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Introduction to special issue: International examinations and extensions of the productive disciplinary engagement framework

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ABSTRACT

The four articles collected in this special issue share a common framework, the productive disciplinary engagement (PDE) perspective (Engle & Conant, 2002). This framework was originally developed to support comparisons across instructional design case studies and to evaluate their relative success. Our aim in this special issue is the application of the PDE framework to additional case studies and to further articulate its overlap with other theoretical frameworks (e.g., the joint action theory didactic framework; Sensevy, 2007). Finally, our conclusions based on these additional studies and two commentaries will be drawn so that the strengths and limitations of the PDE framework can be identified and their implications for future research delineated.

1. Introduction

An international debate about the necessity of changing our approach to science instruction is based on several arguments. First, the largely ubiquitous teacher-centered[1] method of instruction distorts the creative, innovative nature of the scientific enterprise and often discourages young people from continuing to study it. Second, even when teacher-centered instruction is supplemented by laboratory activities, students are typically required to follow particular procedures instead of exploring scientific phenomena in a more open-ended way as scientists do. Third, this instructional approach distorts students' understanding of the nature of science, a fact that has been known for at least 60 years. Schwab (1958) characterized textbook's content as a "rhetoric of conclusions" and called for a change to a "rhetoric of enquiry" that is more consistent with scientific practice. Unfortunately, national tests and curriculum models that emphasize the products of science seem to favor the traditional teacher-centered instruction and procedural laboratory exercises as desirable and normative. Sawyer (2006) characterized this assumed, teacher-centered instructional "contract" among classroom participants as "instructionism" (p. 1).

The changing demographics in schools across the world mean that fewer people who have been attracted to science (typically European or European-American males as well as East or South Asian males) are enrolled in public schools

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[1] By "teacher-centered" we mean teacher-controlled lecture-based instruction that presents students with the intellectual products of science.

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(Venturini, 2007). Increasing interest and proficiency among other demographic groups is critical to the development and maintenance of technologically advanced societies (e.g., NRC, 2012). The global economy depends upon growth in technological fields, which, in turn, depend upon an educated populace that is able and willing to solve difficult and highly abstract problems, such as those that are emerging in STEM fields (science, technology, engineering, and mathematics). Finally, increasing literacy in STEM fields among all citizens is crucial as decisions about political representation, health care, and environmental concerns depend upon an informed citizenry.

The challenge of shifting the way science is taught is substantial because it is related to tacit assumptions about society. As Sawyer (2006) noted, MIT educator, Seymour Papert, coined the term instructionism to characterize forms of traditional schooling that were designed to foster the habits of mind necessary for functioning in early twentieth century industrial economies. Because of the changes that are occurring in technologically advanced societies, Sawyer proposed a new set of instructional goals. In contrast to the focus on factual information and procedural fluency favored by instructionism, Sawyer argues that learning should include deep understanding of conceptual networks and active engagement in pattern recognition, argumentation, and critical thinking. To meet this challenge, a field is developing that some refer to as "learning sciences" (e.g., Sawyer, 2006), which draws on rigorous theories and methodologies from various academic fields to articulate and test coherent ways of shifting educational aims and the means for meeting them. The research base for the learning sciences is extensive and comes from multiple sources (e.g., cognitive science, educational psychology, studies of disciplinary knowledge, educational technology, anthropology, linguistics). To date, this research has been guided primarily by constructivism and socio-cultural theory (Bransford, Brown, & Cocking, 2000; Kilpatrick, Martin, & Schifter, 2003; Sawyer, 2006).

The field of the learning sciences has been growing during the past 30 years to provide theoretical and methodological tools for educators and researchers to create and study learning environments that are conducive to the fostering of STEM literacy without depending upon instructionism[2]. At the beginning of the learning science movement, investigators worked closely with a small group of classroom teachers to design, implement, assess, and revise their instructional settings. Their aim was to offer students opportunities to engage in active investigation, representation, and discussion with the teacher and their classmates. These local teaching experiments were designed as existence proofs whose goal was to demonstrate the possibility of changing practices from instructionism to something closer to authentic disciplinary activity (Confrey, 2006; Schoenfeld, 2006). Most of this work was done in mathematics and science classrooms. One premise of the learning science movement is that classrooms should embody more of the characteristics of professional communities so that students would get a less distorted view of the nature of STEM disciplines (Lampert, 1990; Stewart, Cartier, & Passmore, 2005).

As evidence from these small scale case studies accumulated, investigators began to summarize lessons learned about common design features (Confrey, 2006). One framework motivated by this goal to support comparisons across case studies and to evaluate their relative success was the productive disciplinary engagement (PDE) perspective (Engle & Conant, 2002). In its original presentation, classroom case studies from North America (the United States and Canada) and East Asia (Japan) were discussed as well as its definition and basic principles. Further refinements of the PDE framework were presented in a recent chapter by one of the original authors (Engle, 2011). One advantage of the PDE framework is that it mediates between our understanding of how science is conducted (from the field of science studies) and our knowledge of science education curriculum and student learning. Another asset is that it provides a perspective for analyzing an existing learning environment, even if this setting was not originally devised to align with the PDE framework.

Our broad aim in this special issue is to help advance the important conversation about educational aims and means. The PDE framework is an ideal focus of this conversation, so we have sought reactions from scholars in South America (Brazil) and Europe (France). We also continue to apply PDE to additional case studies in North America (the United States). Our specific goals include the further articulation of the PDE design principles and identification of their overlap with other theoretical frameworks (e.g., the joint action theory didactic framework, Sensevy, 2007). Finally, we plan to scrutinize and challenge the nature of the PDE design principles in order to strengthen their potential theoretical and practical implications for science education.

This introductory chapter is organized in the following way: first, some important definitions and design principles of PDE will be summarized; second, each of the four articles prepared for this issue will be briefly discussed; third, two commentaries (from a North American science educational researcher, Gregory Kelly, and a European learning scientist, Kristiina Kumpulainen) will be introduced; finally, our conclusions based on these additional case studies and commentaries will be drawn so that the strengths and limitations of the PDE framework can be identified and their implications for future research delineated.

2. Overview of the PDE definitions and design principles

This instructional design framework is focused on ways of fostering productive disciplinary engagement, which is a general goal shared by many instructional improvement efforts in the last few decades (Engle, 2011). First, for PDE to be

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[2] Although this special issue focuses on the STEM field of science education, other disciplines such as history education have also used a similar design-based approach to instruction (e.g., Stevens, Wineburg, Herrenkohl, & Bell, 2005).