INFORMED DESIGN: A CONTEMPORARY APPROACH TO DESIGN PEDAGOGY AS THE CORE PROCESS IN TECHNOLOGY

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The Standards for Technological Literacy (ITEA, 2000, 2002) document indicates the centrality of design to the study of technology, “Design is regarded by many as the core problem-solving process of technological development. It is as fundamental to technology as inquiry is to science and reading is to language arts” (p. 90). Design in technology education most closely allies with engineering design. For instance, The Accreditation Board for Engineering and Technology (ABET) defines design in the Criteria for Accrediting Engineering Programs as “the process of devising a system, component, or process to meet desired needs. It is a decision-making process (often iterative), in which the basic sciences and mathematics and engineering sciences are applied to convert resources optimally to meet a stated objective” (ABET, 2000).

Design as an Instructional Strategy

In recent years, there has been a growing recognition of the educational value of design activities in which students create external artifacts that they share and discuss with others (Soloway, 1994; Papert, 1993; Resnick, 1998). A synthesis of the literature reveals that pedagogically solid design projects involve authentic, hands-on tasks; use familiar and easy-to-work materials; possess clearly defined outcomes that allow for multiple solutions; promote student-centered, collaborative work and higher order thinking; allow for multiple design iterations to improve the product; and have clear links to a limited number of science and engineering concepts (Crismond, 1997).

The National Research Council’s How People Learn (Bransford, 1999) hails instruction where students monitor their understanding and progress in problem solving. Research reveals that experts consider alternatives, note when additional information is required, and are mindful if the chosen alternative leads toward the desired end. These strategies are central to the culture of design.

However, in classroom settings, most problems are usually well defined, so students have little experience with open-ended problems. Technological design problems, however, are seldom well defined. The design process begins with broad ideas and concepts and continues in the direction of ever-increasing detail, resulting in an acceptable solution (Thacher, 1989). So using design in the classroom can be challenging, as students are not familiar, or initially not comfortable, with the open-ended nature of design. This can also pose problems for teachers, who must relinquish directive control. However, it also provides opportunity to use constructivist pedagogical practice to engage students in their own learning. The informed design process discussed in this article, and the underlying pedagogical support methodology, provide a way to optimize the use of design as a pedagogical strategy.

Pedagogical Rationale for Design

As a pedagogical strategy, design activities have great potential to:

• Engage children as active participants, giving them greater control over the learning process.

• Assist students to integrate learning from language, the arts, mathematics, and science.

• Encourage pluralistic thinking, avoiding a right/wrong dichotomy and suggesting instead that multiple solutions are possible.

• Provide children an opportunity to reflect upon, revise, and extend their internal models of the world.

• Encourage children to put themselves in the minds of others as they think about how their designs will be understood and used (Resnick, 1998).

All too often, however, design is not used to maximum pedagogical advantage in the classroom. As an instructional strategy, design has all too often focused on the product rather than on the learner. Design is often characterized as “gadgeteering,” and trial-and-error problem solving where students do not always gain important (i.e., standards-based) conceptual understandings.

Informed Design

Informed design is a pedagogical approach to design that was developed and validated through the NSF-funded NYSCATE Project (New York State Curriculum for Advanced Technological Education) (Burghardt and Hacker, 2003). Informed design enables students to enhance their own related knowledge and skill base before attempting to suggest design solutions. In this way, students reach design solutions informed by prior knowledge and research, as opposed to trial-and-error problem solving, where conceptual closure is often not attained. Informed design emphasizes design challenges that rely on math and science knowledge to improve design performance. The approach prompts
An Example in a Familiar Context

Bridge-building design projects have been used for many years; however, they often are not informed by mathematical, scientific, and technological knowledge of the construction of various types of bridges. All too often, bridges are loaded to the point of failure, strengthened at the failure point, and rebuilt without delving into the cause and reasons for failure. 

KSBs for a bridge-building project might include:

1. **Investigation and construction of simple beam bridges, suspension bridges, arches, and truss bridges.**
2. **Investigation of tension and compression in bridge members.**
3. **Gathering and plotting data to reinforce important mathematics and science inquiry skills.**
4. **Determining and developing a fair test to focus on the design specifications and how to test for them.**

To encourage the use of thoughtful alternative solutions, the problem statement is more open-ended than the traditional one of building a bridge to hold the most weight, a single criterion. In the new situation, the goal is to design and construct a cost-effective bridge that will hold the most weight for the least cost while meeting a minimum load specification, two criteria that may be inversely related. This more
accurately models engineering practice. Materials have different costs associated with them, which can encourage a variety of design approaches and foster critical thinking about why they will be the best (Hacker and Burghardt, 2004).

Research Base
The informed design process was created as part of the NYSCATE NSF curriculum materials development project. Of the thirteen modules developed, eight are intended for use on the high school level and can be modified for use in middle school; the remaining modules are for use in community college technology courses. The modules were developed using strategies of backwards design (Wiggins and McTighe, 1998) as replacement curriculum for existing technology and science courses.

There was a great deal of enthusiasm expressed by teachers and students for all the modules. The Project evaluators indicated that the technology and design components were consistently understood by students and teachers, and that the understanding of science and mathematics concepts varied depending on how explicitly they were addressed by the KSBs. For instance, in one module, where students designed a food dehydrator (Drying by Design), the three field-test teachers agreed that students learned important technology concepts and important design processes.

Students were questioned about what they perceived they learned. The following summarizes their responses:

- Students strongly agreed that they learned important science, technology, and design concepts.
- Students strongly agreed that they learned from the design task so that they could do it better if they did it again.
- Students moderately agreed they learned important math concepts.

The modules developed through the NYSCATE Project use informed design as the core instructional strategy. The modules are shown in Figure 2.

Conclusion
The results from reviews by experts, pilot testing, and field testing of the modules has shown that informed design and the pedagogical strategies that support it are effective. The informed design process contextualizes learning and applies the latest constructivist pedagogical practices to enhance student learning. This process complies with current understandings of how students learn and how to create effective learning environments for them.

References


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