I am indebted to Larry A. Hickman’s book, *John Dewey’s Pragmatic Technology* (Bloomington, IN: Indiana University Press, 1990) for helping me to consolidate and articulate my thoughts on technology. Hickman has masterfully elucidated Dewey’s complex notions of technology as the method of inquiry. Much of this manuscript is my interpretation of his analysis of Dewey. As a former student of D. Bob Gowin—also a Dewey scholar—I found myself very responsive to Hickman’s consolidation of Dewey’s positions. As I point out in this essay, Gowin’s “Knowledge Vee” as introduced in his book *Educating* (Ithaca, NY: Cornell University Press, 1981) is a tool directly descended from Dewey’s conception of inquiry and the role of technology as methodology. (The Vee has the potential to help teachers think of science as problem solving while organizing their efforts for doing so.)

The section I have written on “Design and Engineering” closely parallels the thinking of Susan Dunn and Rob Larson in their stimulating book, *Design Technology: Children’s Engineering* (New York, NY: Falmer Press, 1990). In a forward to this book, my colleague Jim Wallace of Lewis & Clark College writes that Dunn and Larson’s conception of technology and children’s learning fits squarely within the teachings of John Dewey. In an era of incessant concern for technological literacy, Dewey continues to provide direction for educators.

Key to Dewey’s philosophy was the concept of inquiry as a characteristically human and cultural commitment. Gowin has elaborated upon this concept of inquiry, framing it as a set of coordinated relationships among prior knowledge, conceptual systems, events of interest, newly derived claims, and trusted methodology (Gowin, 1981). In his philosophy, an educated person grasps the controls of meaning embedded in the commitment to a system of concepts and becomes aware of how concepts function as tools of inquiry. Moreover, the educated person recognizes how the choice of inquiry methods depends upon the conceptualization of a problem. Establishing this relationship—between concepts and processes—becomes a key goal for persons seeking to solve problems. When answers are claimed, they return to this context, changing its configuration for the next round of problem solving. In such a manner, inquiry recycles understanding. Iterations continue until problems are considered solved, but in so doing, new possibilities and puzzles emerge or “come into focus” in Dewey’s language.

Gowin has encouraged educators to use a vee heuristic to keep track of the elements of inquiry. On the left arm of the vee, he represents conceptual understanding. On the right arm appear stages in the derivation of claims. Both arms are anchored in the occurrence of events, reduced to order by making records (right arm category) and signifying patterns in their occurrence (left arm category). Inquiry, initiated by a telling question, prompts interaction between elements of the left and right sides. The sequence of operations and transformations moving inquiry from events towards claims depends on the application of methods. *Technology* is one way of expressing the embodiment of methods.

Gowin would very likely accept Dewey’s proposition that tools are physical artifacts that have co-equal status with concepts as mental inventions serving the purpose of inquiry. However, his writings do not suggest what form this commitment may take in classroom teaching. Dunn and Larson’s writings do so very explicitly.

**The Fundamental Significance of Technology**

As a direct consequence of human culture, the evolution of adaptive structures has shifted from biological to technological forms. It is primarily through our technology that we reorganize matter and utilize energy to our own advantage and in the interests of our survival. As technology evolves, we find ourselves questioning whether it helps us adapt to the world or whether we have come to the point where we must adapt to the world our technology has fashioned. The technologies of production and distribution, information and communication, medicine and sanitation, war and public order, shape our political, educational, and social lives. We take part in communities and struggle to succeed within institutional structures whose problems and needs are inseparable from the evolution of technology. Our technological prowess may bountifully satisfy our immediate needs while at the same time precipitating problems that challenge our long term ingenuity, both in terms of social organization and invention of new technology.
We have reached the point where the success of human technological systems as adaptations which promote our survival have returned to the crucible of biological evolution. The natural world of which we are an inescapable part cannot yield without limit to our technologies. We must learn how to include natural resource depletion and habitat degradation costs in our measures of economic productivity. Whether in terms of forest ecosystem, ocean fishery, agricultural soil, energy resource, wetlands habitat, climatic pattern, atmospheric blanket, or viral pathogen, an alarming story has begun to unfold about the consequences of our technological exploitation of the planet.

This dire side of technology leads directly toward a concept of science as problem-solving. Science as problem solving means a search for a means of control and prediction over problematical and puzzling circumstances. Social concerns dominate the choice of problems. In this context, an evaluation of the consequences of solutions accompanies the search for solutions. In this context, we need to draw upon everything we already know in addressing problems. Our inquiry must continually recycle the best of our understandings.

Control is a concept central to all discussions of technology. It is also the key to grasping the exhilarating dimension of technological evolution and its promise of enhancing human freedom, prosperity, and creativity. We need technology in order to exercise control over our fate; we need control over technology for the same reason. Through design, invention, and experimentation we put technologies to the test. We use them to render problematical situations controllable and to open new possibilities of experience to ourselves. As we are able to subject more and more aspects of nature to the control of our intelligence—as we come to understand—we create novel opportunities for ourselves and the organization of our society. We value the mobility, longevity, diversity, and opportunity afforded by myriad technologies. We have faith that technological challenges unleash human creativity.

There are two themes to this abstract rationalization of the importance of technology in science education: (a) technology is a method of problem-solving and (b) whether physical artifact or mental invention, problem-solving tools evolve. These two themes might be labeled inquiry and innovation. In the context of inquiry we invent appropriate methods and design productive tools. When we recognize the context of inquiry as one permeated by social concerns—whether dire or inspiring—we have arrived at an understanding of technology as a responsible method of human inquiry. Not so subtly, our conclusion equates physical artifacts and mental inventions as the tools of inquiry. Both are constructed in view of valued aims; both are evaluated in terms of their productivity in achieving these aims. This unity of "thing and thought" as testable innovations is central to the integration of technology in science education.

Technology becomes the methods—physical and mental—we use to solve problems. Together with our efforts to define the problems and test the solutions, technology assumes an ineluctable relation with science. Science and technology merge as a synonym for inquiry.

The Criterion of Worth for Concepts and Instruments

Consider the value premises in the following argument: Science has a place in elementary education only to the extent that it furthers the most basic aims of elementary education. Elementary science ought to help children learn to have and persist in pursuing an interest, developing habits of disciplined thought and generating new questions along the way. Learning in science has no place in school if it fails to promote sustained interest or implies that some are not "clever" enough to do science. Learning in science has no place in elementary school if it cannot promote proficient development of language and thinking skills, mathematical reasoning, or cooperative behavior.

The messages in this statement are fourfold: (a) use science to prompt and sustain interest, (b) develop good habits of thinking through science, (c) make science a subject for everyone, and (d) embed science in language, mathematics, and social learning. You can easily substitute the word technology in place of science in each of these four messages. Remember we are striving to construct a curriculum from the premises that science is problem-solving and that technology is the method of solving such problems. Science—as inquiry—puts technology through a test of utility. Does technology further the inquiry, solve the problem, remove the puzzle? In this sense, technology can include mental inventions—concepts. Do our concepts enhance the inquiry, help solve the problem, or illuminate the puzzle? Does a lack of concepts obstruct our progress? Does a lack of instruments inhibit our work? Questions such as these serve to evaluate the worth—the utilitarian value—of our concepts and instruments. Answers portray the utility of a technology, and we may consider both concepts and instruments interchangeable in the evaluation process.

Treating, for instance, both "the cell concept" and "a magnifying glass" as equally good examples of the category technology of course feels awkward. Consider for a moment, however, the relationship between concepts and methods in the context of inquiry. Concepts determine the choice, use, design, and invention of instruments as well as procedures. We use our knowledge of the problem to judge what to do about solving the problem, about what objects to employ, and what steps to follow. More significantly, all physical artifacts invented for and adapted to human purpose embody a conceptual understanding of what the world is and how it works. A hunter’s spear represents knowledge about prey and its behavior just as the skin of the space shuttle represents knowledge about conditions in space.