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THE INTERDISCIPLINARY JOURNAL OF PROBLEM-BASED LEARNING

BOOK REVIEW

Teaching Science in Elementary and Middle School: A Project-Based Approach

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Krajcik, J. S., & Czerniak, C. L. (2014). *Teaching science in elementary and middle school: A project-based approach* (4th ed.). New York, NY: Routledge. 404 pp. ISBN 978-0-415-53405-5, $79.95 (paperback).

In this book on project-based science teaching Krajcik and Czerniak present an educationally grounded well researched 400-page primer on implementing project-based science (PBS) in our school classrooms. As they state it, PBS "situates the learning of science in students doing science to find solutions to questions that they find meaningful" (p. 6). The key features of PBS, as enunciated by Krajcik and Czerniak, are:

1. Asking, and finding solution to, **questions** that are **meaningful** to them
2. Planning and performing **investigations** to answer the questions
3. **Collaborating** with fellow students and teachers and other key members of society in answering the question and making sense of the data
4. Familiarity with **learning technologies** in accessing information, researching the question and developing learning artifacts

Grounding PBS in the actual doing of science, the authors start their book with a discussion on the nature of science by answering the question "what is science?" (Chapter 1, Teaching Science to Children). They describe science not in terms of scientists doing science but as a human endeavor that strives for the explanation of natural events and phenomena. In searching for answers to questions they describe science as an explanatory endeavor resulting in theories and models that are continually refined as new evidence becomes available. Throughout the book they approach science and, correspondingly PBS, more in the realm of asking questions than having answers, describing science as a "dynamic, recursive process that results in tentative findings" (p.11). Moving from the question of what is science to the act of doing science, they describe it as the generation of a question, or hypothesis, followed by a scientific investigation that involves data collection, analysis of data, making claims supported by the data and communicating the findings. They point to this latter point as being key to the process of science because it allows for the evidence put forward by one group of scientist to be examined and further tested by other groups of scientists. Krajcik and Czerniak situate school science in the bigger picture of educating a citizenry that understand science in a way that allows for: (i) the interpretation of world problems; and (ii) responsibility to engage in their solutions. They point to PBS being centered round using meaningful questions to drive investigations that yield examinable data thereby developing in students a "usable understanding of science" (p. 25) and preparing them for our knowledge-based economy that thrives on the generation, use of, and reasoning from ideas.

The authors devote a full chapter to a discussion of children's construction of science knowledge referencing the educational literature from Dewey (1938) to the modern day, which is an excellent read (Chapter 2, How Children Construct Understanding of Science). They deconstruct the term *knowledge* and define content, procedural, and metacognitive knowledge. Applying this to science, they talk about the difference between knowing concepts, knowing how to apply them, and knowing how to take responsibility for one's learning. They integrate knowledge and understanding by describing the difference between inert knowledge and integrated knowledge. An example of the former is the more typical textbook memorization of facts often learned in a vacuum without the means to interconnect ideas or translate the learning into usable knowledge. The key to integrated knowledge, on the other hand, is the incorporation of new information into the knowledge structures the individual has already established, creating webs of connection between ideas and concepts that allow for retrieval and usability. With its attention to continuous questioning, this is the knowledge building approach used in PBS. Linking teaching with this form of learning Krajcik and Czerniak talk about

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transformational approaches to teaching that promote investigative questioning in place of receptional approaches that promote straightforward information transfer.

The authors devote whole chapters to the individual features of PBS providing research evidence supporting these educational approaches while linking them to approved educational standards such as the "Framework for K–12 Science Education." Starting with the underlying feature of PBS of asking questions that have relevance to students' lives they point to a social constructivist model of teaching and learning that involves helping students to make sense of the world in which they live and their experiences in it (Chapter 3, Establishing Relevance to Students' Lives). Key features of this form of learning are: active engagement with phenomenon; authentic tasks; use and application of knowledge; multiple representation of learning; and, engagement with learning communities. The chapter layout, continued throughout the book, includes descriptions of classroom scenarios that promote a PBS approach to teaching and learning in comparison with those that don't and reflective learning activity exercises that allow the reader to integrate their learning into their own experiences. Chapters are illustrated with conceptual diagrams that allow the visual learner to grasp what is being described textually, and well laid out, concise tables describing key features of an approach, such as "Ways to Help Students Generate Driving Questions" (Table 3.2, p. 74).

In the chapter on scientific investigations, (Chapter 4, Developing Scientific Investigations) the authors explain how investigations form the essence of inquiry science as they walk the reader through using investigations webs; making observations; asking and refining questions/hypotheses; assessing the validity of information; and, carrying out the actual procedures, continuously moving between the role of learner and that of the teacher. In describing science as a "messy business" (p. 89) they encourage in our students the exploratory function of messing about. They follow this with a chapter that walks the reader through how to make sense of the data gathered in the investigation with sections on: the analysis and interpretation of data; developing explanations from the evidence; drawing conclusions; construction of models; and, making one's work public through the sharing of information (Chapter 5, Making Sense of Data and Sharing Findings). They talk about the different types of models i.e. physical, conceptual and mathematical in describing how to construct models that explain one's findings. They walk the reader through the construction of a scientific explanation describing: the claim, the evidence and the entertainment of alternative explanations. The chapter is replete with excellent examples of how to use tables, charts, graphs and other visual techniques, and, the employment of descriptive statistics in delivering one's data.

As with the chapter on children's understanding of science the chapter on "Collaboration in the Science Classroom" (Chapter 6) functions as a stand-alone monograph on how to get students to collaborate meaningfully in project-based learning. In defining collaboration, they describe the key characteristics of equality and mutuality, the different types of collaborations, and important features of a collaborative environment. They give ample attention to how to form groups and develop collaborative, decision making, trust-building communication alongside conflict-management and task completion skills. The chapter is illustrated with practical suggestions and tools such as a table of factors to consider when forming groups; charts for building common group goals; and, group building activities.

Having devoted chapters to each of the important features of PBS the authors turn their attention to the instructional strategies that support PBS (chapter 7), assessing student understanding (chapter 8), and classroom management (chapter 9). As in the earlier chapters, these chapters are eminently practical. Describing a range of instructional strategies under the headings of direct strategies (e.g. demonstrations); indirect strategies (e.g. reflective discussions); experiential strategies (e.g. role playing and debates); and, independent strategies (e.g. keeping a journal or blog), the authors deconstruct them in such a way that the reader begins to own these strategies for themselves as they reconstruct them to use in their classrooms. In the chapter on assessment the authors talk about the purpose of assessment, grounding it in the educational literature, and detail ways for the teacher to assess students formatively and summatively using observations, anecdotal records, checklists, interviews, and tests with well developed rubrics. They also give attention to how students can present their work in the form of artifacts and portfolios and how students can self and peer assess.

The chapter on managing the science classroom picks up on the social constructivist model of teaching and learning introduced in an earlier chapter and is grounded in the work of Kohn (2006), "Beyond Discipline: from Compliance to Community." Kohn argues for a classroom in which things are done with children rather than to them and in which students are encouraged to reflect and solve problems together. Features of this classroom include being a role model, giving students real choices and paying attention to affective factors such as student's attitude toward science. They talk about the physical organization of the classroom including safety and how to handle student behavior and, referencing the "No Child Left Behind" Act, they talk about ways in which PBS encourages the involvement of girls in science. The chapter on "Planning a Project-Based Curriculum" (Chapter 10) is packed with tools that walk you through establishing lesson plans, setting learning performance goals, developing

assessments, and integrating with other curricula areas. The final "Next Steps" chapter (Chapter 11) talks about overcoming the challenges that one might feel in instituting PBS in terms of teachers and students inexperience and the time involved in instituting something new. Having engaged with this book I found that the authors left me well prepared to overcome the challenges that they speak of.

The book has an extensive reference list grounding PBS in the work of the major educational theorists of the last century such as: Dewey (early 1900s); Vygotsky (1930s); Kuhn (1960s); David and Roger Johnson (1970–); Gardner (1980–); and Kohn (1990–) (see below). I would highly recommend this book not only for teachers wishing to introduce project-based science into their classrooms but also for those who might like an update on modern approaches to science teaching aligned with National Standards and others who might like to avail of some of the large number of practical approaches and tools for science teaching put forward in this book. There is an accompanying website, with access available upon purchase of the book, that extends even further the resources that are available for teachers and students.

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