Changing the Game: Activity Structures for Science Education Reform

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Abstract

It is often said that students who perform well in school are those that understand the rules of the game. In other words, students need to understand not only the content related to an activity, but also the teacher expectations for how to participate in that activity and how the activity is typically structured (Doyle, 1979; Mehan, 1980). Lemke (1990) provides an example of a predominant activity structure, which can be characterized as following the sequence "Teacher Question-Student Answer-Teacher Evaluation" or as Mehan's (1979) more general sequence of "Initiation by teacher-Reply by student-Evaluation by teacher" (I-R-E). Recently, an investigation of United States mathematics and science classrooms by the Third International Mathematics and Science Study (TIMSS) has confirmed this earlier research indicating that there are clear patterns of classroom activity structures. TIMSS found that most science instruction involves activities that are short in duration and that focus on transmission of information (Valverde, 1998).

Currently, however, the rules of the game in science education are changing. There are several reasons for this. One reason is that national science standards being produced by various groups, such as the *National Science Education Standards,* which suggest that students ask and investigate their own questions. In order to meet these standards, it is necessary for teachers to use alternatives to the I-R-E activity structure. Another reason for a change in the game plan has to do with the increased use of constructivist learning approaches (Yager, 1995). Such approaches represent a radical change both in activity structure and teacher expectations.

Given an environment where traditional activity structures and teacher expectations are evolving, it is likely that students will have difficulty adapting. This hypothesis is based on recent reports that students have a tendency to interpret new activity structures in light of familiar activity structures (McGee, 1998 include other symp. refs here). These interpretations can create difficulties for students trying to adapt to the new rules of the game.

The participants of this symposium believe it is important for curriculum designers to understand these adaptation difficulties. Each of the projects in this symposium represents a variation on the use of educational technologies and constructivist approaches to support scientific inquiry. The papers will discuss the unique issues that have arisen from each variation, which can inform our understanding of how students accommodate to the new rules of the game.

Theoretical Framework for Characterizing Inquiry-based Activities

Unlike traditional science content, which is delivered as "chunks" of information, scientific inquiry involves active, sustained investigation by students. To support sustained student investigations, teachers must link activity structures over several class periods. Instructional designers at the NASA Classroom of the Future (COTF), which produces multimedia materials, help teachers and students sustain scientific investigation by engaging them in the four phases of scientific inquiry: (1) define the problem, (2) develop solution strategies, (3) solve the problem, and (4) share results.

Table 1 provides a framework for linking these phases of problem solving to psychological theories of learning. The table shows the set of theoretical issues that arise within each of the four phases of scientific inquiry. The table also indicates the components of COTF products that support each of the phases. During the process of designing new products, the framework has provided a mechanism for linking theory with practice.

In *Exploring the Environment*, students address real-world problems using remote-sensing images. In *Astronomy Village,* virtual mentors guide students through investigations in astronomy. In *BioBLAST*, students use a simulation environment to design a bioregenerative life-support system for a lunar base.

Research Phase	**Educational Psychology Issues**	**Exploring the Environment**	***BioBLAST***	***Astronomy Village II***
Defining the Problem	• develop interest • activate relevant prior knowledge	• Read and Analyze Problem Scenario • List what is known • Develop Problem Statement	• Orientation phase	• Core Research Question • Exploration phase
Developing Solution Strategies	• generate & attempt solution strategies • make predictions • promote metacognition	• List what is needed • List possible actions	• Research phase	• Background Research
Solving the Problem	• develop scientific skills • compare predictions and results	• Analyze Information	• Mission phase	• Data Collection • Data Analysis
Sharing Results	• synthesize results with prior knowledge	• Present Findings	• Reporting phase	• Virtual Press Conference • Class Presentation

Table 1: Summary of Phases of Scientific Inquiry