# BEARS IN A BOAT: MODELING SCIENCE-CONTENT AND LANGUAGE DEVELOPMENT THROUGH PBL FOR PRESERVICE ELEMENTARY TEACHERS

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**Abstract**: Bears in a Boat is a Problem-Based Enhanced-Language (PBELL) experience deepening conceptual understanding of floating and sinking. We taught this lesson with preservice elementary education students, second graders on the US-Mexico border, and in an urban setting in Arizona with a large population of third-grade English Language Learners (ELLs). The science content outcomes are for students to be able to describe the difference between floating and sinking, to create a boat that can float, and to explain that the more weight in a boat the deeper it floats. The lesson included content scaffolds for ELLs and opportunities for language use and development.

## Introduction

There is no better time than now to implement large scale problem-based learning (PBL) in K-12 schools. PBL integrates science, technology, engineering, and mathematics (STEM) with meaningful experiences, it provides a path to realize the Next Generation Science Standards (NGSS Lead States, 2013), and it is a way to achieve the inquiry depicted in the Common Core mathematics standards (Nariman & Chrispeels, 2015). These standards align with the view that the omnipotent outcome of education is people's abilities to recognize and solve problems. PBL as a method and a philosophy can enrich learning and school experiences for both students and teachers.

PBL can lead to deeper learning and more motivated learners. With some modifications, the approach can meet the unique needs of English Language Learners (ELL) in the United States—many of whose needs are not currently being met (Gándara, 2010; Jimenez-Silva, Gomez, & Cisneros, 2014). In many world regions, there are children whose primary language is not the language of instruction. While advantaged by multicultural perspectives and languages (Luk, De Sa, & Bialystok, 2011), these students often face challenges in schools. Language is the fundamental tool of learning. Difficulty accessing the language of instruction and assessment threatens academic success.

PBL experiences bring rich opportunities for collaboration, thinking, and language. Teachers need to know not only how to implement PBL but how to do so in ways that foster the development of academic language for all students, but especially for language learners. This paper describes our college's approach with a focus on a necessary first step, providing an experience for preservice teachers in a science methods class to experience the approach as learners. The approach is described and preliminary evaluation data are discussed.

## Perspectives and Theoretical Framework

### Problem-Based Learning: From Universities to Grades K-8

With roots in medical education over 50 years ago and permeation throughout professional education, PBL research has documented benefits and led to its evolution as a method (Jerzembek & Murphy, 2013). While diffusion in K-12 classrooms is slow, new standards in mathematics and science education may catalyze greater use (Rillero, et al., 2017). While not as well researched, systematic K-12 reviews and meta-analyses have shown positive effects. Jensen's (2015) meta-analysis indicated that grade 6 to 12 PBL students outperformed traditional students on content and skill assessments. A K-8, PBL systematic literature review (Merritt, Lee, Rillero, & Kinach, 2017) of math and science education studies reported significant differences favoring the PBL group on 87.5% of the academic achievement measures.

### Teacher Understanding of PBL

Successful PBL experiences depend upon knowledgeable teachers (Maxwell, Mergendoller, & Bellisimo, 2005) who "must be intentional in the design of the learning environment and the enactment of support strategies" (English & Kitsantas, 2013, p. 130). Finding balance between supports for students while moving away from direct instruction is a challenge (Pepper, 2009). An additional challenge is that inservice and preservice teachers may not have experienced PBL as a learner and might not have PBL implementers to observe (Lehman, George, Buchanan, & Rush, 2006; Strevy, 2014).

### English Language Learners

When the language in which academic content is delivered to students is not accessible, their academic success is jeopardized (Wright, 2015). The population of ELLs in US schools has

increased steadily over the past thirty years (Shin & Kominski, 2010). The percentage of public school students who were classified as ELLs in 2013-14 was 9.3% or an estimated 4.5 million students (US Dept. of Ed., 2016). In Arizona, the state in which we are situated, the 2013-2014 ELL demographics indicate that 79% of the state's ELLs are in grades K-5 while 13% are in grades 6-8 and 8% are in grades 9-12 (Arizona Department of Education, 2016).

**Theoretical Framework**

Language and learning happen together. As Halliday stated in his language-based theory of learning, "Language is the essential condition of knowing, the process by which experience becomes knowledge" (Halliday 1993, p. 94). Our college of education has committed to produce elementary teachers with the dispositions, knowledge, and skills to implement PBL and effectively work with English language learners (ELLs). The combined goals are merged into an instructional approach called Problem Based Enhanced Language Learning (PBELL) (Rillero, Koerner, Jimenez-Silva, Merritt, & Farr, 2017).

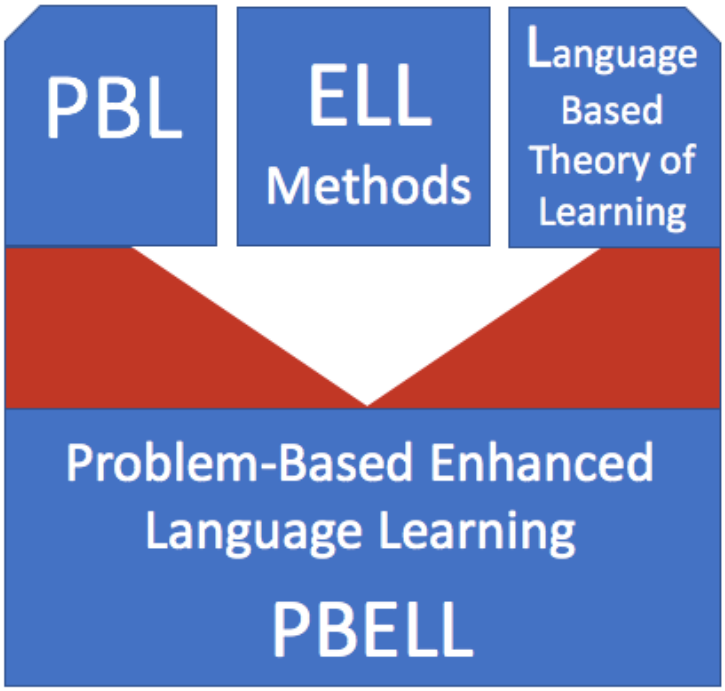


*Figure 1*. A graphical depiction of the components of PBELL.

**Bears in a Boat as a Model PBELL Experience**

Two science educators and two ELL specialists developed the Bears on a Boat Experience as a model for PBELL. To have a credible experience, we field tested the experience in a second-grade urban Phoenix classroom and a third-grade classroom in a USA/Mexico border town. Both classrooms had large populations of ELL and children on free lunch programs.

**Goals of the Experience**

The learner outcomes for the two day, one-hour per day experiences are show in Figure 2. Learners develop the ideas of floating and sinking, as they observe that the more weight added to a boat the deeper it floats. This serves as the basis for later understandings concepts of weight, mass, volume, density, relative density, buoyancy, and Archimedes Principle. The design, building, and testing of their boats also provides engineering experiences. Supports for language ELLs' language development are built into the experience.

***LEARNER OUTCOMES***

***I can***

- Describe the difference between floating and sinking
- Create a boat that can float
- Explain that the more weight in a boat the deeper it floats

*Figure 2*. Learner Outcomes for Bears in a Boat.

**Implementing the Experience**

Preservice teachers are told they are second graders and that some of their classmates are English Language Learners. Before the lesson starts, the words bear, boat, and aluminum foil are reviewed with pictures and Spanish translations of each. This models the practice of introducing operational vocabulary before the lesson begins. The introduction of conceptual vocabulary, however, happens after the experience, which models explore *before* explain. A story creates the context for two bears that need to get across a lake by creating a foil boat.

Students are shown two small plastic counting bears and an 8-cm by 8-cm square of aluminum foil. They are asked to write the problem in their own words. Then they are asked to

draw a possible design of the boat. The sentence stem "I think my boat will sink/float because…" is provided as a writing prompt. With a partner, they compare diagrams and their statements, and then choose only one boat to build, which prompts sharing of ideas. Each small group, composed of two dyads, was given a tub of water and two bears to test their boats' abilities to float with two bears and write to this sentence stem: "I think my boat sank/floated because…". Through discussion, the words sink and float are reinforced. Whether with children or adults, about half of the boat trials sink. As students share their writings a word bank is created to capture the emerging vocabulary.

Day two presents a challenge to build a boat for eight bears with 12-cm by 12-cm foil. Again, they work in pairs, drawing their boats and writing why their boat would float. They discuss their designs and choose the best boat to build and test. Sometimes there are audible gasps when this eight-bear boat is introduced and in the most recent implementation, one student suggested that we are setting them up for failure. Nevertheless, in the trials almost all the boats float in this second round.

Each group tests exactly eight bears in a tub of water. They are asked to add two bears at a time and notice what happens as more bears are added. This important concept—adding more weight, causes the boat to float deeper into the water—is also reinforced with a demonstration. This content scaffold has the teacher use a large clear container floating in a larger tank of water. As weight is added, students can readily observe that the tub floats deeper and deeper. As learners progress through the PBL experience, they engage in discussions, make decisions, analyze results, and write.

Then the final problem is revealed. Students predict which boat in their small group will hold the most bears and use that in a classroom competition. The group only had eight bears to test their boats so they must extrapolate beyond their observations to make their prediction. They then created a team name.

An NBA pregame situation was created with the room lights turned off, flashlights moving like spotlights, and music playing. Students cheered as their team representative announced their group name. Students were directed to add two bears at a time to their boats. Students had previously tested their boats with eight bears but in the competition, there was still excitement as each boat hit the eight-bear mark. Then the suspense intensified as bears were added beyond the eight. One-by-one, boats sank under their load until one boat remained with students celebrating.

**Processing the Experience**

The experience was designed to have preservice teachers experience a science PBELL experience as learners—in this case as second grade children. After the experience, the students now returned to their preservice teacher selves. They first answered a survey (the data are presented in the results section). Then there was a class discussion with the following questions as prompts: What was the role of PBL in the experience? How was the use of language encouraged? Why would the experience be appropriate for ELLs? What was the science content of the experience? After the discussion, it was reiterated that the preservice teachers would be developing and implementing their own PBELL experiences in their internship classrooms.

**Preliminary Evaluation Data**

The analysis of the survey's likert-items where the choices were from 1 (weak) to 5 (great) shows a range of 4.07 to 4.70. The first three questions focused on the perspective of the preservice teacher on how beneficial the experience would be for second graders regarding learning science (x=4.41, SD=0.93), language (4.14, 0.84), and problem solving skills (4.70, 0.54). The results suggest their perspective was the experience was most beneficial for promoting problem solving abilities in second graders, followed by learning science, and learning language. Regarding how beneficial the experience would be for second grade ELLs, the preservice teacher mean was 4.04 (SD=0.81).

Using thematic analysis, the open-ended responses were analyzed, initial categories and codes created, followed by the generation of themes (Braun & Clarke, 2006). The most mentioned reasons for liking the experience were categorized by the themes of fun and hands-on. The next theme, boat creation, included they liked building or designing a boat. The most common category for "What did you not like about the experience?" was nothing (28.6%). The next was the materials, and these were mostly concerns about the limited amount of foil provided. Time was the next most mentioned aspect they disliked, with a small percentage of students (5%) stating it took too long.

For the next question, the language supports mentioned by most students were the sentence stems (40%), followed by general vocabulary supports, and then using the home language, which was done in presenting Spanish translations of the operational vocabulary. The biggest concern in thinking about implementing their own PBELL lesson is the timing and how it would fit into their internship classrooms (37%). The next was coming up with a good problem.

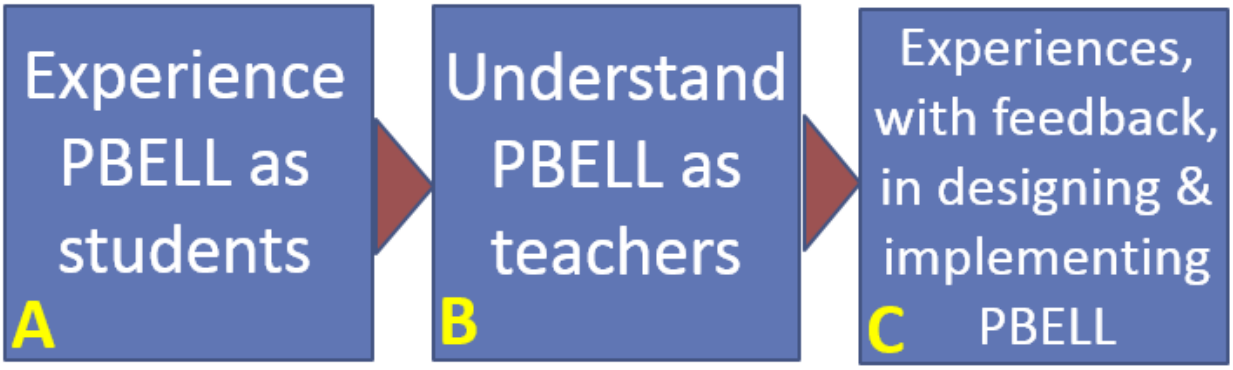


*Figure 3*. Phases of preservice teacher education for PBELL implementation.

**Discussion and Conclusions**

The increasing number of students from diverse languages, with assorted abilities, and various cultural backgrounds offers us the opportunity and presents the need to prepare teachers to design and implement PBL in K-8 classrooms. PBELL is an instructional model that combines PBL with ELL methods to enhance the use and development of language. Bears in a Boat and other experiences help our students to first learn through a PBELL experience so later they can implement the approach in their classrooms. Figure 3 shows how the experiences fits into our overall approach. Data suggest that students perceived value in the experience and the approach and it helped them to think about challenges in their own implementation of the method.

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