# About Project DESIGNS

## Project DESIGNS Goals that Cross All Modules

Each of the six DESIGNS modules contains three or more challenges. Embedded within each challenge of every module are three important goals. They are as follows:

1. Support learning through clear student goals. Each student goal is presented as a clearly defined challenge in physical science. These challenges are invitations to students to improve the performance of a simply designed device commonly found in their world.
2. Empower students as problem-solvers. Students are encouraged to use their prior knowledge to develop strategies to make progress in each DESIGNS challenge. Students discover and utilize physical science concepts as they achieve the goal characterized by the challenge.
3. Encourage students to be critical creators of knowledge. Students propose, test, and eventually defend their ideas. Teachers probe student strategies and interpretations, and encourage students to assess their own and other's evidence.

Students quickly recognize the goal that is posed as a challenge. For example if the challenge is to improve a working model of a windmill, students easily visualize what is expected and what constitutes a successful outcome. The student who encounters the poorly designed windmill interacts with the basic model, decides what might be changed, makes those changes, and evaluates the results. DESIGNS makes two important assumptions about students who accept the challenge: 1) they understand the goal, and 2) they accept the goal as their own. Students who accept ownership of the goal are more likely to be motivated to complete the work they begin. Students also appreciate the link between each DESIGNS challenge and its real world application. Student interaction with science is often through the technology that results from scientists' work. Each challenge offers students an interesting task centered on the theme of improving an existing design (e.g., a windmill, a battery, or an electromagnet).

DESIGNS challenges were crafted so that students could easily recognize the goal, quickly obtain feedback from their work, and effectively act on that feedback. This strategy is intended to invite students to act, and to empower and support their learning once they accept the invitation. Students who accept the challenge soon find that the problem becomes very compelling. They are motivated for several reasons. The iterative nature of the activity provides timely feedback. The feedback provided by nature is always available, always impartial, and typically unambiguous. Students can quickly determine if their ideas and actions are bringing them closer to the goal they recognized in the challenge. The interaction between the DESIGNS challenge, the supportive teacher, and the problem-solving student is critical in helping students to be self-directed, critical creators of knowledge.

DESIGNS challenges/goals are also intended to encourage teachers to continually assess whether the classroom setting supports student work in meeting the module goals. From this perspective, teachers focus on encouraging students to follow their own convictions. As a result, students are less dependent on the instructor for the "right answers." Instead, they seek to improve the strategies they use in meeting the design challenge. Often great progress is made when students discover that their beliefs are not supported in nature. Students who learn to question nature directly learn to increasingly value their experiments and become more interested in their results. Students who are motivated to accept the challenge need less assistance from the teacher to proceed. Students uncomfortable with this freedom may still seek the teacher's help. However, teachers who let the challenges guide the students help build students' confidence in their problem-solving ability. Teachers ultimately act to support student understanding of how science proceeds instead of what science has produced.

## DESIGNS Versus National Standards

DESIGNS' goals agree philosophically with the following goals for school science as articulated in the *National Science Education Standards* (p. 13):

- Experience the richness and excitement of knowing about and understanding the natural world.
- Use appropriate scientific processes and principles in making personal decisions.
- Engage intelligently in public discourse and debate about matters of scientific and technological concern.

However, in an attempt to go beyond philosophical agreement with these goals, DESIGNS strives to create guiding principles that help direct the work of students and teachers. To this end, DESIGNS' goals support the grades 5-8 Content Standards in the *National Science Education Standards* for Science as Inquiry which include (p. 143):

- Abilities to do scientific inquiry.
- Understanding about scientific inquiry.

Furthermore, DESIGNS' goals directly support the grades 5-8 Science and Technology requirements in the *National Science Education Standards.* In particular, DESIGNS seeks to create opportunities for children so that, "as a result of activities in grades 5-8, all students should develop abilities of technological design" (p. 161). The underlying objective is that students will be able to perform the following (pp. 165-166):

- Identify appropriate problems for technological design.
- Design a solution or product.
- Implement a proposed design.
- Evaluate completed technological designs or products.
- Communicate the process of technological design.

All DESIGNS goals provide a framework to support scientific inquiry and technological design. This framework is the foundation on which students distinguish the difference between science and technology. Students work towards recognizing that the goal of science is to create knowledge, while the goal of technology is to apply that knowledge into developing the tools people use to solve problems. To support experimenting as well as the building of tools DESIGNS uses materials that are inexpensive, readily available and easily recognized by students as common items that constitute a part of their everyday world.

Skills that Cross all Modules

Science is a unique tool for understanding nature. It assumes that systems (such as the devices in a module) can be understood by first breaking them down into parts that can be later modified. Students learn by making changes to the variables they identify within a design (e.g., increasing the number of wire wrappings in an electromagnet). Students are encouraged to experiment, generate ideas, formulate conclusions, and support their ideas and conclusions with explanations. At the end of the project the students should be able to perform the design process and fabricate their best designs. As a result, they formulate and articulate theories about how each design works. Whether their theories are naive or sophisticated, students test their beliefs through each of their design modifications.

An important outcome of the module goals is that students develop both manipulative and cognitive skills in science. Three skills in particular are realized through student work:

1. 1. Articulating and testing prior notions about how a design works. In many ways this skill represents the traditional view of what scientists do: asking questions, forming hypotheses, testing those hypotheses, etc. Students can easily identify the parts of the devices with which they are working. These "parts" represent the design variables that students can control as a scientist or engineer might. Students want to know what will happen to their designs when they choose to modify, add, or remove variables. Their questions become the guiding principles behind how they test their ideas.
2. 2. Judging the impact or magnitude of a change. When a student wonders how a change might impact the original design, the student is posing the question directly to nature. Once the change has been implemented, nature provides the answer. Students judge the impact of their own ideas. They see that not all changes result in the same effect or even have any effect. Because the teacher is outside the question-answer cycle, students concentrate on looking to nature to find answers to their questions.
3. 3. Making convincing arguments that a change has resulted in a meaningful improvement to the design. Students are expected to evaluate the impact of changes as well as judge the magnitude of change. They are encouraged to employ tools (such as graphs, tables, and charts) to support claims that some changes had a greater impact than others, or that a change had no impact at all.

Sadler, P. *Project DESIGNS Goals that Cross All Modules.* (1996) Project DESIGNS (pp. 3-6).The President and Fellows of Harvard College. Project DESIGNS, NSF grant ESI-9452767.

To the extent that these skills are practiced in the module, DESIGNS supports the broadest standard in the *National Science Education Standards*. "As a result of activities in grades K-12 all students should develop understanding and abilities aligned with the following concepts and processes" (p. 117-118):

- Evidence, models, and explanation: Evidence consists of observations and data on which to base scientific explanations. Using evidence to understand interactions allows individuals to predict changes in natural and designed systems.
- Constancy, change, and measurement: Energy can be transferred and matter can be changed. . . . Changes can be quantified. . . . Different systems of measurement are used for different purposes.