Interdisciplinary Journal of Problem-Based Learning

Volume 10 | Issue 1 Article 5

Published online: 10-9-2015

PBL in the Era of Reform Standards: Challenges and Benefits Perceived by Teachers in One Elementary School

Nahid Nariman
Transformative Inquiry Design for Effective Schools and Systems, nahid858@gmail.com

Janet Chrispeels
Transformative Inquiry Design for Effective Schools and Systems, jchrispeels@ucsd.edu

IJPBL is Published in Open Access Format through the Generous Support of the Teaching Academy at Purdue University, the School of Education at Indiana University, and the Educational Technology program at the University of South Carolina.

Recommended Citation

Nariman, N. , & Chrispeels, J. (2016). PBL in the Era of Reform Standards: Challenges and Benefits Perceived by Teachers in One Elementary School. *Interdisciplinary Journal of Problem-Based Learning*, *10*(1).
Available at: https://doi.org/10.7771/1541-5015.1521

THE INTERDISCIPLINARY JOURNAL OF PROBLEM-BASED LEARNING

ARTICLE

PBL in the Era of Reform Standards: Challenges and Benefits Perceived by Teachers in One Elementary School

Nahid Nariman and Janet Chrispeels (Transformative Inquiry Design for Effective Schools and Systems)

We explore teachers' efforts to implement problem-based learning (PBL) in an elementary school serving predominantly English learners. Teachers had an opportunity to implement the Next Generation Science Standards (NGSS) using PBL in a summer school setting with no test-pressures. To understand the challenges and benefits of PBL implementation, a case study method was used and a variety of data collected. Results suggest collaboration amongst teachers is essential to design and implement PBL units. A challenge was the tension between the contradictory accountability and curriculum coverage goals of the regular academic year versus letting go to promote inquiry. Both teachers and students valued working in collaborative teams. An important insight is the need to help teachers connect NGSS to students' lives and to consider their background knowledge in unit development and problem formulation.

Keywords: problem-based learning, Next Generation Science Standards, K-12 implementation, challenges, elementary school science, benefits, PBL in teaching science, NGSS

Introduction

The adoption of the Common Core State Standards (CCSS) in 2010 by most states and the Next Generation Science Standards (NGSS) in 2013 by 26 states has created a new policy discourse with a focus on realigning curriculum, instruction, and assessment to match inquiry and problem-solving approaches. These reform standards (i.e., CCSS and NGSS) were designed to help students succeed in the 21st century in mathematics, English language arts, and science. The CCSS and NGSS, in part, were developed because on international assessments U.S. students lag behind other developed nations in terms of problem-solving and critical-thinking skills. These reform standards resulted from collaborative efforts of practitioners, teachers, researchers, content experts, and leaders in both business and higher education.

The challenge now facing educators, especially those serving low-income diverse students from underserved schools, is to shift to a student-centered approach that will help students meet the learning demands of reform standards. The purpose of this study was to explore how one underperforming elementary school serving predominantly Latino heritage students began the process of rethinking and refining its instructional approach in alignment with the reform standards and the challenges teachers and students faced as they implemented problem-based learning (PBL) in a three-week science-focused summer school.

Problem-Based Learning

Problem-based learning is a student-centered approach that supports the instructional demands of the reform standards. It is characterized as a teaching model consistent with the principles of constructivism, driven by stimulating, open-ended questions and collaborative learning (Hmelo-Silver, 2004; Savery & Duffy, 1995). Research shows that "high quality standards-based PBL curriculum is a valuable addition to the classroom" (Gallagher & Gallagher, 2013, p. 127). Active learners, Savery and Duffy (1995) identified, are engaged in working at authentic tasks and real-world problem-solving activities. These problems are introduced to act as triggers for learning. In the PBL setting, the responsibility for learning falls on learners, and teachers assume a facilitator, enabler, or activator (Fullan, 2013; Hattie, 2009) role in guiding students' learning. According to Barrows (1996) the main tenets of PBL are that learning happens in small student groups where meaning is negotiated in a collaborative team setting. PBL takes place through self- and team-directed quests and questioning; uses problems as an impetus for learning, and a medium for improving problem-solving skills; and shifts the role of teacher to one who facilitates and scaffolds learning to enhance students' meaning making of new information.

http://dx.doi.org/10.7771/1541-5015.1521

Benefits of a PBL environment. Research suggests that PBL engages students in research and inquiry, communication, collaboration, creativity, critical thinking, and teamwork (Ertmer & Simons, 2006; Hmelo-Silver, 2004). Students learn and retain information better and longer when they are actively engaged in their own learning in an environment that is designed to motivate them. In a meta-analysis of the effects of PBL, Dochy, Segers, Van den Bossche, and Gijbels (2003) found when PBL students are compared with those in traditional curricula on measures of application of knowledge, the measurement showed a larger effect size for PBL students compared to the control. PBL has been shown to help students acquire adaptive expertise (Bransford et al., 2006; De Corte, 2010) and engage in the deep learning (Azer, 2009; Delisle, 1997), skills mandated by reform standards. Students, working in teams, play a key role in constructing their own learning through active participation.

Researchers have found that PBL is effective in enhancing learning for socioeconomically disadvantaged diverse students, which is particularly relevant for our study. A development and research study of twenty-five third and fourth grade students from six elementary schools of diverse linguistic and cultural groups engaged in PBL indicated that the PBL curriculum enhanced the inquiry skills of all students including lower socioeconomic and English language learners, regardless of grade, prior achievement, gender, and ethnicity (Cuevas, Lee, Hart, & Deaktor, 2005). In a quasi-experimental study of ten middle schools, five schools were randomly selected to implement an inquiry-based chemistry unit (Lynch, Kuipers, Pyke, & Szesze, 2005). The other five schools taught the regular chemistry curriculum and served as a control. There were approximately 1,200 eighth grade students in the treatment and 1,000 in the control. Groups were ethnically, linguistically, and socioeconomically diverse. Posttests on conservation of matter, assessments of motivation, and engagement indicated students in the treatment group made higher gains than the control.

Challenges arising from a PBL environment. PBL poses challenges for teachers in reconstructing their own understanding of teaching in which students and their inquiries drive instruction (Park & Ertmer, 2007). Barell (2010) and Ertmer and Simons (2006) have argued that teachers' and students' roles need to be rethought, and educational programs and goals reenvisioned based on a constructivist theory of learning. Ertmer and Simons's (2006) review of the literature identified three types of challenges teachers are likely to encounter in PBL: creating a culture of collaboration and interdependence; adjusting to changing roles; and scaffolding students learning and performance. Similarly, Tamim and Grant (2013) identified five challenges for teachers implementing PBL: taking a constructivist approach; adopting new instructional strategies; developing curriculum and selection of topic; managing and designing of PBL; and nurturing collaboration. Their findings are relevant to the current study in which we empirically document the challenges of elementary teachers working to shift their teaching from scripted textbooks to teachers designing PBL units aligned with NGSS standards.

Collaborative Teamwork

Collaborative teamwork or cooperative learning commonly is associated with PBL, making it relevant to explore research on its effects on learning. Cooperative learning has long been valued in education because of its positive results on students' academic achievement as well as affective domains (Hall, 1989; Michaelsen, Knight, & Fink, 2004). Collaborative learning refers to students working together toward a common goal in small groups (Johnson, Zhang, & Kahle, 2012) and emphasizes collaboration, teamwork, and student interaction (Duch, Groh, & Allen, 2001; Prince, 2004).

Benefits of collaborative teamwork. Collaborative teamwork and cooperative learning are research-based, effective instructional approaches. In a meta-analysis comparing classroom instructional practices, Marzano, Pickering, and Pollock (2001) found an effect size of .78 for cooperative learning. Several concrete benefits have been identified: higher academic achievement; increased attendance and motivation; improved intergroup relations and longer time on task (Slavin, 1995); higher role-taking abilities (Ziegler, 1981); and improved communications skills (Neo & Neo, 2009). These benefits extended to student perceptions as well. Students who participated in cooperative teamwork viewed their learning as interesting, motivating, and enjoyable (Haberyan, 2007; Hernandez, 2002). In another meta-analysis, cooperative learning was linked with higher student self-esteem (Johnson & Johnson, 1989). Relevant to this study, research has also shown that collaborative learning is beneficial for lower socioeconomic and underserved students, and helps to close the achievement gap (Aronson, Blaney, Stephan, Sikes, & Snapp, 1978). In one study, students in a high poverty school made significant academic gains from the teacher's use of cooperative learning approaches (Heusman & Moenich, 2003). Dotson's (2001) study of the sixth graders demonstrated that students who used Kagan (1994) Cooperative Learning Strategies obtained higher scores in social studies than those in classrooms that did not use them.

Challenges of collaborative teamwork. In spite of the benefits, research also has surfaced challenges in using collaborative teamwork. These include unclear goals (Fowler, 1995), unequal participation (Ingham, Levinger, Graves, & Peckham, 1974), and lack of leadership and lack of team development (Gentry, 1980). Despite these challenges, it is

clear the use of collaborative teamwork is a skill necessary to be successful in the 21st century (Hmelo-Silver, 2004; Savery, 2006).

The body of literature on PBL, cooperative learning, and teamwork helped frame this study. The purpose of this study was to create a holistic case about teachers' efforts to shift their instruction from teacher to student-centered learning. The specific research question that guided this study was: What challenges and benefits did teachers and students perceive as they engaged in a three-week science-focused summer PBL program?

Methods

This study used a single exploratory case study design to investigate teacher implementation of PBL in a three-week summer school session. Yin (2003) identified three elements for a case study: (1) "how" and "why" questions are posed, (2) when the researcher has minimal control over the course of the events, and (3) when "the focus is on a contemporary phenomenon within some real-life context" (p. 1). This study demonstrated these three elements and as such was regarded as a single exploratory case study. Typical of a case study, data were collected from multiple sources. This exploratory approach was appropriate given a need to understand what may facilitate and what challenges teachers may face as they shift from textbook-driven instruction and transition to teaching reform standards.

Context of the study. The setting was an elementary school in southwestern United States serving Latino heritage students, with 93% of the students qualifying for free lunch and 82% classified as English language learners. The school was designated underperforming[2] and applied for and received a three-year federal Turnaround School Improvement Grant[3] in the fall of 2010. As part of the grant, the school invested heavily in technology (one-to-one iPods, rolling carts of laptops, a computer lab, teacher computers and document camera, and five desktop computers for each classroom), with the expectation that teachers would integrate technology into their lessons. Another component of the Turnaround Grant was to increase learning time for students. This was accomplished through a three-week Extended Learning Time (ELT) of science-focused summer school session. Before the start of each summer session, teachers received one week of professional development (PD). This study examines the second year of ELT.

Professional development: Year 1. In the first year, teachers were provided one week of PD prior to the start of the summer school session. The purpose of this first year PD was to initiate teachers in basic concepts of PBL as an approach to teaching a science unit. To accomplish this, teachers in their grade level teams selected a National Science Teachers Association's *Picture Perfect* and *Great Exploration* unit in Math and Science—GEMS, Lawrence Hall of Science (Ansberry & Morgan, 2005, 2007). These units were selected because: (a) the school already had copies of them, (b) they were aligned with CCSS reading standards, and (c) had accompanying fiction and nonfiction books for each lesson. Teachers did not align these units to current NGSS science standards. Teachers also were introduced to the collaborative engagement strategies, the principles of Kagan's (1994) book, *Cooperative Learning*, and were given instruction on how to use daily journaling to reinforce the academic year focus on reading and writing.

Professional development: Year 2. In the second year (the focus of this study), the emphasis of the summer school PD shifted to teacher developed standards-aligned PBL unit. Teachers in their grade level teams reviewed the DRAFT Next Generation Science Standards (n.d.) and California science standards, and then selected one or two standards that would be the focus for the summer PBL (see Table 1 for a list of standards, big idea, essential questions, and performance tasks designed by each team). The PD provided in year 2 had four major foci: (a) deepen teachers' knowledge of PBL, (b) learn a protocol to engage students in asking questions, (c) extend teachers' knowledge of how to engage students in cooperative learning, and (d) link writing and science. To deepen teacher knowledge of PBL, they reviewed the characteristics of PBL and explored their roles within a PBL environment—particularly how to gradually move from teacher-directed instruction to teacher-guided PBL. Rather than use previously published units, teachers were to develop their own units based on NGSS standards. They began by investigating what the standards were asking students to know and do, identifying the big idea, essential questions (embedded in the standards), and developing problems/performance tasks students were to address (see Table 1).

A second major focus of the PD was to learn a protocol designed to have students generate questions when given a prompt (headline) such as "Farmers in distress as bee colonies collapse" (Burke, 2011). This protocol, along with a reinforcement of how to use What I Know, What I Wonder, What I Learned (KWL) charts (Ogle, 1986), were designed to give teachers tools to identify students' prior knowledge and interests, increase student engagement, and assist teachers to assume a more facilitative role.

Third, during the PD teachers reviewed information on how students learn (Bransford, Brown, & Cocking, 2000) and on Kagan (1994) Cooperative Learning Strategies to engage all students, through mixed ability grouping, pair-share, and round-robin sharing. Finally, a subsidiary goal was to encourage student writing. The book *Writing in Science* by

Fulwiler (2007) and small notebooks for every student to use as science journals were provided to all teachers. Students were expected to write in their journals daily and teachers were urged to incorporate writing as part of their assessment activities. Each afternoon of the PD week time was devoted for grade level teams to plan their units.

Table 1. Grade level, standard, big idea, essential questions, and performance tasks.

Grade	Standard	Big Idea	Essential Questions	Performance Tasks
1	**1-LS1** From Molecules to Organism: Structures and Processes **1-LS1-1** Use materials to design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs.	Animal structure and function Animals have external structures that help them meet their needs.	What external structures do animals have? How do they use these structures to meet their needs? What do people and animals need to survive?	1. Students use graphic organizer to identify three different examples of external structure and label functions of those structures. 2. Students illustrate, label, and use note taking to describe the function of the external structure for their chosen animal. Students test different materials that most resemble how bees pollinate plants and decide which ones are most effective that humans could use to address problem of collapsing bee colonies. 3. Create a Zoonooz type magazine featuring different animals. Each student picks an animal and creates an information page illustrating external structures and functions.
2	**LS2.A** Interdependent Relationships in Ecosystems Plants depend on water and light to grow. (2-LS2-1) Plants depend on animals for pollination or to move their seeds around. (2-LS2-2)	Plants and animals depend on their environment to meet their needs. Animals depend on plants and/or each other for survival.	Why is the environment important to plants and animals? What do plants and animals need to survive?	1. Students create a graphic foldable identifying plant needs. 2. Students completed a graphic organizer based on their research of a chosen animal including the name of the animal, using pictures and/or words to show what the animal needs. 3. Create a book based on the organizer.
3	**3-LS1** From Molecules to Organism: Structures and Processes LS1.1B Growth and development of organisms. Plants and animals have unique and diverse life cycles.	Plant and animals depend on their environment to meet their needs. Animals depend on plants and/or each other for survival.	What do plants and animals need to live and survive?	1. Classify several animals into two groups based on what they eat. 2. Using Venn diagram compare and contrast land and water plants. 3. Write a book, illustrating that all animals need food to live and grow and where they get their food from.

Table 1. Continued.

4/5	**NGSS 4.2** All organisms need energy and matter to live and grow. a. *Students know* plants are the primary source of matter and energy entering most food chains. b. *Students know* producers and consumers (herbivores, carnivores, omnivores, and decomposers) are related in food chains and food webs and may compete with each other for resources in an ecosystem.	Producers, consumers and decomposers are related to one another in a food chain.	Why do great white sharks need seaweeds? (How does energy flow amongst organisms?)	1. In teams students create marine food chain/web. 2. Students record in their science notebooks correct order of their food chain. *2. In groups students investigate and research how multiple organisms are related in a food chain. Students receive an envelope with several organisms and make connections between the organisms. They explain their reasoning for the positioning of the organisms in the food chain and their role (consumers, producers, or decomposers). They illustrate the relationship to the other organisms in terms of energy flow on a group poster.
5	**NGSS 5LS2-1** Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment. **RI 4.1/RI.5.10** Read and comprehend informational text. W 4.2 Write informative/ explanatory text to examine a topic and convey ideas and information clearly.	All living organisms need energy.	How do organisms get their energy?	1. Students designed a movie trailer using i*Movie* to illustrate a possible ocean food chain and describe how this chain would be viable a newly discovered planet. The trailer must communicate the relationship between the sun, plants, and other organisms in potential food chains, with emphasis on oceanic plants.

Data Sources and Collection

Multiple data collection methods were used to address the purpose of this study, which was to explore how teachers began the process of rethinking and refining their instructional approach in alignment with the reform standards and to understand the problems and challenges that emerged.

Interviews. Semistructured interviews were conducted with eighteen grade 1–5 teachers. These interviews lasted 25–45 minutes. A pseudonym was assigned to each teacher to ensure confidentiality and anonymity. The interviews investigated teachers' perceptions of: (a) the PD and team planning time, (b) team participation with grade-level colleagues, (c) PBL unit implementation, (d) the effect of a PBL approach on their instructional practices, (e) student teamwork, (f) technology integration in the PBL process, (g) the support of students' learning, and (h) the challenges and benefits in implementing the PBL unit. An external transcription agency transcribed the interviews. The lead author listened to each interview to check quality and correctness of the transcription.

Classroom observations. Given time and resource constraints, we selected two groups of teachers for observation—three fourth and three fifth grade teachers who were implementing the same standard. The purpose of the observations was to collect descriptive data that would supplement and corroborate the interview data. The observers were the authors of this article and three graduate students. The lead author trained the team in the protocol she developed and the team met after each of the first few

observations to review the protocol and calibrate observations and observation techniques. The protocol focused on three main themes: (a) gaining a whole class perspective of the day's lesson and intended outcomes, (b) the nature of teacher dialogue and PBL strategies to engage students, and (c) student teamwork. In addition, the authors observed planning sessions of the fourth and fifth grade teachers during the PD week and two or three other times during the summer school.

Student pre- and post-survey on teamwork. We created a mirrored pre- and post-survey (referred to as either pre-survey or post-survey) asking fourth and fifth grade students' opinions on teamwork. One hundred and eleven students completed both the pre-survey on the first and post-survey on the last day of the summer school. This survey consisted of 11 Likert-scaled questions with responses ranging from "always, most of the time, sometimes, or never." In addition there were two open-ended questions: (a) What is the best thing about teamwork? and (b) What is the hardest thing about teamwork?

Documents. Other sources of data included teacher lesson plans, student work samples of formative assessments, and final products.

Data Analysis

We recorded and transcribed the participants' interviews. We read the transcripts to gain a holistic picture of how teachers worked to implement PBL, the challenges they faced, and their perceptions of benefits. Separately, we analyzed a few transcripts through an open coding approach, allowing for potential categories and concepts to emerge. Then we compared notes to identify common patterns and categories. This iterative process facilitated categorizing and grouping codes together to develop themes. A sample of the codes that emerged from this analysis of data is presented in Table 2. There were high levels of agreement between us and differences were resolved through discussion and consensus.

The findings from the interviews were triangulated with the observations of the grade four and five classrooms. A similar analysis process was followed with the observation notes (Esterberg, 2002; Saldaña, 2009). The observation notes helped to highlight more fully teacher roles and the use of teacher-created materials, group dynamics, and student roles in knowledge construction. To triangulate the data, there was a constant back and forth between coding and comparing the observation results with analysis of the interviews, teacher lesson plans, and students' pre- and post-survey data. The challenges and benefits presented in the findings were reported if supported by both interview and observation data. The student survey data was analyzed using descriptive statistics to measure frequencies, percentages, averages, means, minimum, and maximum values. The findings of the student survey were then juxtaposed to interview and observation data regarding teamwork.

Limits of the Study and Rigor and Trustworthiness

This study has limitations. First, this is a study of only one elementary school in a lower socioeconomic and underserved neighborhood. Second, it was short in duration—three weeks, which is a minimal amount of time to implement a complex new instructional approach. Third, only one set of interviews was conducted and they were generally of short duration (25–45 minutes), which allowed limited time for in-depth probing. However, the multiple sources of data provided convergent evidence to support teachers and students' perspectives.

Member checks and peer debriefing. All teachers received opportunities to review and change their transcripts and none requested any change. A draft copy of the research paper was e-mailed to participants. Authors participated in numerous debriefing sessions to discuss the codes and emerging themes, to check for consistency, and to resolve differences.

Findings and Interpretations

A significant theme that emerged from the data analysis was teachers' enthusiasm for PBL in spite of the challenges they faced as they worked to shift their teaching from teacher-centered to student-centered classrooms. Time and teachers' efforts to integrate technology emerged as significant challenges. Since these two challenges have been well-documented by others (Brinkerhoff & Glazewski, 2004; Hmelo-Silver, 2004; Simons, Klein, & Brush, 2004), we primarily focus the presentation of our findings on teachers' and students' experience and inexperience with PBL in the context of the reform standards and teamwork. Table 3 provides a summary of various data organized by the major components of PBL.

Consistent with previous studies, teachers in this study identified time as a chief challenge to PBL implementation. Seven of 18 teachers commented that the planning time allotted was insufficient to explore all the possibilities of implementing a new teaching pedagogy. One-third of the summer school teachers considered the shortage of time to let the students explore as a critical challenge to student learning. These views expressed in the interviews were confirmed in observations of the grade level planning time. The fourth and fifth grade teachers repeatedly voiced the concern that they did not have time to do all the research they felt necessary to adequately develop their unit (Observation notes, June 27, 2012, July 5, 2012, July 17, 2012).

Table 2. Summary of codes, categories related to two major themes: students' lack of experience with inquiry and teachers' challenge in moving to student-centered instruction.

Teachers' challenge in moving to student-centered instruction	Students' Engagement with inquiry
Category: Inquiry process • Keeping students engaged • Being just one step ahead of students • Expecting students to come up with questions • Lack of complex instructional tasks • Not knowing about appropriate web sites and other resources for student research	**Category: Inquiry process** • Challenges in understanding concepts • Taking some responsibility for own learning / inquiry • Requests and ability to record research results • Enthusiasm for doing research • Writing in their journals
Category: Asked questions • Facilitating learning through probing questions	**Category: Asked questions** • Responding to recall questions Have difficulty developing their own questions
Category: Collaboration • Planning time with other teachers • Focus on end project rather than inquiry • Planning too much • Pair/Share strategies • Lack of experience with teambuilding and teamwork	**Category: Collaboration** • Listening to other team members • Being on the same page with other team members • Being ready to collaborate • **Heterogeneous** grouping • Talking / discussing with teammates Helping teammates (e.g. with *iMovie*)
Category: Letting go • Hard to not tell and let students do the research • Hard not to give students the answers	**Category: Performance tasks** • Tasks not sufficiently complex to require all team members to collaborate to accomplish task
Category: Classroom management • The classroom is too noisy • Knowing students strengths before embarking on inquiry	

In regards to technology, all teachers were observed using the teacher laptop and the document camera to present videos and PowerPoint presentations. They all reported that technology was a valuable addition/tool in their classrooms and saw its benefits as a way to engage students. Nevertheless, 8 of the 18 teachers identified technology as a challenge for them, and expressed their lack of comfort in using computers and incorporating technology in their lessons. Another concern voiced by all teachers was finding appropriate *kid-friendly* Internet sites that provided information in an "easy-and simple" format that English language learners could understand.

Classroom observations of fourth and fifth grade corroborate these interview comments. For example, Nora, during several observations, expressed her discomfort with technology to the researcher and was not observed guiding students in using the iPods or computers for students' research. Tom, who was comfortable, provided additional web-based resources for his students, and his students appeared to be more engaged in their inquiry. Observations of the fifth grade classes indicated that students searched the web using the key phrase "who eats whom" regarding their specific ocean food web animal—and were not encouraged to explore more about various organisms in the food web (Observation notes, July 9, 2012, July 11, 2012).

Teacher Enthusiasm for PBL

Even when teachers struggled with finding time to adequately develop and implement their units, they expressed considerable enthusiasm for PBL and had no difficulty in citing its benefits. Sixteen of 18 teachers reported that their students were more interested in science than they had been during the regular school year, and all indicated students were more engaged. When asked how he felt about moving toward PBL teaching, Kirk exclaimed that teachers are finally "getting back to what schools should be." He added: "As teachers it

Table 3. Summary of data based on major components of PBL.

Components of PBL	Summary of Triangulated Evidence Across Data Sources (Interviews, Observations, Student Survey, and Student Work)
Use of problems as motivation for learning	Interview and observation notes indicated high levels of student engagement with the problem presented. Teachers expressed in their interviews how they found students to be more engaged in problems presented and took greater interest in the content.
Use of problems as medium for problem-solving	Samples of student work from every class validated that students completed the final performance task by making and producing tri-folds, graphic organizers, food web posters, and iMovies for their end of the summer school presentations. Observations of fourth and fifth grade classes and the final tasks revealed a "real and relevant problem" had not been sufficiently formulated by the teachers.
Student-centered learning (i.e., learning occurs in a social setting, with meaning negotiated in a collaborative team setting)	Interviews revealed both challenges and benefits of teamwork. Observations indicated and student survey corroborated that it was difficult for students placed in teams of four to start working together in the first week, since they had little experience and little instruction on how to work together. The post-survey data indicated that working together was seen as the best thing about teamwork. Students valued it because of the opportunity to help each other. This view was a shift from pre-survey, in which students said they valued teamwork so they could get help. Observations indicated that opportunities to create meaning were minimal because students had minimal resources, engaged in constrained research, and were given simple sentence frames for responding to teacher prompts.
Learning happens in small student groups	Observations indicated that both teacher and students received opportunities to participate in small groups. Teachers had multiple opportunities to collaborate and interact with their grade-level colleagues using various resources and technology to plan their unit. Teacher interviews, observation notes, and student post-survey revealed that students worked in heterogeneous groups with other students.
Learning happens in self-directed quests	Teachers referred to students' construction of knowledge throughout their interviews. Examples fourth and fifth grade students in teams of four observed and student work indicated they constructed a food chain from four organisms. Students observed identifying "who eats whom," in the food chain. In the fifth grade each team's food chain became a part of a class food web. Observations of fourth and fifth grade documented that often tasks required students to work by themselves even though they were in groups or the task was not sufficiently complex to require every student to have a role.
Teacher as facilitator and activator	Teachers interacted with whole class, with small groups, or with individual students. Teachers used document cameras and projector to show movies or PowerPoints to whole class. Teacher selected Brain Pop videos on iPods in place of textbooks and brought in preserved specimens of sea life for students' observations. Fifth grade teachers provided them with support in using iMovie program to create a trailer for the final project. Teachers also facilitated students' presentation of their final performance tasks to the parents, other students, and a team of local community researchers from a nearby university.

is our job to design curriculum that is interesting, engaging, and fun."

Claire, who reported using teacher-led instruction for over 13 years, believed: "Students, especially English learners, learn better through PBL." She said, "Students need to get excited about their learning and PBL just does that, plus it helps them to remember." Teachers referred to PBL as the "best way for students" and as "student-centered learning" because students are able to really take ownership of their learning. Gabby stated that with PBL and students' engagement in learning, "No child *is* left behind." Heidi said that after years of telling her friends about her doubts as to whether teaching was her calling, she had to admit that after teaching this summer school it was ". . . like I found my mojo again." To explain this further she acknowledged that time for change has come: "Direct instruction had its time and place . . . now we want more from kids. We want them to be creative thinkers . . . to be part of a global solution that's outside the box."

Teachers' and Students' Experience and Inexperience with PBL

The data suggest that both teachers and students found it difficult to take on new roles as Ertmer and Simons (2006) say they must. Ruth, Ida, Lori, and Claire expressed a belief that students have grown accustomed to getting all their answers from teachers, and they do not know how to explore *how* and *why* questions. Lori said: "They're really used to just taking stuff and not really having to think about it, but spitting it back out, like filling in the bubble. Now all of a sudden you're asking them to think for themselves and then explain their thinking. They haven't been asked to explain their thinking before."

A related issue was teachers' perceptions that students could not express their thoughts in writing or orally. Teachers attributed this expressive weakness to students' lack of being in charge of their own learning and in developing their own questions. Ruth related this problem to the historical and contextual traditions of teachers providing students with beginning prompts and sentences to get them started, with students only having to fill in the blanks.

Classroom observations confirmed that teachers continued to provide students with many sentence stems that often required them to respond with one or two words. In addition, in the fourth and fifth grade classes, students had few opportunities to conduct research or read extensively about different organisms in the ocean food web they were required to construct; therefore, they had little to write about (Observation notes, July 17, 2012, July 18, 2012). Students also confirmed that writing was a challenge. In both the pre- and post-survey when students were asked about what they expected to be the hardest thing about working in teams, "writing" was the most frequently mentioned item. Without opportunities for in-depth exploration, students seemed greatly limited in their ability to create meaning—a crucial component of PBL.

Teachers struggled with letting go. In the interviews teachers repeatedly mentioned how difficult it was for them to "let go" and give students permission to explore and do their own research. Loren argued the hardest thing was:

> being able to let go . . . as a teacher and let the students explore, because we're so used to having exactly what we want the students to know and understand, but giving them the teacher role on their own, so that they can facilitate their own learning and . . . to figure out the science concepts through their own observations and not just through mine. I had to let go a little bit, which is out of my comfort zone, at first, but that became very beneficial for their learning.

Suzy added, "Being able to let go and to have your students go through the PBL process is a learning process for teachers, as well."

Shelly regarded using PBL as "a change in mindset or a paradigm shift" for her. She mentioned that during the regular school year, her classes are teacher-centered "because that's what I was required to do. And . . . a lot of schools are in the same situation where you're doing direct instruction that's mandated." Therefore, switching to PBL is "a shift in thinking for both [teacher and students] because the students were used to having information given to them." Shelly's perception regarding the instructional mandates during the regular year were reported by 11 of 18 teachers during the interviews. Lori identified PBL as an important part of reform standards and said that although a PBL environment is "hard" to create, it is "great" for students.

Classroom observation confirmed how hard it was for teachers to let go of control of their classrooms. The fourth grade teachers struggled with student team searches and frequently found it difficult to not intervene. For instance, Nora was observed stopping a team of students to suggest how to divide the research tasks (Observation notes, July 10, 2012, July 17, 2012). In contrast, Kathy was observed being able to actively engage students both as a whole class and in small groups. For example, she repeated students' questions back to them and encouraged them to rethink what they were asking. Also, she redirected students to discuss their issues with their group before coming to her.

Teamwork

Teamwork has been recognized as one of the major tenets of PBL (Barrows, 1996). Teachers from this school received professional development on Kagan (1994) Cooperative Learning Structures as a way to increase student engagement and collaboration prior to the start of summer school. Teachers were observed using the pair-share, round table, think-write-round-robin, and numbered-heads together strategies fairly frequently. Nevertheless, teachers expressed in the interviews that implementing teamwork and establishing effective teams was not easy even when they recognized the benefits.

Three of the five first grade teachers found it particularly challenging to implement cooperative group work. In the upper grades the problem cited by teachers revolved more around ensuring everyone on the team had a role and contributed to the work. Observations of Tom's class suggested that his students were more actively engaged in research through using the Edmodo website he crafted, thus creating a link between technology and student collaboration. Kathy also found ways to have students work as a team by scaffolding the work for them and ensuring everyone had an organism to investigate. Then collectively the team decided how their organism fit into the food chain.

However, two other fourth and two of the fifth grade teachers did not have the same success. Observations in

these classes indicated that each student in a team did not have a meaningful research task. For example, each team was to create a food chain based on the cards of organisms they were given. Instead of requiring each member to research one of the organisms and then pool individual knowledge to create the food chain, usually one or two team members took the cards and made the chain. These observations confirmed the teachers' comments that one or two students were doing all the work. The failure to give each student a task undermined an opportunity to build both individual and collective responsibility for the task. Previous research has shown that without an instructional design (e.g., complex instruction) that involves everyone on a team, student teamwork is often ineffective (Cohen, 1994). Furthermore, it was observed that on many occasions grade four or five teachers posed a probing question to the class, similar to instructional practices previously used, and only a few students responded to the question. Teachers were not observed inviting teams to discuss the question and come up with a team response.

Pre- and post-survey results on teamwork also showed that when students were asked "When I am in a team, I help my team to gather information and useful ideas to complete our work," 51 (or 49%) out of 105 students selected *always* on the pre-survey compared to 49 (or 44%) of 111 who selected *always* on the post-survey. For the question, "When I am in a team, I do my fair share," on the pre-survey 68 (or 65%) out of 105 selected *always* and 42 (or 53%) out of 111 chose *always* on the post-survey. Neither of these changes proved noteworthy, but may be important as they reflect that teamwork may not have provided sufficient complexity to engage all students. In response to the open-ended question on the student teamwork survey, students were asked about what is hardest in working on a team. Many students (66 of 111) wrote "teamwork" or expressed a related challenge such as "listening to others," "talking with the group," "explaining to the team," "dividing up the job," and "helping others." On the pre-teamwork survey, only 37 (out of 105) students in response to the same question indicated that "teamwork" would be the hardest thing. This finding suggests that the more students worked in teams over the summer, the more they became aware of the challenges of teamwork.

The benefits of teamwork. Although teachers and students struggled with implementing teamwork, both teachers and students indicated there were benefits. During observation (July 11, 2012), Nora commented to the researcher that the idea of researching independently and bringing it back to the team has been "really constructive . . . it's a model that . . . they're not used to." She further emphasized that "once they [students] realize that . . . others are interested in what they're thinking, they can have 'ah-has'. Then, the level of work increases dramatically in quality." Suzy pointed to the value in students realizing that they needed to be in charge of their own learning. She said, "In their groups, they had to think about everything, come up with their own questions . . . do their own research, and talk about their findings." Teachers perceived that collaborative small groups gave students a chance to internalize their learning and to retain it longer.

Kathy commented that through teamwork students learned how to work in a team and how to use each other's strengths to complete the assigned task: "They learned how to divide the work . . . how to help each other. Because they had to rely on each other to complete the task, and all students were held accountable for knowing the answer." This was also observed in fourth grade classes where teams had to present collaboratively and each team member was required to participate (Observation notes, July 18, 2012).

The student teamwork survey also confirms teachers' perceptions of the value of teamwork. Comparing the "always" responses of the pre- and post-survey, nine of the 11 questions that asked about teamwork showed a positive trend with a higher percentage of students indicating "always" on the post-test. This positive trend from the pre-survey should not be over interpreted, but does suggest that students felt they could ask questions, which had been a focus of the PD, and that they could get help from their teammates. The survey asked students to complete the sentence, "The best thing about working in a team is . . ." On the pre-survey 15 students indicated working together was the best thing; 25 students gave the same response on the post-survey. Getting help from teammates remained constant and high on both pre- and post-survey with 35 responses.

Discussion and Conclusion

This study adds to the limited empirical literature on how a school in a lower socioeconomic and underserved neighborhood is striving to shift its instructional approaches to be more in alignment with reform standards by implementing a teacher-designed PBL unit. Although its experience is unique, our findings may offer insights useful for policy and practice as other schools work to shift their instructional practices. An important finding was that the teachers welcomed the idea of PBL and were committed to experimenting with how to shift their teaching from a scripted curriculum to one where students were engaged in PBL. What still needs to be explored is how to help teachers make this shift, especially when high-stakes testing is still a powerful force. In our interpretation of the data, teachers in this study recognized the tensions between the way standardized testing has pushed them to teach and the value of more actively engaging students (Mahiri, 2005; Rubin & Kazanjian, 2011; Savery, 2006). Three insights emerged from this study: (a)

changing teacher roles, (b) fostering teacher collaboration, and (c) developing a relevant problem.

Changing Teacher Roles

This study confirmed findings of Ertmer and Simons (2006) that it is difficult for teachers to shift from teacher-led instruction to student-centered learning. The PD helped teachers to explore their role and relationship to students in a PBL classroom by learning strategies for students to work in teams. Nevertheless, our findings indicate teachers struggled to let go of their control in the classroom and let the students experiment in their teams. One possible explanation is the lack of experience in having students work in teams during the regular school year because of the scripted nature of the language arts and math programs in this school. However, at the end of the study teachers saw the benefits of student teamwork.

Results from this study suggest that students also value teamwork because they were helping each other in their work and were learning from other team members. However, the post-survey results indicated that students perceived they did not have equal roles and responsibilities for the work. In addition, observations suggested that teachers constrained the teamwork and did not have sufficient strategies to help the student-teams delve deeply into the science content knowledge. We concur with McCaughan (2013) who states: "To facilitate small group learning well requires a shift in behaviors for most teachers . . . from disseminating expertise and knowledge through lecturers to self-restraint of expertise, and the utilization of communication techniques, actions, and strategies that promote self-directed learning" (p. 21).

Fostering Teacher Collaboration

The research literature focuses primarily on student collaboration as a critical role in the implementation of PBL (Barell, 2010; Ertmer & Simons, 2006). This study highlighted the importance of time for teacher collaboration if teachers are to design a PBL NGSS-aligned unit and implement it in their classrooms. This significance was confirmed when the first grade team collectively realized the lessons they planned were neither engaging their students nor developing their observational skills. As noted, they revamped their lessons and brought in live animals for students to touch, feel, and observe.

This study confirmed Grant's (2002) findings that teacher collaborative planning helped them construct new knowledge of their practice and define new roles as they shared resources within and across grade levels. One area of knowledge that needs to be developed is how to design instruction in alignment with the new reform standards assessments. Experimenting with PBL gave teachers in this case study an opportunity to gain insights into classroom learning experiences that might best support students to be more successful on the new assessments that require them to analyze problems and explain their reasoning (e.g., the Smarter Balanced and Partnership for Assessment of Readiness for College and Careers [PARCC]). Teachers equipped with PBL knowledge and skills may be better able to help students develop their problem-solving and critical-thinking skills. As schools move to implement reform standards, the value of this collaborative time cannot be underestimated.

Developing A Relevant Problem

A significant component of PBL is that problems are used to motivate students' learning and as a medium for problem solving (Barrows, 1996). Findings from this study suggest there may be a need to help teachers connect NGSS standards to students' lives and to consider student background knowledge in unit development and problem formulation (Moll, Amanti, Neff, & González, 1992). The decision to focus on the ocean food web with the fourth and fifth grade students proved problematic since so few of students had ever been to the beach. The students were of course familiar with *Finding Nemo* and fascinated by sharks. However, the unit needed to start with a local connection. These students, who knew that mountain lions had been spotted at a nearby school, may have connected more readily with exploring the disrupted food web of the mountain lion and understood food webs at a deeper level if teachers had first tapped into this local knowledge. The science of ocean food webs then would have moved beyond small fish being eaten by larger fish.

As Barton (1998) stressed, the role of science classes is to help students fit "exploration of the natural world, questioning, and critique into their [students'] experiences" (p. 389). The work of Moll and colleagues (1992) on tapping into the funds of knowledge of students and families also is relevant to the design of strong PBL units. Teachers who have had to primarily follow a textbook-based curriculum may inadvertently disregard the inherent knowledge their students bring to their classroom. Working with diverse learners, teachers must draw upon students' background knowledge to be able to build from what students already know and construct bridges to what must be learned (NGSS).

Riojas-Cortez, Huerta, Bustos Flores, Pérez, and Riojas Clark (2008) found they could deepen students' understanding of science concepts by drawing on cultural practices such as gardening, cooking, and home remedies. A key component of PBL is engaging students in real and relevant problem solving connected to their lives. A challenge for teachers is to take relatively abstract NGSS standards and identify real community problems for students to address. Researcher-practitioners who tap into a community's funds of knowledge through home visits and community walkabouts illustrate a

strategy for teachers to use in identifying how to design powerful PBL units that take into account student and community funds of knowledge (González, Moll, & Amanti, 1995; Moll et al., 1992; Riojas-Cortez et al., 2008; Street, 2005; Sugarman, 2010).

Similarly, Barton (1998), who explored what it means to teach science to all children from the standpoint of urban homeless children, has argued that all students learn science in and out of school from family, friends, and the media. Bringing in the immediate community and its problems for students to study connects science to students' lives. It can affect "how children perceive science and the kinds of interactions they believe they can have—or that they want to have—with that science" (Barton, 1998, p. 382). When the first grade teachers in our study brought in live animals instead of preserved sea life specimens, they found their students more engaged. The short time frame for unit planning and the newness of designing science units limited the opportunity for teachers in this study to design units that drew on the community's funds of knowledge.

Implications for Practice and Future Research

It is evident that the shift to PBL in the era of reform standards will not be easy because teachers have learned to teach with text-driven approaches and students have learned to be passive recipients of knowledge (Hung, 2011). This study has three implications. First, it shows the importance of teacher collaboration in developing NGSS-aligned PBL units. However, it also is clear that teachers must be given more time and space to do this work. One possible solution to the time conundrum would be to have teachers work in collaboration to adapt previously developed units that now need to be aligned to the reform standards.

Second, fully understanding the social nature of learning combined with the practical knowledge of how to build strong student-teams who are able to tackle complex, messy problems (Cohen, 1994; Kagan, 1994; Slavin, 1995) would significantly facilitate the implementation of PBL. Knowing how to work as part of a team is a skill that must be taught and learned by students. The teachers in this study were given some essential strategies but insufficient instruction in how to design complex instruction that would engage the whole team. Further research is needed to explore how students learn to work in teams.

Third, PBL requires teachers to focus on depth of instruction, with an increase in student exploration. This means teachers, especially those teaching second language learners, need a wealth of diverse, appropriate language-level resources and connect the content to the lives and the funds of knowledge of their learners (Moll et al., 1992). Helping teachers to begin PBL units with students' questions related to standards can be a step in the direction of making content relevant and more connected to student lives. This suggests that a final area for further research is how to teach students to ask their own questions related to standards and set learning goals, and how to engage them in their search to find answers.

Notes

1. The authors wish to thank the turnaround coach for the school and the teachers who make this research possible. Their enthusiasm and dedication to enhancing the learning of their students was wonderful to observe. In addition the authors wish to thank student researchers who assisted in observing the fourth and fifth grade classrooms. The authors also are very grateful for the thoughtful and helpful comments from three anonymous reviewers. Finally, **t**he authors wish to thank the teachers who graciously and willingly opened their classrooms for observations and shared so eloquently their struggles and the benefits they saw from engaging in this bold experiment of PBL.

2. This is despite the district's allocation of more time to reading and math and cutting out of the time for other subjects. The district GATE/Title I coordinator mentioned in an interview with the Center on Education Policy that "there is 'no time in the day' for science and social studies" (McMurrer, 2007, p. 9).

3. The Turnaround model selected by this school required the district to select a new administrator who in turn replaced over 2/3 of the former classroom teachers. All teachers in the district could apply for and all, including current teachers at the school, were interviewed for these positions.

4. In the summer of 2013, the teachers again developed their own units based on standards and continued in their journey to implement PBL. In the spring of 2014, after the grant funding had ended and standardized testing was finished, every grade level once again decided to develop and implement an even longer PBL unit during the regular school year.

References

Ansberry, K. R., & Morgan, E. R. (2007). *More picture-perfect science lessons: Using children's books to guide inquiry, K-4*. Arlington, VA: NSTA.

Ansberry, K. R., & Morgan, E. R. (2005). *Picture-perfect science lessons: Using children's books to guide inquiry, Grades 3–6.* Arlington, VA: NSTA.

Aronson, E. N., Blaney, N., Stephan, C., Sikes, J., & Snapp, M. (1978). *The jigsaw classroom*. Beverly Hills, CA: Sage Publications.

Azer, S. A. (2009). Problem-based learning in the fifth, sixth, and seventh grades: Assessment of students' perceptions. *Teaching and Teacher Education, 25,* 1033–1042. http://dx.doi.org/10.1016/j.tate.2009.03.023

Barell, J. (2010). Problem-based learning: The foundation for 21st century skills. In J. Belanca & R. Brandt (Eds.). *21st century skills: Rethinking how students learn* (pp. 175–201). Bloomington, IN: Solution Tree Press.

Barrows, H. S. (1996). *Problem-based learning in medicine and beyond: A brief overview.* In L. Wilkerson & H. Gilselaers (Eds.). *Bringing problem-based learning to higher education: Theory and practice.* San Francisco, CA: Jossey-Bass. http://dx.doi.org/10.1002/tl.37219966804

Barton, A. C. (1998). Teaching science with homeless children: Pedagogy, representation, and identity. *Journal of Research in Science Teaching, 35*(4), 379–394. http://dx.doi.org/10.1002/(SICI)1098-2736(199804)35:4<379::AID-TEA8>3.0.CO;2-N

Bransford, J. D., Brown, A. L., & Cocking, R. R. (Eds.). (2000). *How people learn*. Washington, DC: National Academies Press.

Bransford, J. D., Vye, N., Stevens, R., Kuhl, P., Schwartz, D., Bell, P., . . . Sabelli, N. (2006). Learning theories and education: Toward a decade of synergy. In P. A. Alexander & P. H. Winne (Eds.). *Handbook of educational psychology* (2nd ed.) (pp. 209–244). Mahwah, NJ: Lawrence Erlbaum Associates.

Brinkerhoff, J., & Glazewski, K. (2004). Support of expert and novice teachers within a technology enhanced problem-based learning unit: A case study. *Interdisciplinary Journal of Learning Technology, 1,* 219–230. http://dx.doi.org/10.1504/IJLT.2004.004877

Burke, P. H. (2011). *Inquiry designs for deep learning*. Workshop conducted El Cajon, CA.

Cohen, E. G. (1994). *Designing groupwork* (2nd ed.). New York: Teacher College Press.

Cuevas, P., Lee, O., Hart, J., & Deaktor, R. (2005). Improving science inquiry with elementary students of diverse backgrounds. *Journal of Research in Science Teaching*, *42*(3), 337–357. http://dx.doi.org/10.1002/tea.20053

De Corte, E. (2010). Historical development in the understanding of learning. In H. Dumont, D. Istance, & F. Benavides (Eds.). *The nature of learning: Using research to inspire practice* (pp. 35–67). Paris: Organization for Economic Co-operation and Development. http://dx.doi.org/10.1787/9789264086487-4-en

Delisle, R. (1997). *How to use problem-based learning in the classroom*. Alexandria, VA: ASCD.

Dochy, F., Segers, M., Van Den Bossche, P., & Gijbels, D. (2003). Effects of problem-based learning: A meta-analysis. *Learning and Instruction*, *13*, 533-568. http://dx.doi.org/10.1016/S0959-4752(02)00025-7

Dotson, J. (2001). Cooperative learning structures can increase student achievement. *Kagan Online Magazine*. Retrieved from www.Kaganonline.com

Duch, B. J., Groh, S. E., & Allen, D. E. (2001). Why problem-based learning? A case study of institutional change in undergraduate education. In B. Duch, S. Groh, & D. Allen (Eds.). *The power of problem-based learning*. (pp. 3–11). Sterling, VA: Stylus.

Ertmer, P. A., & Simons, K. D. (2006). Jumping the PBL implementation hurdle: Supporting the efforts of K-12 teachers. *Interdisciplinary Journal of Problem-based Learning*, *1*(1), 40–54. http://dx.doi.org/10.7771/1541-5015.1005

Esterberg, K. G. (2002). *Qualitative methods in social research*. Boston: McGraw-Hill.

Fowler, A. (1995). How to build effective teams. *People Management*, *1*(4), 40–41.

Fullan, M. (2013). *Stratosphere: Integrating technology, pedagogy, and change knowledge*. Don Mills, ON: Pearson.

Fulwiler, B. R. (2007). *Writing in science: How to scaffold instruction to support learning*. Portsmouth, NH: Heinemann.

Gallagher, S. A., & Gallagher, J. J. (2013). Using problem-based learning to explore unseen academic potential. *Interdisciplinary Journal of Problem-based Learning, 7*(1), 111–131. http://dx.doi.org/10.7771/1541-5015.1322

Gentry, J. W. (1980). Group size and attitudes toward the simulation experience. *Simulation & Games, 11i*(4), 451–459. http://dx.doi.org/10.1177/104687818001100405

González, N., Moll, L., & Amanti, C. (1995). Introduction: Theorizing practices. In N. González, L. Moll, & C. Amanti (Eds.), *Funds of knowledge: Theorizing practices in households, communities, and classrooms* (pp. 1–24). New York: Routledge.

Grant, M. M. (2002). Getting a grip on project-based learning: Theory, cases and recommendations. *Meridian: A Middle School Computer Technologies Journal, 5*(1). Retrieved from http://www.ncsu.edu/meridian/win2002/514/

Haberyan, A. (2007). Team-based learning in an industrial psychology course. *North American Journal of Psychology*, *9*(1), 143–152.

Hall, L. (1989). The effect of cooperative learning on achievement: A meta-analysis. *Dissertation Abstract International, 50,* 343A.

Hattie, J. (2009). *Visible learning: A synthesis of over 800 meta-analyses relating to achievement*. New York: Routledge.

Hernandez, S. A. (2002). Team learning in a marketing principles course: Cooperative structures that facilitate active learning and higher level thinking. *Journal of Marketing Education, 24,* 73–85. http://dx.doi.org/10.1177/0273475302241009

Heusman, S., & Moenich, D. (2003). Achievement still on the rise at Catalina Ventura School. *Kagan Online Magazine.* Retrieved from www.Kaganonline.com

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn? *Educational Psychology Review, 16*(3), 235–266. http://dx.doi.org/10.1023/B:EDPR.0000034022.16470.f3

Hung, W. (2011). Theory to reality: A few issues in implementing problem-based learning. *Educational Technology Research and Development, 59*(4), 529–552. http://dx.doi.org/10.1007/s11423-011-9198-1

Ingham, A. G., Levinger, G., Graves, J., & Peckham, V. (1974). The Ringelman effect: Studies of group size and group performance. *Journal of Experimental Social Psychology Psychology, 10,* 371–384. http://dx.doi.org/10.1016/0022-1031(74)90033-X

Johnson, D. W., & Johnson, R. T. (1989). *Cooperation and competition: Theory and research.* Edina, MN: Interaction Books.

Johnson, C. C., Zhang, D., & Kahle, J. B. (2012). Effective science instruction: Impact on high-stakes assessment performance. *Online Research in Middle Level Education (RMLE), 35*(9), 1–14.

Kagan, S. (1994). *Kagan cooperative learning* (2nd ed.). San Clemente, CA: Kagan Publishing.

Lynch, S., Kuipers, J., Pyke, C., & Szesze, M. (2005). Examining the effects of a highly rated science curriculum unit on diverse students: Results from a planning grant. *Journal of Research in Science Teaching, 42,* 921–946. http://dx.doi.org/10.1002/tea.20080

Mahiri, K. (2005). From 3 R's to 3 C's: Corporate curriculum and culture in public schools. *Social Justice, 32*(3), 72-88.

Marzano, R. J., Pickering, D. J., & Pollock, J. E. (2001). *Classroom instruction that works: Research-based strategies for increasing student achievement*. Alexandria, VA: Association for Supervision and Curriculum Development.

McCaughan, K. (2013). Barrow's integration of cognitive and clinical psychology in PBL tutors guidelines. *Interdisciplinary Journal of Problem-based Learning, 7*(1), 11–23. http://dx.doi.org/10.7771/1541-5015.1318

McMurrer, J. (2007). *Choices, changes, and challenges: Curriculum and instruction in the NCLB era.* Washington, DC: Center on Education Policy.

Michaelsen, L. K., & Knight, A. B., & Fink, L. D. (Eds.). (2004). *Team-based learning*. Sterling, VA: Stylus.

Moll, L. C., Amanti, C., Neff, D., & González, N. (1992). Funds of knowledge for teaching: Using a qualitative approach to connect homes and classrooms. *Theory into Practice, 31*(2), 132–141. http://dx.doi.org/10.1080/00405849209543534

Neo, M., & Neo, T. K. (2009). Engaging students in multimedia-mediated constructivist learning –students' perceptions. *Educational Technology and Society*, *12*(2), 254–266.

Next Generation Science Standards. (n.d.). Retrieved from http://www.nextgenscience.org/next-generation-science-standards

Ogle, D. (1986). K-W-L: A teaching model that develops active reading of expository text. *The Reading Teacher, 39,* 563–570. http://dx.doi.org/10.1598/RT.39.6.11

Park, S. H., & Ertmer, P. A. (2007). Impact of problem-based learning (PBL) on teachers' beliefs regarding technology use. *Journal of Research on Technology in Education, 40*(2), 247–267. http://dx.doi.org/10.1080/15391523.2007.10782507

Prince, M. (2004). Does active learning work? A review of the research. *Journal of Engineering Education, 93*(3), 223–231. http://dx.doi.org/10.1002/j.2168-9830.2004.tb00809.x

Riojas-Cortez, M., Huerta, M. E., Bustos Flores, B., Pérez, B., & Riojas Clark, E. (2008). Using cultural tools to develop scientific literacy of young Mexican American preschoolers. *Early Child Development and Cares, 178*(5), 527–536. http://dx.doi.org/10.1080/03004430600851223

Rubin, D. I., Kazanjian, C. J. (2011). "Just Another Brick in the Wall": Standardization and the devaluing of education. *Journal of Curriculum and Instruction, 5*(2), 94–108. http://dx.doi.org/10.3776/joci.2011.v5n2p94-108

Saldaña, J. (2009). *The coding manual for qualitative researchers*. Thousand Oaks, CA: Sage Publications.

Savery, J. S. (2006). Overview of PBL: Definitions and distinctions. *Interdisciplinary Journal of Problem-based Learning, 1*(1), 9–20. http://dx.doi.org/10.7771/1541-5015.1002

Savery, J., & Duffy, T. (1995). Problem based learning. An instructional model and its constructionist framework. In B. Wilson (Ed.). *Constructivist learning environments: Case studies in instructional design* (pp. 135–148). New Jersey: Educational Technology Publications.

Slavin, R. E. (1995). *Cooperative learning: Theory, research, and practice* (2nd ed.). Boston: Allyn and Bacon.

Simons, K. D., Klein, J. D., & Brush, T. R. (2004). Instructional strategies utilized during the implementation of hypermedia, problem-based learning environment: A case study. *Journal of Interactive Learning Research, 15,* 213–233.

Street, C. (2005). Funds of knowledge at work in the writing classroom. *Multicultural Education, 13*(2), 22–25.

Sugarman, S. (2010). Seeing past the fences: Finding funds of knowledge for ethical teaching. *The New Educator, 6,* 96–117. http://dx.doi.org/10.1080/1547688X.2010.10399592

Tamim, S. R., & Grant, M. M. (2013). Definitions and uses: Case study of teachers implementing project-based learning. *Interdisciplinary Journal of Problem-based Learning, 7*(2). http://dx.doi.org/10.7771/1541-5015.1323http://dx.doi.org/10.7771/1541-5015.1323

Yin, R. K. (2003). *Case study research.* Thousand Oaks, CA: Sage.

Ziegler, S. (1981). The effectiveness of cooperative learning teams for increasing cross-ethnic friendship: Additional evidence. *Human Organization, 44,* 264–268. http://dx.doi.org/10.17730/humo.40.3.0m0q1143l43r4x44

Nahid Nariman is the director of research of the Transformative Inquiry Designs for Effective Schools and Systems (TIDES), a nonprofit educational organization located in San Diego. Her research interests include the use of instructional scaffolding and strategies of PBL, particularly for teaching science, online teaching and learning, and technology integration. Correspondence concerning this article should be addressed to Nahid Nariman at the Transformative Inquiry Design for Effective Schools and Systems (TIDES), nahid@tideseducation.org.

Janet Chrispeels is professor emeritus at the University California, San Diego, and currently serves as the California director of TIDES.