Literacy & Arts Integration in Science: Engaging English Language Learners in a Lesson on Mixtures and Solutions

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Abstract

Students who struggle with vocabulary knowledge often see a decline in comprehension of content. Even students who receive strong reading instruction in the early elementary years may still experience the fourth-grade slump (Chall, 1983), which more often affects students from underserved populations. Many of those same students are also affected by the 30-million word gap (Hart & Risley, 2003), or the difference in the number of words heard by young children in homes from varying socioeconomic statuses. When working with culturally and linguistically diverse (CLD) students, it is important to provide opportunities for conversations that allow students to draw on their own cultural wealth (Au, 2000; González, Moll, & Amanti, 2006; Moje, McIntosh Ciechanowski, Kramer, Ellis, Carrillo, & Collazo, 2004; Yosso, 2005). In a recent pilot study, fifth-grade students engaged in Reciprocal Teaching (RT) (Palincsar & Brown, 1984) strategies to determine effective supports for English language learners (ELLs) when reading expository text. Multiple science lessons were developed and embedded with RT strategies. Two additional components were added to a lesson on mixtures and solutions: arts integration and literacy integration. This lesson further supported ELLs' comprehension of content material. Students in both classrooms had mixed levels of English proficiency, but all ELLs spoke Spanish as their first language. The use of RT supported students' active engagement in learning, vocabulary acquisition, and academic growth. Researcher's analysis of student-participants' assessments and engagement, across multiple lessons, demonstrated students had increased understanding of content, particularly students with higher English proficiency. However, a lesson on mixtures and solutions provided a more engaging learning environment and practical application of new content knowledge for students by adding literacy and arts integration; this lesson will be the focus of this article.

Across the United States, elementary science teachers provide opportunities for students to engage in a learning environment, conduct investigations, and think critically about content. Students need opportunities to explore the world and make connections between content learned in school and how that knowledge applies to their lives. It is essential that all elementary students are motivated to learn and that instruction in science classrooms is engaging and accessible to all students (Bathgate, Schunn, & Correnti, 2014). However, ensuring that English language learners (ELLs) are engaged and able to access content is critical (e.g., Artiles & Ortiz, 2002; Klingner & Vaughn, 1996; Lindquist, & Loynachan. 2016). A metacognitive strategy such as Reciprocal Teaching (RT) (Palincsar & Brown, 1984) embedded in a science lesson which is further enriched with arts and literacy components to allow students to elaborate on learning may provide ELLs with greater opportunities for critical thinking and enhanced comprehension of science content. During a series of collaborative teacher/researcher lessons in an elementary school situated on the U.S.-Mexico border, the first author/principal investigator (PI) introduced higher-level, content area material to student-participants using RT strategies. In one lesson on mixtures and solutions undergirded with RT, the PI added arts and literacy extension activities. Student-participants' outcomes were enhanced, as demonstrated by researcher reflections, post assessments, and finished products.

Statement of the Problem and Potential Solution

Students who speak English as a second language are often from culturally and linguistically diverse (CLD) backgrounds. It is important to note that many ELLs across the United States may not have opportunities to engage in culturally relevant pedagogy (Gay, 2010; Ladson-Billings, 1995b). Likewise, ELLs may not be able to access their own cultural wealth (Kanagala, Rendón, &Nora, 2016; Valdez & Lugg, 2010; Yosso, 2005), which can be used to support and enhance academic learning. Furthermore, educators may not be aware of Yosso's (2005) Cultural Wealth Model that can guide teachers in supporting CLD students. Yosso's model includes six key components: (a) aspirational–supporting students in their dreams, (b) linguistic–supporting students' communication skills, (c) familial–inviting families into the educational process, (d) social capital–assisting students in staying connected with communities, (e) navigational–acknowledging that institutions have a history of being unsupportive and/or hostile to families, and (f) resistance–preparing students for a diverse democracy (Locks, n.d.). Kanagala, Rendón, and Nora (2016) adapted the model to provide a framework for understanding the cultural wealth Hispanic students can draw on to support educational goals. Students from CLD backgrounds, including ELLs, need access to their cultural wealth to help ensure they successfully navigate through the school system and into college classrooms.

Culturally responsive pedagogy is well researched (Gay, 2010), and teachers who use this pedagogy can assist students in drawing on their cultural wealth to include native language and to support academic growth. For a variety of reasons, including English-only policies in some districts, students may remain silent in a classroom (Casey & Gillis, 2011; Casey, 2014). Educators need to prepare environments where CLD students can capitalize on their cultural wealth to support academic, social, and emotional growth (Au, 2000; Au, 2013; Gee, 1996; Kanagala, Rendón, & Nora, 2016; Yosso, 2005). Gay (2013) argued that "the education of racially, ethnically, and culturally diverse students should connect in-school learning to out-of-school living" (p. 49). This idea beautifully identifies the foundation of culturally responsive pedagogy.

Although they are not synonymous, there are intersections between the terms ELLs and CLD students. It is essential educators understand how to support CLD students, many of whom are ELLs, to address one of the underlying problems of inequity in educational systems. This study focused on supporting ELLs in using the cultural wealth they bring into a classroom via a culturally responsive pedagogical approach. Teacher-participants and/or PI provided student-participants with explicit instruction in RT to support students in (a) acquiring new vocabulary and (b) comprehending dense science content. Students had opportunities to engage in conversations with peers, in Spanish and/or English, as they read and summarized portions of text using RT strategies.

Review of the Literature

This study took place in a school on the U.S.-Mexico border, where 96% of the population is Hispanic. The use of culturally responsive pedagogy is critical in supporting CLD students. Likewise, understanding how a research-based strategy can support students' academic success with a variety of student populations is also necessary.

Reciprocal Teaching

Educators and researchers using Reciprocal Teaching (RT) (Palincsar & Brown, 1984) have determined there is a positive effect on students' academic growth across a variety of settings. Palincsar and Brown (1984) designed RT to provide students with four strategies to support learning; their theoretical framework drew heavily upon the work of Vygotsky (1978). Strategies include (a) making predictions about text, (b) summarizing portions of text, (c) creating teacher-like questions, and (d) clarifying unknown vocabulary words. RT can assist students as they navigate dense science content material. Furthermore, RT can be used in whole group or small group instruction. After explicit instruction in strategies, students take on more of the learning of content (Palincsar & Brown, 1984).

Analysis of studies included in a review of the literature indicated that RT enhances students' comprehension of metacognitive strategies (Hacker & Tenant, 2002; King & Parent Johnson, 1999; Lederer, 2000; Olson & Land, 2007; Rosenshine & Meister, 1994). Studies focusing on RT interventions with ELLs were fewer. However, metacognitive strategy instruction has enhanced ELLs' academic outcomes as noted by several studies in this literature review (e.g., DaSilva Iddings, Risko, and Rampulla, 2009; Jiménez , 1997; Klingner & Vaughn, 1996; Muñoz-Swicegood, 1994). Jiménez (1997) designed one study that pulled five ELLs out of the regular classroom and taught RT strategies directly to students using code-switching (Lantolf, 2000) during the process. Code-switching is the act of moving between two languages, and students engaged in dialogue in English, Spanish, or both languages. Students' dialogues about texts improved and Jiménez recommended further similar research in inclusive settings. DaSilva Iddings, Risko, and Rampulla (2009) also conducted a RT intervention with ELLs with positive results.

Unlike Jiménez (1997), who spoke English and Spanish, DaSilva Iddings et al. (2009) conducted a RT investigation with three elementary-age ELLs using a code-switching approach with an English-only teacher. The purpose was to determine if monolingual teachers could effectively introduce a RT intervention using a dual language approach. The teacher encouraged students to share social and cultural experiences while conversing about the story in continuous dialogue that extended conversations; students discussed ideas with each other and extended their own and other students' ideas (Da Silva Iddings et al., 2009). The authors concluded that ELLs could improve in English proficiency and have meaningful discussions about text with support from monolingual teachers.

Muñoz-Swicegood, (1994) designed a RT study to test the effects of a RT intervention on ELLs' reading performance in Spanish and English. The study included 95 third-grade ELLs split into control (n=47) and treatment (n=48) groups. Students were taught metacognitive reading strategies in Spanish (Muñoz-Swicegood, 1994). Initially, classroom teachers in treatment groups modeled this strategy, and students moved to small groups, where they took turns being group leaders. The groups eventually became smaller until students worked in pairs. Results demonstrated a slight increase in growth on *La Prueba Spanish Reading,Test* for students in treatment groups over control students, but it was not significant.

Padrón (1992) noted that specific metacognitive strategies should be selected to match ELLs' ability levels, and that use of the strategies, i.e., when and how to use the different strategies as described by Meyers and Paris (1978), must be made explicitly clear to the students. In this manner, responsibility is transferred to students (Padrón, 1992). As U.S. schools become more diverse, research-based instructional strategies and interventions to support the academic needs of ELLs, a diverse population of students, are necessary.

Culturally Responsive Pedagogy and Language. Researchers (e.g., Artiles & Ortiz, 2002; Bernhardt, 2003; Genesee, Lindholm-Leary, Saunders, & Christian, 2005; Jiménez, 1997; Moll & Diaz, 1987; Moje & Hinchman, 2004) have noted that ELLs can improve their use and understanding of the English language by maintaining and improving their native language. ELLs who are not yet fully proficient in English may struggle with Basic Interpersonal Communicative Skills (BICS) and Cognitive Academic Language Proficiency (CALP) (Cummins, 1999), but access to their native language will support English acquisition (Krashen, 1981). An effective intervention such as RT that includes culturally responsive pedagogy via a sociocultural framework (Vygotsky, 1978) and/or a dual-language approach may be key in supporting the academic needs of ELLs.

Cummins (2008), in an argument toward a better understanding of language development, proposed, "The most productive direction to orient further research on this topic, and one that can be supported by all scholars, is to focus on creating instructional and learning environments that maximize the language and literacy development of socially marginalized students" (p. 79). Thus, ensuring ELLs have access to research-based strategies such as RT is important. However, it is essential that teachers use a culturally relevant pedagogical approach to ensure students can access their cultural wealth as they acquire new vocabulary, language, and content.

Through increased opportunities for conversations in small groups using RT strategies, students had opportunities to access cultural wealth (Au, 2000; Moje et al., 2004), such as searching for cognates. When RT is used with small groups, a bilingual or monolingual teacher can act as a facilitator, moving between groups to provide support as needed. Along with a RT intervention, educators who work with ELLs may need to utilize a dual language approach by allowing students to converse in Spanish (L1), English (L2), or a combination of both languages to achieve greater understanding (Riojas-Cortez, Huerta, Flores, Perez, & Clark, 2008). In this manner, ELLs working in small groups have opportunities to clarify unknown words (Quinn, Lee, & Valdés, 2012) through dialogue in L1 and L2, drawing on their cultural wealth to support educational outcomes with support from peers and/or teachers.

Method

Formative and design experiments are based on an architectural model and fall under design-based research (Van den Akker, Gravemeijer, McKenney, & Nieveen, 2006). Reinking and Bradley (2008) outlined one framework that can be used in a formative design experiment, which includes six questions to guide a researcher. The PI observed and/or taught in two fifth-grade science classrooms over a four-month period, using the aforementioned six questions to guide the research. Questions included: (a) What is the goal, why is it important, and what theory and prior research undergirds the foundation in accomplishing the established goal?; (b) What intervention, from research and theory, might effectively achieve the goal?; (c) What aspects might enhance or diminish achievement of the goal when introducing the intervention into a classroom?; (d) What modifications might make the intervention more appealing to all stakeholders, effectively achieving the pedagogical goal?; (e) Were there unanticipated results, both positive and negative, that the intervention produced?; and (f) What changes resulted in the instructional environment as a result of the intervention? (Reinking & Bradley, 2008).

Goals were selected to enhance student-participants' academic outcomes, and included (a) increasing student-participants' use of metacognitive strategies to enhance academic performance, (b) increasing student-participants' opportunities to engage in critical thinking and scientific inquiry with hands-on learning experiences, and (c) increasing students' self-efficacy in STEM inquiry. RT was the selected intervention. However, one aspect involved in introducing the intervention that diminished achievement toward goals included time involved in allowing students to use strategies in groups and still cover standards.

Setting and Participants

This pilot study was conducted in preparation for a larger, grant-funded study. It took place in a Title I elementary school located on the U.S.-Mexico border. The population of the city is 96.5% Hispanic. Of the 804 students attending this school, 95% are identified as economically disadvantaged and 80% are ELLs. The school has not earned a distinction in science, math, or reading, according to state assessments.

The PI conducted this pilot study in two separate fifth-grade classrooms during the 2016-2017 school year. Approximately 50 students, with ages ranging from 10 to 11, and their two classroom teachers participated. Student-participants, including boys and girls, engaged in activities in classroom and lab settings, with instruction in metacognitive strategies embedded in all lessons. Five student-participants in one classroom had limited English proficiency. The two teacher-participants spoke Spanish and English. One of the participating teachers taught only science for three of the four fifth-grade classes, while the other teacher had a self-contained class and taught all subjects. The fifth-grade science teacher-participant had more than ten years of experience, while the other teacher-participant had less than five years of experience. The teacher with less experience required more support during the intervention and requested the PI to teach more lessons.

Materials and Procedures

PROFESSIONAL DEVELOPMENT. The PI provided professional development (PD) training to teacher-participants through meetings and literature. However, both teacher-participants preferred that the PI teach the initial lesson so they could observe a more knowledgeable other (Vygotsky, 1978) using RT strategies. In collaboration with teachers, the PI observed, prepared, and/or presented multiple science lessons embedded with RT strategies, which included the four aforementioned components: (a) clarifying unknown vocabulary, (b) making predictions, (c) summarizing texts, and (d) creating teacher-like questions (Palincsar & Brown, 1984). The PI embedded a culturally responsive pedagogical approach in the intervention, and students had access to support in their native language. The PI is not bilingual, however, it is important that a teacher/researcher provide space for students to feel comfortable using their cultural capital in a classroom. During the course of these lessons, students spoke in Spanish and English, and translations were provided by more knowledgeable others; in this situation, many of those were students.

INTRODUCTION OF THE INTERVENTION. Prior to the intervention, the PI observed in classrooms during late fall of 2016, collecting field notes on typical classroom instruction. With IRB approval and PD completed, the PI introduced a RT intervention into two separate classrooms; the study continued across four months during the spring of 2017. The PI continued to observe and/or teach in the two control and two treatment classes after introduction of the intervention. After PD training, the PI requested that teacher-participants develop lessons to ensure students had opportunities to (a) demonstrate content mastery or learning through pre/post or post-test, (b) write summaries, (c) create teacher-like questions to elaborate on content, (d) explain new knowledge and explore topics as they made predictions, and (e) engage in the learning environment in collaboration with peers. However, teacher-participants developed lessons that used RT strategies in a limited manner. Students had inadequate opportunities to use strategies unless the PI intervened, as was the case in prior studies (Casey & Gillis, 2011). To provide additional support for teacher-participants after the initial PD training and introduction of the intervention, the PI developed four complete, multi-part science lessons that included instructional materials to extend over a week of instruction. The PI designed these lessons to address multiple standards. One teacher-participant taught each of these lessons while the PI observed; the second teacher-participant requested that the PI teach these lessons, and the PI complied.

PROCEDURE

All lessons incorporated student engagement. Along with lessons developed by teacher-participants, the PI developed four multi-part lessons to maximize student engagement and move students closer toward set goals. A lesson on mixtures and solutions was the third lesson developed by the PI in this pilot study on effective metacognitive strategies for ELLs. This lesson, developed and taught by the PI in one of the two classrooms, incorporated activities into a weeklong lesson to ensure student-participants learned, retained, and used content area vocabulary during instructional time, and again during follow-up teaching. The PI added arts and literacy components to the lesson to further engage students and extend learning through art-based activities. Analysis of post-assessments, students' products, and observational data demonstrated that this lesson had a greater effect on students' engagement and academic performance. Although students' engagement in this lesson improved across both classrooms, student-participants instructed by the PI demonstrated a much stronger understanding of content, as well as an increased level of content vocabulary acquisition based on post-test data analysis. The PI looked at various aspects of this lesson to determine effectiveness in achieving set pedagogical goals.

STUDENT ENGAGEMENT. It is important for students to have opportunities to discuss science content with peers to enhance vocabulary acquisition and increase comprehension of expository texts. For the lesson on mixtures and solutions, RT was an integral part of instruction. Students had opportunities to engage in learning by (a) reading and summarizing science content, (b) making predictions, and (c) creating questions with peers. The lesson on mixtures and solutions began by having students think aloud about science-specific vocabulary. Two vocabulary words were selected for explicit instruction on day one, with an additional four vocabulary words to be presented during the lesson, but not elaborated upon until later in the week (Table 1).

Table 1.
Vocabulary Framework

Target Vocabulary	Students' initial predictions on word meaning	Common definition	Examples
mixture	S1: "When you mix things together like in a cake." S2: "Like when you mix sugar and water together."	A combination of two or more substances that keep their identities.	Fruit cup, salad
solution	S3: "When you solve a math problem." S4: "Like when you add two numbers together."	A liquid mixture that has components that are evenly distributed throughout.	Tea, kool-aid
Secondary vocabulary: solute, solvent, composition, and identity	S5: "A composition is when you write a poem or a paper." S6: "A composition is like music."		

Acquiring content area vocabulary is important, but critically so for students identified as ELLs (Artiles & Ortiz, 2002) and/or students from underserved populations (Chall, 1983). The terms *mixtures* and *solutions* were repeated multiple times throughout the lesson. After a think-aloud, discussion, and brief review of text definition, the PI and students developed an initial classroom definition using a modified explanation from the think-aloud (Someren, Barnard, & Sandberg, 1994). During this 60 minute lesson, students were asked to (a) define both words aloud as a class and individually, (b) use both words in sentences, (c) write down the classroom created definition in science journals, and (d) incorporate both words into an arts enrichment activity.

The first author/PI wanted to address possible misconceptions about mixtures and solutions, and thus, an active discussion during the pre-assessment phase was encouraged (Campbell, Schwarz, & Windschitl, 2016). When prompted, students provided varying definitions of the word *solution*, to include: "a solution to a math problem-like when you solve a problem" and "solutions to multiplication facts." Likewise, students provided the following definition to one of the secondary vocabulary terms on day one, *composition*: "A composition is when you write a poem or write a paper" and "a composition is like writing music." Once students began to acquire the content vocabulary more fully, students were asked to read silently from textbooks. With teacher/researcher support, students then worked in groups to write summaries in science journals. This took place just prior to an exploratory activity to further enhance content understanding (Shepardson & Britsch, 2001). Students had grown stronger at writing summaries after continuous use of RT strategies. Initially, writing summaries was a difficult endeavor for student-participants, and the PI had to model summarizing portions of text repeatedly. A "ten words or less" strategy assisted students in identifying important facts from text and then arranging facts into sentences of ten words or less.

EXPLORING SCIENCE. After summarizing, students remained in groups for a five-minute activity that provided them with an opportunity to separate a *mixture* into individual components (Figure 2) and make predictions about the mixture using new vocabulary terms that would assist with acquisition and retention. Students removed items from baggies and spent time sorting items into their "identities"; students had to determine whether smaller and larger glass beads and pompoms belonged in the same group or different groups. All students were engaged in the activity, and when students were done sorting, the PI asked students if the mixture in the baggies could be turned into a *solution*. More than half of the students said yes, and a lively debate ensued. This occurred in both classrooms (Isabelle, 2017), but the conversations were relevant and cleared students' misconceptions about mixtures and solutions. One student in each class was able to explain why the mixture could not be turned into a solution and acquisition of content vocabulary was further enhanced.

Figure 2

EXPLAINING CONTENT. Immediately following the *mixtures* activity, students watched a brief video, *The Great Picnic Mix-up* (Szymanski, 2015). Although the video was approximately three minutes long, the PI paused several times to (a) ensure students understood the narrator, who spoke at a rapid pace (b) review primary and secondary vocabulary terms and (c) allow students time to elaborate on narration in the video by summarizing science content presented. During the video, students' conceptions of physical and chemical changes were addressed. Likewise, students had another opportunity to hear about two secondary vocabulary terms: *solute* and *solvent*.

A lab entitled "Separating Mixtures" was led by the fourth author and teacher-participant later in the week; this further assisted students with content-area vocabulary acquisition. During the science lab, students had to demonstrate that mixtures could be separated; students then had to identify a solution as a type of mixture. Students used the physical properties of mixtures and solutions to decide whether the properties changed or remained the same. There were six stations with a different "mixture" bowl at each station; students were placed in groups of four to rotate easily between stations. Students had to determine which tools and method to use to separate each mixture. The tools were placed on a separate table, and this allowed students to make decisions to determine which tools they would need to complete the activity. Students also had to document the tools they chose and the method they used to separate the different mixtures. Students wrote down the choices they made on a science handout.

EXTENDING LEARNING THROUGH ARTS AND LITERACY INTEGRATION. The PI embedded a literacy and arts enrichment component into this week-long lesson on mixtures and solutions to allow students' opportunities to elaborate on learning in creative ways. All students had an opportunity to create persuasive brochures describing destination places (Figures 3, 4, & 5).

Figure 3

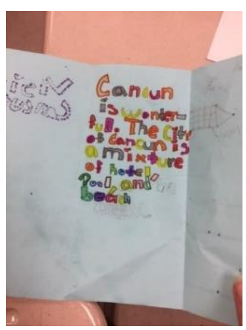


Figure 4

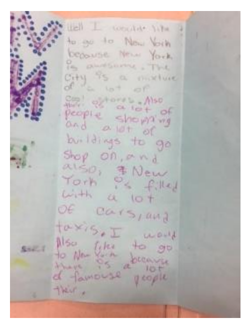


Figure 5

Students wrote with purpose and audience in mind. This activity began during the lesson on Monday, just after a review of the content. According to a study of creativity by George Land in 1968, students' creativity decreases significantly from age five to fifteen (Land & Jarman,1992). Providing students with an opportunity to create a brochure links to the highest levels of learning, according to Bloom's revised taxonomy (Forehand, 2005). Likewise, embedding an ELA standard into the science lesson allowed students to apply newly acquired vocabulary in a fun and creative way. Students began their brochures after the lesson, and the teacher-participant/fourth author provided time for students to complete them during the week. The embedded literacy component allowed students to demonstrate acquisition of content vocabulary in creative ways that correlated to a selected destination location. On Friday, when the first author gave all students a post quiz on vocabulary and content to assess learning, students were excited about their completed brochures. Several students wanted the PI to take their finished products, but students were thrilled that pictures of their creations were taken (Figures 6, 7, & 8).

Figure 6

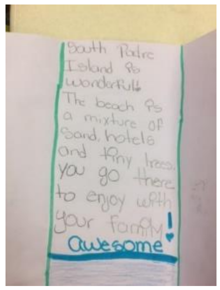


Figure 7

Figure 8

After the post-test, students were still talking about their brochures. "I want to go to New York," one student commented, and other students made similar remarks about their destination choices. A discussion of how science can be found in and around destination places came up, and a conversation about the "science around us" brought up more questions from students. Students began to identify land forms, features, and space science. Getting students to see science all around them through connecting technical language, implicitly and explicitly, to real-world application is important, and the embedded arts-integration and literacy component did j.t that. Overall, students' excitement over the embedded literacy component in the lesson on mixtures and solutions allowed them to elaborate on learning; it turned out that creating travel brochures using science content vocabulary terms was a big hit.

RESULTS

For this formative experiment, the PI collected and analyzed quantitative and qualitative data, to include (a) researcher's field notes/reflections, (b) observational data from informal questioning, (c) students' finished products, (d) pre/post or post-tests, and (e) teacher interviews and feedback. The PI used grounded theory (Corbin & Strauss, 2008) to analyze qualitative data. Coding led to emergent themes. Analysis of observational field notes prior to the intervention revealed that in the class with the less experienced teacher-participant, students did not engage in collaborative learning and the teacher used an authoritarian approach to instruction. The more experienced teacher had students engage in cooperative learning groups for a few minutes prior to the beginning of almost every lesson. However, data analysis revealed both teachers most frequently asked students to engage in note taking via whole group instruction. Students were often off task and engaged in activities that detracted from learning content. Off-task behaviors included playing with objects in desks, resting head on desk, refraining from note-taking, and leaving seat to go to restroom, sharpen pencil, and/or retrieve items from backpacks. Cooperating teachers utilized few metacognitive strategies prior to the intervention. After PD training, cooperating teachers used some RT strategies in a limited manner. When the PI was developing and teaching lessons in one of the two classrooms, all four strategies were used.

Quantitative data included pre/post tests or post-tests. Depending on the design of a lesson, assessments were given at varying times, with students taking pre/post-tests or only a post-test. Student-participants understood these tests were not part of their grade, but the PI determined that test-overload was a struggle for many student-participants. Students in all groups were preparing for state standardized testing, and state testing preparation was a factor in the test overload. Qualitative data was observational, reflective, and in many instances, recalled after the fact. Field notes contain researcher bias for a variety of reasons including (a) reflections written from memory, (b) researcher recalling events that she participated in, and (c) researcher's active engagement with one treatment group over the other. PI's reflections included observations, classroom activities conducted by the PI, and notations about students' excitement to see PI enter the classroom, with students asking what they would be doing. Likewise, field notes contained phrases such as "students were happy that they would be engaged in small group work" (March, 2017).

Although the purpose of formative design experiments is not to assume "the role of a teacher in another teacher's classroom" (Reinking & Bradley, 2008, p. 85), this pilot study resulted in just that in one of the classrooms due to a request from one of the teacher-participants. Thus, researcher-bias may be present in field notes and researcher's reflections. Likewise, small group instruction was a novel approach in one class, and it is unclear if student engagement would have continued if the teacher used small group instruction embedded with RT strategies on a regular basis.

Furthermore, comparing two groups of students in treatment classrooms, with one group being taught by the PI, presented a confounding variable (Denzin & Lincoln, 2000). Nonetheless, the PI tried to remove researcher bias to the greatest extent possible. Research-bias in analyzing field notes was lessened by the second author acting as a second reader. One final difficulty in this study was retrieving all pre/post and/or posttests from control groups. Often, the science teacher-participant would forget to give assessments to control students. It was determined that a comparison of science scores from state exams could be used to compare students. However, PI was not able to access the scores.

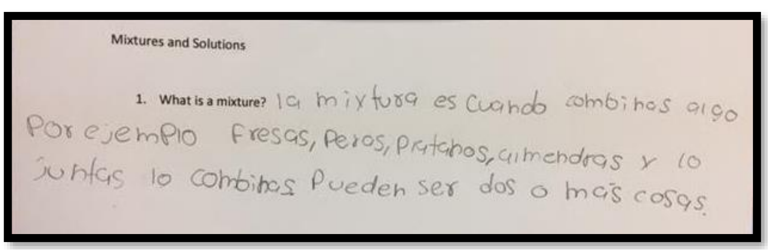
Qualitative data analysis across all RT lessons revealed positive correlations between student motivation, academic performance, and/or engagement. Lessons developed and taught by PI included (1) states of matter, (2) periodic table of elements, (3) mixtures and solutions, and (4) programming/coding floor-robots. The most significant and surprising lesson in this pilot study introduced student-participants to floor-robots. Data analysis of pre/post assessments demonstrated an increase in students' awareness of programming and code, as well as an increase in students' self-efficacy in science (Casey, Gill, Pennington, & Mireles, 2017).

EVALUATING A SINGLE LESSON FOR STUDENT SUCCESS THROUGH DATA ANALYSIS. The PI kept a running journal after teaching and/or during observations in each classroom. These field notes were more accurate when the PI was observing a lesson. It was more difficult to teach a lesson, and then recall from memory everything that occurred in a classroom after the fact. During the lesson on mixtures and solutions, student-participants took a post-test on Friday. The post-tests in both treatment classrooms were identical, however, there was a difference in content mastery between the two classes. Students who were taught by the PI demonstrated a higher level of understanding. There are several reasons that this might have occurred. First, the class that showed less improvement had a student population with a higher percentage of ELLs who were still acquiring the English language. Secondly, the PI is more familiar with RT strategies than the cooperating teacher who selected to teach lessons.

On Friday, four days after the PI introduced the initial lesson in one of the classrooms, all students took a five-question quiz. The post-test contained one short answer question and four multiple choice questions, some of which were developed by students when they created teacher-like questions in the lesson on Monday. Results demonstrated strong mastery in the class with students who were taught by the PI, with an average test score of 89% (n=22). Several students in both classes were absent. In the class taught by one of the two teacher-participants, mastery was not demonstrated, as indicated by the class average of 64% (n=20). However, many students in this second class had limited English proficiency. The quiz was in English, and language may have impeded their ability to demonstrate content mastery.

The short answer question: "What is a mixture?" was answered by 41 students, with one student leaving the question blank. Three students responded entirely in Spanish (Figure 9).

However, many students still acquiring the English language provided a response in English (Figures 10 & 11). On the four multiple choice questions, there was a significant difference in students in the two treatment classes. A higher percentage of students taught by the PI selected the correct answers (Figures 12 and 13) over student-participants taught by the teacher-participant (Figures 14 & 15) on all four questions. This presents a confounding variable (Denzin & Lincoln, 2000).


Mixtures and Solutions

1. What is a mixture? la mixtura es cuando combinos algo Por ejemplo Fresas, Peros, Pratanos, almendras y lo juntas lo combinos Pueden ser dos o mas cosas

Figure 9

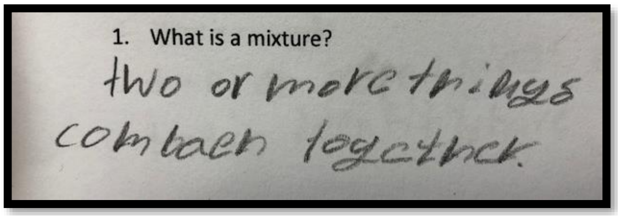


Figure 10

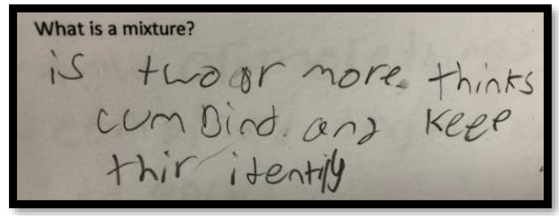


Figure 11

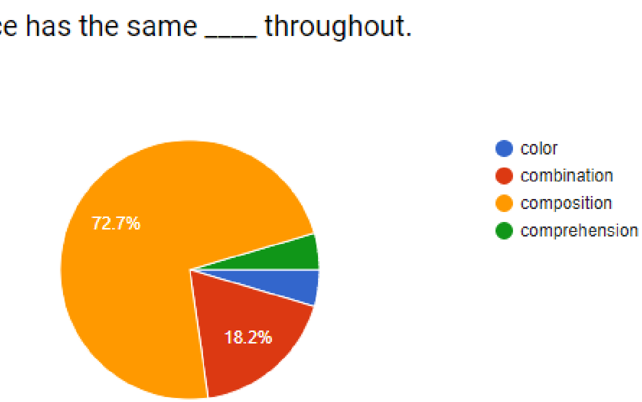


Figure 12

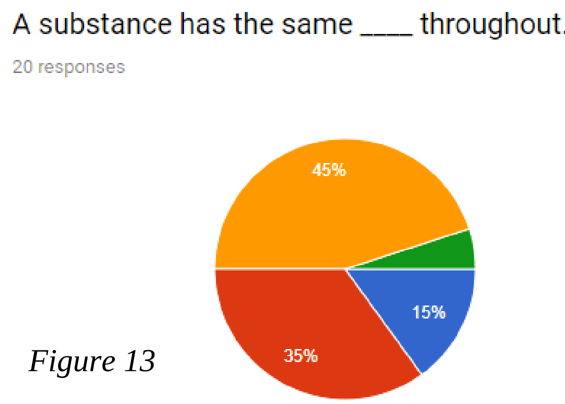


Figure 13

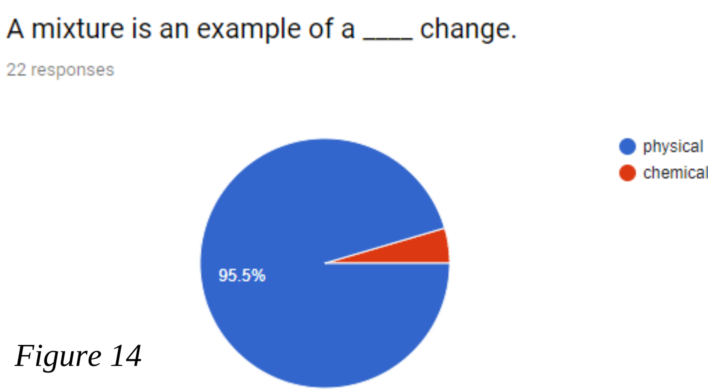


Figure 14

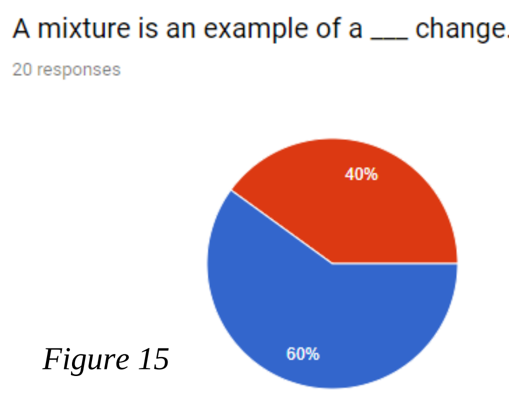


Figure 15

Although there were several variables that may have skewed results, RT has a strong research base that has demonstrated the effectiveness of the intervention. Introducing student populations that are largely Hispanic to metacognitive strategies such as RT is important. Students need support in becoming more aware of strategies that can assist with reading and comprehending content; and if these strategies are embedded with a culturally relevant pedagogical approach to support CLD students, this study has provided some evidence that students will achieve improved academic growth.

DISCUSSION, LIMITATIONS, & CONCLUSIONS

This one lesson on "Mixtures and Solutions" was part of a larger pilot study that included multiple science lessons embedded with RT to assess the effects of a metacognitive strategy on ELLs' academic progress in a science classroom. This lesson occurred toward the end of the study, and students were becoming adept at utilizing RT strategies. The embedded art and literacy standards were added to (a) increase opportunities for writing, (b) provide students with new purposes for writing, (c) generate opportunity for creativity, and (c) allow students to create a brochure with real-world application. These components added a layer of engagement that further enhanced comprehension of content. This lesson demonstrated how arts and literacy integration provided students with multiple strategies to make connections between academic content and personal, lived experiences. When taken as a single lesson, it is nothing more than that, a lesson in a science class. When taken as a multi-component lesson that goes beyond teaching a science standard, it may provide teachers with ideas for adding engaging and enriching experiences to enhance lessons involving expository texts.

There are several limitations to this study. First and foremost, student grouping for classroom instruction in this school is configured based on students' academic achievement, aptitude, and test scores. The highest achieving students were all grouped in one fifth-grade class, and the lowest achieving students, many of whom had limited English proficiency, were all grouped together for all instruction. The control class in this study was made up of the highest achieving students, making it difficult to compare students in the control and treatment groups. Next, pre/post assessments were strong indicators of academic growth over the duration of the intervention, but constant testing of student-participants became problematic. Toward the end of the study the PI began using only post-tests and other observational data when possible. A third limitation the PI faced included the comparison of two treatment classrooms with dissimilar student-participants. One of the treatment classes had a much higher percentage of ELLs with limited English proficiency. Finally, comparing students' academic growth when the PI was instructing student-participants in only one of the classrooms was challenging. However, when working with teacher-participants, ensuring that their voices and suggestions are heard is important to maintaining a feeling of collegiality and partnership in the study.

There is limited research on arts and literacy integrated science lessons (Graham & Brouillette, 2016; Gray, Elser, Klein, & Rule, 2016), and this research base is even less when adding in arts-integration research on effective supports for ELLs (Brouillette, Grove, & Hinga, 2015). Incorporating multiple standards across instruction, with an added arts activity embedded in a lesson, may increase students' (a) engagement and interest in a lesson, (b) academic success with content and (c) content-area, vocabulary acquisition and retention. Further research on the effects of literacy-rich, arts-embedded science lessons when working with ELLs may be necessary to add to the knowledge base.

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