How Loud Is too Loud?
Project-based Inquiry as a Model for Teaching, Learning, and Assessing Science

Regina Toolin and Beth White

Abstract
Our nation's teachers and students benefit when STEM content and research skills are grounded in Project Based Inquiry (PBI)—an approach to teaching science that focuses on authentic problem solving and turns students into citizen scientists by bringing relevance and meaning to the classroom and beyond. Research has shown that educators exposed to PBI principles through professional development opportunities are likely to successfully implement inquiry-based practice in their science classrooms. This paper highlights a PBI-focused professional development workshop presented at the 2012 Midwest Noyce Regional Conference in Indianapolis. It summarizes the main tenants and current literature on PBI as it relates to teacher professional development and student learning, presents a PBI curriculum template for instructors, and discusses common challenges and strategies for optimizing project-based learning principles and practices in science classrooms today.

Keywords
Project-based inquiry (PBI), project-based learning (PBL), STEM, social justice, standards-based learning, collaboration, problem solving, citizen scientists, science literacy, social action, advocacy.

INTRODUCTION

Students recognize the local reporter talking with their instructor as they file into their 9th grade physical science classroom. Class begins with an official introduction of this reporter who has come with one purpose: to ask the 9th graders to help study a local science dilemma that involves sound, geography, and equity in a neighborhood adjacent to a busy international airport.

The reporter presents the pressing challenge to the class via a Public Radio broadcast about a Federal Aviation Administration (FAA) funded program that is buying up and demolishing a whole street of one-story homes in the "unbearable" noise region of the airport. While residents from approximately 120 of these homes have willingly moved, there are some who are accustomed to the noise and do not want to relocate.

A student volunteers to write notes on the Smart Board as the reporter fields questions from the class: How are noise levels measured? What agency is responsible for collecting this data? Was there a similar study conducted that we could replicate? How did the noise map get drawn? Who has been asked to relocate? What are their personal stories? If the mayor of the city lived on this street would this issue be different?

What would it be like if our nation's science classrooms were transformed into investigative labs where students generate their own driving questions and use knowledge and research skills to solve real-world problems that positively impact society such as the one presented in the above vignette? This vision of a learner-centered classroom is known to many in educational circles as project based inquiry (PBI), an approach to teaching science that focuses on authentic problem solving and turns students into citizen scientists by bringing relevance and meaning to the classroom and beyond. With philosophical underpinnings rooted in Dewey, Vygotsky, Piaget, and Frere, PBI allows students to work alongside instructors and experts in the field to build knowledge through personalized, rich experiences.

These ideas and others were explored in an interactive, inquiry-based workshop called "Project-based Inquiry as a Model for Teaching, Learning, and Assessing Science in the Grade 7-12 Classroom" presented at the 2012 Midwest Noyce Regional Conference. A critical and creative project-based atmosphere that portrayed true-to-life vignettes about the airport neighborhood demolition was modeled so that participants could experience PBI first-hand. Throughout the workshop, opportunities and scaffolding were provided so that the audience could construct meaning about the dilemmas facing the FAA and local citizens from a variety of standpoints. The attendees, consisting of pre-service science teachers and teacher-educators, were enthusiastic to learn about the underpinnings of PBI and how they could integrate this approach into their own teaching practices.

This paper begins with a working definition of PBI and a review of current literature as it relates to teacher professional development and student learning in the project-based environment. A PBI curriculum design template is presented that provides a framework for instructors to explore science and society issues, pose relevant and meaningful questions for inquiry, and transform their classrooms into "think tanks" that investigate important, local dilemmas with the goals of science literacy, social advocacy, and action. We conclude by discussing common challenges and strategies for optimizing project based learning (PBL) principles in science classrooms today.

PRINCIPLES OF PROJECT-BASED INQUIRY

Project-based inquiry is a comprehensive approach to classroom teaching and learning that is designed to engage students in the investigation of authentic problems over an extended period of time. In the PBI classroom "students pursue solutions to nontrivial problems by asking and refining questions, debating ideas, making predictions, designing plans and/or experiments, collecting and analyzing data, drawing conclusions, communicating their ideas and findings to others, asking new questions, and creating artifacts" (Blumenfeld et al., 1991, p. 371). Science teachers who utilize PBI capitalize on finding challenging projects that are collaborative, cooperative, and interdisciplinary in nature. Blumenfeld et al. (1991) describe two essential elements of inquiry science, both of which require a question or problem that serves to organize and drive activities; and these activities result in a series of artifacts, or products, that culminate in a final product that addresses the driving question. Students [and teachers] can be responsible for the creation of both the question and the activities, as well as the nature of the artifacts (p. 371).

PBI requires a commitment to iterative, incremental learning that leaves room for students to experience continual improvement, build knowledge, and respond to relevant and meaningful issues and questions over an extended time frame. Quality PBI science curricula integrates educational goals based on state or national standards in a way that allows students to work autonomously and build on prior knowledge, think critically, and get exposure to a wide cross-section of issues and science content.

PROJECT-BASED INQUIRY AND STUDENT LEARNING

Current reform efforts in STEM literacy promote a pedagogical shift that de-emphasizes direct-instruction in favor of an approach that "make[s] science learning meaningful and more focused on learning science by doing science [author emphasis]" (Krajcik, McNeill, & Reiser, 2008, p. 3). National STEM associations (e.g. American Association for the Advancement of Science, National Council of Teachers of Mathematics, National Research Council and National Science Foundation) have a vested interest in understanding and promoting instructional approaches that "emphasize the connection of knowledge to the contexts of its application" (Barron et al., 1998, p. 272). This review of the literature identifies a number of important themes related to PBI and student learning; particularly the way in which PBI prepares students for 21st century careers and challenges.

Researchers have consistently found that inquiry-based classrooms provide deeper, more meaningful learning experiences with higher instances of motivation, especially when it comes to traditionally underserved students (Blumenfeld et al., 1991; Cuevas, Lee, Hart, & Deaktor, 2005; Geier et al., 2008; Kahle, Meece, & Scantlebury, 2000; Krajcik, McNeill, & Reiser, 2008). Classroom atmospheres that rely on "constant teacher direction and passive student compliance lead to teacher "burn-out" as well as to student resistance to meaningful learning" (Kahle et al., 2000, p. 1021). This has been particularly acute for students from underserved schools (Brownstein & Destino, 1994; Griffard & Wandersee, 1998; Kahle et al., 2000; Teel, Debruin-Parecki, & Covington, 1998). Kahle (2000) found that "African-American students' attitudes about and/or perceptions of science are positively influenced by inquiry-oriented teaching strategies that involve interactive, stimulating laboratory experiences in a noncompetitive environment" (p. 1022).

Research suggests that PBI prepares students for 21st century careers (Cuevas et al., 2005). Embedded in the PBI design is an opportunity for students to "reflect on, question, and analyze the enormous amount of digital, print, and media information that characterizes our complex technological society" (Cuevas et al., 2005, pp. 37–38). This pushes beyond traditional classrooms that emphasize the memorization of facts and figures and requires students to be self-directed.

It creates a forum for students to "question, hypothesize, design investigations, and develop conclusions based on evidence that gives all students the problem-solving, communication, and thinking skills that they will need to take their place in the 21st century world" (Cuevas et al., 2005, p. 338).

As with implementing any educational reform initiative, PBI has utilization challenges. Those schools that successfully adopt PBI have ample resources, including time, small teacher-to-student ratios, and flexible, committed educators and administrators (Barron et al., 1998; Blumenfeld et al., 1991; Geier et al., 2008; Krajcik et al., 2008)—all of which underserved schools traditionally lack. Because PBI involves cognitively complex tasks where students develop original questions about local, place-based dilemmas (Geier et al., 2008), freedom to allow for sufficient time and space for learners to construct knowledge and refine skills is vital to its success. Due to the student centered and less prescriptive nature of this approach, some educators struggle with how to sequence STEM concepts with real-world problems (Barron et al., 1998). PBI professional development is a critical element in providing support to educators and administrators in planning, teaching, and broadening their content knowledge (Desimone, Porter, Garet, Yoon, & Birman, 2002; Garet, Porter, Desimone, Birman, & Yoon, 2001).

A GUIDE TO CREATING CONTEXT AND CONTENT RICH PROJECTS

Drawing from research on PBI, one of the biggest challenges for teachers is to shift from thinking about isolated lesson plans and activities to a flexible curriculum and teaching approach that is driven by student needs, interests, abilities, and questions over an extended period of time. As a consequence, PBI can be more demanding of a teacher's planning and instructional time and requires a structure that is organized yet flexible and adaptable to the needs and pursuits of students and colleagues (Toolin, 2008).

The process of developing a PBI curriculum can be facilitated by support from professional development initiatives and curriculum resources such as the PBI planning template found in Appendix A. PBI planning begins with an in-depth examination of project goals and utilization of the backward design process (Wiggins & McTighe, 2005) whereby teachers consider the standards and enduring understandings that frame the overall project and define what students are expected to know, understand, and do by the project's completion. In the "How Loud is too Loud?" project-planning template example (See Appendix A), enduring understandings related to sound waves and energy transformations and their effect on humans define the big ideas that students will investigate.

Developed next are the essential questions that capture the essence of the enduring understandings and learning standards, which speak to student questions and interests. "How Loud is too Loud?" is the essential question that drives the sound project and leads to other critical questions such as: What is "noise"? What is "sound"? How is sound measured? What makes sound loud? In turn, this line of questioning naturally leads to new questions that relate to issues of equity and social justice including: Who are the stakeholders? What do they have to say? To what extent do they have a voice in the decision making process? In this regard, many teachers find it helpful to coordinate with humanities, media specialists, or art instructors to unpack the social justice, history, and art for social change components of these projects.

The project-planning process is not complete without incorporating appropriate learning outcomes, concepts and skills that students will know and be able to do within the scope of this project. Integrating these specific learning objectives ensures compliance to state/district curriculum guidelines (e.g. some school districts require students to understand sound waves, propagation of sound, mathematical calculations, terminology, etc.) as well as the important skills required for developing scientific thinkers (e.g. engaging in the scientific process, measuring, graphing, reporting, etc.).

After initial goal setting, it is important to consider the modes of assessment that will closely align with the enduring understandings and essential questions previously discussed. Guiding questions for consideration when designing the actual project or other summative and formative assessments include: What projects, investigations and assignments will provide appropriate learning experiences as well as evidence that students are achieving the intended learning goals? Is this the kind of project that will involve data collection, processing, and analysis? Will it require statistics? What sources of technology will be needed? As we value authentic demonstrations of proficiency, a final presentation to stakeholders is a major component of the assessment plan in “How Loud is too Loud?”

Finally, in order to ensure success of the project goals, educators and students need to consider the availability of resources as well as time management strategies. Instructors should take inventory of materials that already exist such as free-use materials or applications or materials and resources that can be borrowed. Students should be enlisted to determine what is needed and encouraged to generate ideas for how these can be obtained together. To effectively manage the implementation of a vast number of student projects over time, teachers must be on board with every project and commit to guiding students through each phase. The establishment of milestones throughout a project is essential to help students readily complete project tasks so that teachers can provide frequent formative assessment and feedback. Teachers considering PBI for the first time might have multiple student groups work on the same driving question. This allows groups to compare project plans and results and thus learn from one another (Toolin & Watson, 2010).

CONCLUSION

Successful examples of PBI are found in schools where educators and administrators believe in the basic tenants of PBI and are devoted to establishing a project-based culture in their educational communities. Creating this sort of culture requires teachers, students, and administrators to value a certain level of “tinkering” and accept that this type of learning may look “messy” at times. While we recognize that many schools are not in the position to overhaul their entire school curriculum to adopt PBI, we recommend that the commitment to PBI be evident in artifacts from lesson and project plans to everyday discussions between teachers, administrators, and community stakeholders. Further, administrators who pledge support for resources, flexible scheduling, ongoing professional development, and interdisciplinary teaching make PBI a reality for any educational setting.

To garner such support, faculty may consider having students design and conduct original research on learning. Classes can decode, analyze, and synthesize literature on project-based and other forms of learning. They may even design and carryout original experiments and create informational materials for those individuals who influence policy. Students can become invaluable spokespeople for advocating the advantages of project-based pedagogy and the rationale for moving towards PBI classrooms and schools. Most policymakers respond well to evidence-based research and student-initiated appeals.

Imagine the kinds of careers our students would be prepared for if our nation’s science classrooms transitioned to PBI. Imagine a learning environment where students are given the opportunity to explore relevant, real-world issues that challenge their STEM content and research skills on a daily basis. Research has shown that with support from professional development and administration, educators can successfully implement inquiry-based practices into their curriculum and pedagogy. Through continued efforts to support schools as they adopt PBI principles and practices, students will have the opportunity to realize this vision and step into the role as citizen scientists as they gain the 21st century knowledge and skills that will inevitably transform their lives and the world beyond.

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