

Chapter 7.11

“Virtual Inquiry” in the Science Classroom: What is the Role of Technological Pedagogical Content Knowledge?

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ABSTRACT

The article examines prior research on students' difficulties with inquiry learning and outlines research-based decisions for the consideration of software-based scaffolds for inquiry teaching and learning. The objective is to detail research findings in a way that assists teachers in their development of pedagogical content knowledge as relevant to the selection and use of technological tools for classroom inquiry in the high school biology or college introductory biology classrooms. Employing a worked-out-example in the popular domain of DNA science, the article illustrates the research-based integration of instructional design decisions coordinated with the features of selected software tools. The coordination of software-design with instructional design has the potential of significantly enhancing students' learning while also supporting the development of teachers' technological pedagogical content knowledge.

INTRODUCTION

National calls to enhance students' understanding of the real-life, complex processes via scientific inquiry (NRC, 2000) draw attention to examining the opportunities technological tools offer for authentic learning. Of specific promise are virtual laboratories (VRLs) that allow the user to conduct the same scientific inquiry afforded by hands-on apparatus albeit at reduced expense, increased safety and at a fraction of the time. In trained hands, these tools support students in learning the skills necessary for real-life decisions related to medical treatment choices, ethical considerations of modern research and understanding everyday news related to modern science. However, the instructional application of VRLs is often based on trial and error rather than cognitively-based methodologies. Using the research-based pedagogy of providing worked-out examples for learning (Renkl, 1997; Chi, Bassok, Lewis, Reimann, & Glaser, 1989), this article takes the approach of

illustrating key instructional design decisions for the use of a virtual laboratory tool. The practical implementation thus developed, has the potential to fuel further research and support the development of practitioners’ pedagogical expertise.

THEORETICAL GROUNDING

The theoretical grounding for this article is provided by prior research in three areas of study: (1) students’ difficulties of learning authentic science via complex inquiry, (2) software design principles to support inquiry-learning and (2) prior theories about how teachers’ organize their knowledge for teaching. Research from these areas is examined below in order to set the stage for the analysis of instructional design decisions illustrated by a worked-out-example focusing on gel-electrophoresis and the use of a virtual laboratory.

What Does Research Tell Us About Scaffolding Inquiry-Learning?

Inquiry learning is defined as the coordination of asking questions, designing experiments, using evidence to respond to questions, formulating explanations based on evidence, connecting explanations to prior knowledge and communicating explanations and justifications for domain understanding (NRC, 2000). In a classical study on problem solving Fay and Klahr (1996) refer to these phases of searching the experimental space, evaluating data and mapping the results to prior knowledge to make inferences. Accordingly, this article uses the phases of search, evaluation and reasoning to categorize the conceptual activities involved in scientific inquiry.

It is well documented by the literature that students are often unsuccessful in learning science via inquiry. They do not scientifically control experiments (Chen & Klahr, 1999; Toth, Klahr, & Chen, 2000), misrepresent empirical results based on prior belief (Chinn & Malhotra, 2002) and are not successful in formulating inferences to explain

the results of their inquiry (Fay & Klahr, 1996; Schauble, 1996, Kozlowski, 1996). As a result of these research studies, a variety of views exist on how to best structure these complex inquiry-experiences for improved learning.

One perspective is to present students with the full complexity of inquiry learning in an authentic manner that keeps students’ attention and motivation high, focuses students’ interest on real-life examples and thus prepares students for their future work experiences (Roth, 1995 Chinn & Malhotra, 2002). Another perspective for inquiry teaching is to gradually build students’ expertise of independent inquiry by constraining students’ activity to only a few steps of inquiry at time (Rezba, Auldridge, & Rhea 1999; Bell, Smetana, & Binns, 2005). For example, in the case of *confirmatory inquiry* students’ activity is constrained to the pre-determined steps of searching the task environment, evaluating data results and reasoning to explain the outcome. During *structured inquiry* students may receive a pre-determined research question to focus their search, as well as the methods by which they should evaluate data results. At the same time, however, students can independently develop inferences about the task domain based on these results and data evaluations. In a less structured inquiry setting, also called *guided inquiry* students may only receive guidance about the method of searching the task environment, for example in the form of a pre-determined research question. Students then independently develop their own data evaluation methodology and the inferences that explain data results. At the final end of the continuum of structuring inquiry, *open inquiry* refers to activities where all phases of inquiry (search, data evaluation and reasoning) are determined independently by students. This article integrates key ideas from both research perspectives above by way of engaging students in authentic inquiry, but scaffolding their inquiry in each phase so as to gradually build expertise. To illustrate the possible contribution of software

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