is “a mixed blessing” are chased away like thieves -- replaced by a pedagogy that fosters school identities of “success” -- a success in critical thinking dialogues.

We do not intend to be overly critical of an example from the practice of an exemplary teacher. In fact, we intentionally highlight a re-thinkable moment in an example of excellent teaching to serve as a caution, a red flag of sorts, to signal to all of us that we must continually reflect upon our educative choices and especially the language we choose when guiding students in
learning—a way of teaching language and dialogue that moves an ESL science ECE curriculum away from disconnected vocabulary words, concepts, skills and knowledge and moves toward a celebration of creativity and theory, a dialogue about thought, where inquiry-based learning is theory-building, even in schools with limited resources and limited access to verdant realia.

References


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