Web-Based Design Guidelines for Promoting Scientific Inquiry Learning: Virtual Design Center

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Abstract

This paper shares new knowledge about how learning theories can be applied practically to technology and classroom environments for promoting scientific inquiry in K-12 students. The paper is a part of the Virtual Design Center (VDC) online workshop. Researchers at the NASA Classroom of the Future developed the VDC to provide research-based educational technology design guidelines for NASA designers, teachers, scientists, educational researchers, and curriculum and technology developers.

Conceptual Framework of the Virtual Design Center

Science education research has made much effort to create rich and innovative learning environments for facilitating scientific inquiry. Inquiry involves observing, classifying, formulating hypotheses, identifying and controlling variables, experimenting, and making valid conclusions (Gagne, 1974). Those activities facilitate scientific problem solving because they let students question their own observations, generate and refine hypotheses, deal with experimental data, test those hypotheses by experimentation, and evaluate evidence (Bybee, 1993; Collins, 1998; Kuhn, Amsel, & O'Loughlin, 1988; Moore, 1993; National Research Council, 1996; Roth & Roychoudhury, 1993; Toth, Suthers, & Lesgold, in press; Uno, 1990; Windschitl, 2000). Researchers have demonstrated that inquiry learning enhances students' attitudes toward science, science process skills, and scientific problem solving (Green & Damnjanovic, 1999; Krajcik et al., 1998; Mattheis & Nakayama, 1998; Windschitl, 2000). In addition, these studies have suggested various principles for improving students' scientific inquiry.

Although the results from these studies have yielded a rich collection of promising principles, a problem has existed—how can these principles contribute most effectively to practice? Research findings extend successfully to the understanding of science teaching and learning and the refinement of theoretical explanations for science education phenomena. However, the results of this research have been presented as either too abstract or too open-ended to guide educators on how to apply the principles practically (Baumgartner & Bell, 2002). In addition, the use of the principles by educators has not been well explored. More attention needs to be paid to making the principles useful for educators.

NASA Virtual Design Center

The NASA Classroom of the Future seeks to apply learning theories in a practical way to stimulate development of technology-enabled solutions and classroom activities for promoting scientific inquiry in K-12 students. To create it, the Classroom of the Future brought together an advisory board of experts in cognitive science and educational technologies along with scientists, researchers, and teachers.

The content of the VDC consists of six sessions: introduction, learning outcomes, investigation question, acceptable evidence, helping students articulate, and supporting the investigation. Each session has learning goals, objectives, and activities.

Session Outline

Session 1—Introduction

- Complete an investigation as an example.
- Discuss important features of the investigation.

Session 2—Identify Learning Outcomes

- Bring your own dataset and brainstorm how students could use the dataset to learn specific national standards.
- Select one way to use the dataset to learn a specific national standard.

Session 3—Formulate Investigation Question

- Examine summary of motivation, prior knowledge, and ill-structured problem-solving research.
- Determine the relevant NASA enterprise big question.
- Formulate investigation question that encourages ill-structured problem-solving skills, motivates students, activates relevant prior knowledge, and uses a NASA dataset to learn a specific national standard and investigate a NASA enterprise question.
- Administer the investigation question to target population to check whether the questions are appropriate for the target population.

Session 4—Determine Acceptable Evidence of Learning

- Search for performance tasks on PALS, TIMSS, NAEP, and state and local assessment web sites.
- (Or) Develop a performance task that students should be able to solve after completing the investigation.
- Administer the performance task to the target population and to a more experienced population.
- Identify knowledge and skill gaps and compare to the target national standard. The primary gaps should be the target national standard. If not, participants may have to rethink sessions 1-3.

Session 5—Design Principles for Helping Students Articulate What They Learn

- Examine summary of argumentation and knowledge organization research.
- Explore the following tools that support students' articulation and select an appropriate tool to have students articulate what they know throughout the investigation (question, background information, conclusions):
  - Argumentation
  - Knowledge organization
  - Problem solving
  - Modeling

Session 6—Design Principles for Supporting the Investigation

- Examine summary of self-regulated learning, team research, multiple abilities, and learner choices research.
- Discuss how the principles would apply in designing the participants' investigation.

Design guidelines are introduced in sessions 3, 5, 6: formulate investigation question, help students articulate what they learn, and support the investigation. Each design guideline consists of three subcategories: What is it, why is it important, and how does an instructional designer improve it? (See details on http://www.cotf.edu/vdc/.)

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