GUEST EDITARTICLE Technological Literacy: Concepts and Constructs

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The increasingly powerful role of technology in late 20th-century society and the related global concern to establish technology as a component of general, rather than vocational, education has led to an emphasis on the promotion of technological literacy. Such literacy, however, carries a variety of meanings and underpins a range of curricula and other initiatives in the field of technology education. Some of these meanings and initiatives are reviewed here.

Technological literacy is a term of much more recent origin than scientific literacy. This is partly because the institutionalized study of technology as an activity is of more recent origin than the history and philosophy of science and partly because, in most advanced societies, the theoretical and scientific have come to be privileged at the expense of the practical and technological. However, this privilege may itself owe something to the fact that an essential element of technological capability is tacit, rather than explicit. Mitcham (1994) has described technology, "or the making and using of artifacts," as a "largely unthinking activity." He goes on to write that it

> emerges from unattended—to ideas and motives, while it produces and engages with unreflected-upon objects. We make dinner, sew clothes, build houses, and manufacture industrial products. We use tools, turn on appliances, answer phones, drive cars, listen to radios, and watch television. In our technological society, all this happens mostly by habit—but even in less technological-framed cultures, the context of making and using is not so different, although the minds of making and using certainly are, and artifice is less prevalent. (p. 1)

If tacit knowledge is indeed central to technological capability, then not only is it unlikely to yield readily to scholarly scrutiny but it also presents problems for the accommodation of knowledge within educational systems which, for the most part, are committed to teaching knowledge and understanding, which are explicit and of cognitive, rather than practical, significance. Finally, we should also acknowledge that for those for whom technology is merely applied science, technology does not have its own knowledge base, and technological literacy reduces the ability to apply scientific knowledge. The important point here, of course, is that some clarification, and ideally some consensus, about the nature of technological activity is fundamental to defining technological literacy and, beyond this, to devising relevant programs of technology education.

Like scientific literacy, technological literacy is a slogan, not a prescription for action. It serves as a rallying call to which individuals, governments, groups, organizations, and associations can respond positively since they perceive it as advancing their own interests. Differences and tensions are absorbed in a coalition that allows financial and other resources to be marshalled in pursuit of a seemingly common end. However, such a coalition is readily fractured in response to tensions or conflict between the various interest groups when attempts are made to translate technological literacy into curriculum or pedagogic practice. Such a practice, therefore, reflects multiple meanings and interpretations and accommodates a variety of rationales and value positions.

It is also helpful to consider how individuals and societies understand technological change to which technological literacy is, presumably, in some way related. It is now common to refer to the information revolution and to compare it with the industrial revolution in an attempt to signal the major social, economic, and other changes associated with it. Any revolution based on technological change makes some groups of workers redundant while simultaneously creating new forms of employment. In addition, the consequences of any large-scale technological change can never be fully anticipated, and new systems are often a replacement, rather than a development, of what came before. However, technological revolutions are not caused by single technological inventions but constituted in multiple, mutually-influencing technological and social innovations. Human choices, preferences, and values, and the political, social, and moral forms in which they are expressed must be accommodated if we wish to understand what is too easily hidden by referring to a revolution simply as technological. Exposing and scrutinizing such choices, preferences, and values are arguably central to any notion of technological literacy.

For many professional technologists, technological literacy offers the hope of disseminating to the wider public a better understanding of their day-to-day work and, thereby, of strengthening public—and in a broad sense, political—support for their activities. From

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this perspective, technological literacy is essentially concerned with an understanding of, and sympathy towards, technological capability.

In recent years, it has often been the economic instrumentalists who have been prominent in pressing the case for greater technological literacy. The emphasis here is on the relationships between such literacy and economic prosperity, even though these relationships are very inadequately understood and many of the underpinning assumptions are of questionable validity. Nonetheless, it is difficult to gainsay the general observation that modern technologies are transforming not only the nature and location of work but also the perceptions by many individuals of their place and role within a global, rather than a local, community and that such transformation requires changes in education and training to give greater emphasis to the necessary skills and attitudes. In many countries, these changes are already underway, though the nature and pace of change varies. Responsibility for enhancing technological literacy in response to these changes often lies as much with employers as with education systems, although partnerships of various kinds are of growing importance. Some caution is necessary, however, in basing the case for technological literacy on economic grounds. The contribution of education to economic prosperity is important but limited. If investment in technology education designed to promote technological literacy fails to deliver increased prosperity, then political and other support for such education will decline and current attempts to accommodate technology within general education will fail. This is why other rationales are important, not least the claim that technology has something unique and valuable to offer to the education of all students.

Arguably, more attention needs to be given to promoting this claim. Doing so will require help from those, notably historians and philosophers of technology, whose prime concern is not technological literacy. Such experts can help clarify the boundaries between what is, and what is not, technology and provide an intellectual framework that allows us to engage in the necessary conversations. Mitcham (1994), for example, provides a fourfold categorization of technology as object, as knowledge, as an activity, and as volition, each of which he explores in detail. Thus, his analysis of technology as activity embraces crafting, inventing, designing, manufacturing, working, operating, and maintaining. This seems to speak directly to any understanding of technological literacy, as does his exploration of the relationships between his four categories and the different ways in which we understand or perceive our relationships with the technological world we have created.

Linking technological literacy to economic growth is a common feature of the debates about sustainable development. Such development, it should be noted, is not a concept restricted to countries with a low per capita income since, in all cases, the emphasis is on the modification of the biosphere and the application of human, financial, living, and nonliving resources to satisfying human need and improving the quality of life. There is also an emphasis on meeting the needs of the present without jeopardizing those of future generations. Answering the question "How can development be sustainable?" is a far from straightforward task, but the broad goal for technological literacy is clear. It is to help to make the best practicable use of natural resources for the welfare of the people.

Such a goal highlights the conative and political dimensions of technological literacy. For defenders of participatory democracy, such literacy offers a means of challenging and, if necessary, countering technological expertise. At the heart of the matter is accountability, whether this be of expert élites or, as the technological research agenda becomes increasingly subject to political control, of politicians and other and wider constituencies. While such an understanding of technological literacy is difficult to oppose in principle, it presents formidable practical problems, not least in giving substance to the notion of participation and in establishing mechanisms to facilitate it. The fate of the Ethics and Values in Science and Technology program, financed by the National Science Foundation (NSF) in the mid-1980s, serves as a reminder that interrogation can sit uncomfortably within many educational programs and institutions and that it is rarely welcomed by those who see themselves as being interrogated, especially if they are providing the funds to sustain the interrogation.

These conative and political dimensions have also received attention from some feminist scholars who see technological literacy as offering, as a minimum, a means of addressing some social, economic, or other imbalances related to technology and, at the other extreme, an opportunity to construct a politically radical technology education. The issues have been well outlined by Appleton and Ilkkaracan (1994) and Hynes (1989), and it will be sufficient to note here that technological literacy offers an opportunity to many girls and women to counter and redress gender biases that have been established within present-day technol-

ogy. Again, some re-evaluation of priorities, some recasting of technological problems and their solutions, are likely to be entailed.

Given the multidimensional and contentious nature of technological literacy, technology educators have inevitably found it difficult to give curriculum and pedagogic substance to technology as a component of general education. There is, therefore, a range of diverse courses and programs. Some reflect distinctions drawn within a hierarchy of technological awareness, technological competence, technological capability, technological creativity, and technological criticism (Todd, 1991). Others can be categorized in terms of the ways in which individuals relate to technology, for example, as receiver, user, maker, monitor, or critic (Layton, 1993). Appealing though these and other hierarchies might be, they are also beguiling and lack any empirical foundation. More importantly, they add up to a demanding and sophisticated profile for any student, teacher, or lay citizen and one which suggests that, rather like scientific literacy, technological literacy is in some danger of being burdened with responsibilities it cannot realistically hope to meet. Well-grounded and replicated studies of technological literacy are notable by their absence, and there is a pressing need for research studies into children's and adults' understanding of technology, comparable to some of those already in place in science and mathematics.

A more pragmatic approach to imposing a degree of order upon the diversity of programs of technology education is evident in the useful typology devised by de Vries (1994). Although this typology was prepared with the education systems of Western Europe in mind, it can be readily extended to other parts of the world. De Vries uses six descriptors to classify the programs which he reviews. These descriptors relate to such issues as the kinds of activities that students carry out, the way in which classrooms are equipped, the way teachers are educated, gender, and the concept of technology that students will develop. On the basis of these descriptors, de Vries has distinguished approaches to technology education that he describes as craft-oriented, industrial/production oriented, high-tech, applied science, general technology, design, key competencies, and science, technology, and society (STS). It is important to acknowledge that these approaches do not define existing technology programs but attempt to identify elements and characteristics that allow them to be differentiated in some conceptually useful way.

Two issues need to be emphasized by way of conclusion. The first is the importance of context in characterizing and giving meaning to technological literacy. In a country such as India, where citizens experience technology as part of broader social issues such as pollution, environmental protection, population growth, health, and hygiene, any conceptualization of technological literacy is likely to be driven by these concerns. In China, which raises almost a quarter of the world's population on about 7% of the world's land, the emphasis is likely to be upon practical production skills within the rural community. In some technologically advanced countries, the emphasis may be upon revaluing the practical and the technological to allow their accommodation and integration within the family of activities regarded as cultural. It would be a mistake, however, to regard these technologically advanced countries as homogeneous. The meaning of technological literacy and of technology education in France, the United Kingdom, and the United States, for example, remains more than colored by the history of these countries, not least by those complex events known as the French Revolution, the Industrial Revolution, and the American Revolution, respectively,

The second issue is the centrality of values to technological literacy, however this is conceptualized. The most obvious general question relates to what technological literacy is for. What, and whose, interests and purposes is it intended to serve? These questions, of course, do no more than parallel questions that can be asked about technology itself. Who benefits, who loses? Who pays? What are the social, environmental, personal, or other consequences of following, or not following, a particular course of action? What alternative courses of action are available? These questions are not always, and perhaps only rarely, going to yield agreed answers, but addressing them is arguably fundamental to any educational program that claims to advance technological literacy for all.

The cultural dependence and conative dimensions of technological literacy point firmly, therefore, towards a variety of educational programs and diversity in the form of institutional provision. This also distinguishes technology education from traditional science education where the emphasis is on the abstract and universal, and from which the world of values is commonly excluded. The challenge to technology educators is to generate a language that is sufficiently common to permit discourse, yet flexible enough to accommodate the diversity and variety that lie at the heart of technology education.

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