Beyond Bloom's *Taxonomy*: Rethinking Knowledge for the Knowledge Age

CARL BEREITER
Ontario Institute for Studies in Education of the University of Toronto

MARLENE SCARDAMALIA
Ontario Institute for Studies in Education of the University of Toronto

This chapter focuses on how schools could function as places where students become proficient in all aspects of knowledge, including its creation. Traditional forms of knowledge are inadequate because they are based on "mental filing cabinets". New conceptions are based on enabling learners to construct knowledge drawing on a range of information enabling them to obtain greater depths of understanding which they can apply in new situations.

From two quite different sources comes a similar message: Knowledge is far more important than has previously been realized. One source is the study of wealth creation and economic competition. From this source come such as-yet little understood ideas as knowledge-based economy, knowledge workers, and knowledge as an economic product and as a dominant 'means of production,' taking precedence over labor and capital (Drucker, 1993). The other source is cognitive research, now spanning three decades, on the nature of expertise. This research has demonstrated with great consistency and in many different domains that experts are distinguished from non-experts mainly by the extent and depth of their knowledge, not by their mental abilities, thinking skills, or general cognitive strategies (Chi, Glaser, & Farr, 1988).

These ideas have begun to have an impact on the thinking of educational reformers. In particular, many curriculum reforms are afoot that emphasize depth of understanding. Yet an examination of both the products and the rhetoric of many programs for educational change will reveal that they are based on the conception of knowledge that was current forty years ago, and whose roots go back not only to before the 'cognitive revolution' and before the advent of the 'knowledge society' but to before the printing press and the microscope. It is a conception that trivializes knowledge and subordinates it to a panoply of intellectual abilities and skills of doubtful teachability. It is a conception that fixes knowledge within individual minds and therefore can make little sense of the social and economic role of knowledge.

Our objective in this chapter is to advance new ways of looking at knowledge that are more consistent with current understanding and with the ascendant social

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importance of knowledge. The old way of conceiving of knowledge is well represented in an important and still influential work of four decades ago, the *Taxonomy of Educational Objectives, Handbook I: Cognitive Domain* (Bloom, 1956), more familiarly known as Bloom's *Taxonomy*. This taxonomy played an important role in expanding the scope of curriculum objectives and achievement testing beyond those of itemizable subject-matter content, but at the same time it served to entrench the idea that knowledge is only such items of content. In the taxonomy, knowledge occupies the lowest of six levels of cognitive objectives. In explaining this level, the authors suggested that the reader

> . . .think of knowledge as something filed or stored in the mind. The task for the individual in each knowledge test situation is to find the appropriate signals and cues in the problem which will most effectively bring out whatever knowledge is filed or stored (Bloom, 1956, p. 29).

The higher levels of the taxonomy – Comprehension, Application, Analysis, Synthesis, and Evaluation – were conceived of as "intellectual abilities and skills." They constituted the person's capacity to operate on the contents of the mental filing cabinet. Contents of the filing cabinet might go out of date and need to be changed, but the intellectual abilities and skills would continue to serve the person throughout life. Accordingly, they were the objectives of most long-range significance for education (pp. 38–43).

These ideas should sound familiar. They are part of the rhetoric of contemporary educational reform. They do, of course, have some validity. Some knowledge does go out of date (although the great bulk of what we know does not). What one can do with knowledge *is* crucial. But the limitations of these ideas, which we will explore more fully in later sections, can be glimpsed at by considering how they could serve to answer two questions: (1) What does it mean to have a deep understanding of something? (2) In what way is a knowledge worker different from any other kind of white-collar worker? A conception of knowledge that is of no help, that may even get in the way of answering questions such as these, is surely in need of updating itself.

EMERGENCE OF THE KNOWLEDGE SOCIETY

Taken at face value, terms such as 'knowledge-based economy' and 'knowledge society' do not carry much meaning. When was there ever an economy that was not based on knowledge applied to producing or acquiring tradeable goods? What society does not embody the accumulated knowledge of its past? To impart meaning to these terms, we need to look at historical changes in the status of knowledge.

Throughout most of the human past, knowledge was embedded in traditional practices, tools, and myths. Practices, tools, and myths evolved over time, and in this sense knowledge grew. But, said Whitehead (1925, 1948, p. 91), "[t]he process of change was slow, unconscious, and unexpected." Major advances occurred in response to new conditions, which continues to be the case in traditional societies.

But there was little capacity to envisage and create new conditions. That would have required a detachment of knowledge from its embedding practices and myths, so that ideas could be manipulated and recombined in a speculative way.

Such a detachment or, as we shall say, *objectification* of knowledge began to take place in all the major civilizations a few thousand years ago. Many social factors conspired to bring this about, but the invention of writing systems undoubtedly provided a powerful tool (Olson, 1994). Philosophers, historians, mathematicians, and theologians began to appear. These, along with attendant librarians and scribes, became the first knowledge workers. Knowledge work differed from that of the present day in three important respects, however: (1) There was no general conception of a *state of knowledge*, which advanced through the cumulative contributions of knowledge workers; (2) Knowledge work was not applied to practical arts. Such knowledge continued to be embedded in the various trades and crafts, evolving slowly and with little crossover from one trade to another; (3) Knowledge work of any kind was the province of a tiny minority of the working population.

With the Industrial Revolution came the deliberate application of knowledge in the advancement of practical arts. Yet, according to Whitehead (1925, 1948, p. 92), it was not until the nineteenth century that we got "the full self-conscious realization of the power of professionalism in knowledge in all its departments, and of the way to produce professionals, and of the methods by which abstract knowledge can be connected with technology, and of the boundless possibilities of technological advance." This led to what he called "disciplined progress," progress achieved through the deliberate and orderly pursuit of solutions to theoretical and technical problems.

The next and current stage in the evolution of knowledge work is not very well defined. Peter Drucker, who coined the term 'knowledge society,' dates its emergence as the end of World War II. The change, he said, is that knowledge began to be applied to knowledge, whereas previously it had been applied to materials and to work. This rather barren definition may gain more meaning through use of an analogy. What comes to the silversmith's workbench is silver and what leaves it is still silver, but it is worth more than it was before. The silversmith's work has *added value* to the silver. Similarly, what comes to the knowledge worker's desk is knowledge and what leaves it is also knowledge, but the knowledge worker has done something to add value to it. What arrives might be market research; what leaves might be the draft of a marketing plan. What arrives might be functional specifications for a new software application; what leaves might be technical specifications. What arrives might be excerpts from airline schedules; what leaves might be an itinerary. What arrives might be student journals; what leaves might be entries by the teacher that stimulate further thought. What arrives might be customer complaints; what leaves might be ideas contributed to a design database, or what leaves might be only an organization of the complaints into useful categories. Knowledge work may go on at different levels. It need not always be creative, but it must in some fashion render the knowledge more meaningful, accessible, reliable, relevant, or applicable to particular purposes. Clearly, it takes

knowledge in order to do this. In order to organize the customer complaints into a useful set of categories, you need more than 'classification skills,' whatever that might mean. You need to understand the product or service customers are complaining about and you need to understand the contexts within which those complaints are arising and what capacities the organization has for responding. This, as we take it, is the sense in which knowledge work means applying knowledge to knowledge.

We are not intellectual historians. The preceding sketch is highly derivative and no doubt flawed but its main theme is, as far as we are aware, uncontroversial. That theme is the gradual shift from knowledge being completely embedded in practice, myth, and artifact to its becoming objectified as abstract objects that are recognizable human creations and that can be described, compared, criticized, disseminated, improved, discarded, rediscovered, and so on. An important question, accordingly, is whether education has kept up with this transformation. "Professionalism in knowledge," which Whitehead dated from the nineteenth century, can certainly be found in many classrooms, but the literature on teacher professionalization would indicate that it is still to be fully realized. As for students functioning as knowledge workers, engaged in adding value to knowledge, however, this is virtually unheard of except at postgraduate levels. Bringing such a conception into elementary and secondary schooling is a new challenge, which later sections of this chapter will address.

EXPERT KNOWLEDGE

Research on the nature of expertise has been one of the most active areas of cognitive research. The earliest research on expertise, which set the paradigm for much of what followed, dealt with experts at chess. This was a fortunate choice because there was already a firmly established conventional belief that the essence of skill at chess is reasoning ability. To this day, chess is fostered in some school programs as a means of teaching children to think (Marjoram, 1987). However, it was found that chess grand masters did not differ from lesser players in reasoning out the consequences of possible moves. The difference was that grand masters only reasoned about good moves. This seemed to deepen the mystery, but another finding offered a clue. Grand masters had a phenomenal ability to memorize whole chessboard configurations at a glance. Yet it was not that they had generally superior memory abilities. The ability was confined to chessboard configurations and – most interesting of all – only to *meaningful* configurations, which is to say, arrangements of pieces that might actually occur in a well-played game. Give them a randomly arranged chessboard configuration and their ability to memorize it was not much better than that of a novice.

Through a series of ingenious experiments and analyses, Chase and Simon (1973) deduced that the secret of the chess experts' performance was that they knew from memory tens of thousands of patterns in which chess pieces might be arranged. A particular chessboard configuration would consist of a combination of several of

these patterns. For them to memorize a chessboard layout in a few seconds was no more difficult than it would be for you to memorize a sequence of 30 letters of the alphabet when they form a readable sentence of four or five words – as compared to what it would be like to memorize the same letters randomly arranged. Thus the secret is knowledge, but not a kind of knowledge that had been appreciated before. It is far vaster in quantity that the knowledge we commonly recognize. It is not readily verbalizable; those who have it are typically not even aware of it. And yet it is integral to what we generally regard as highly intellectual activity.

Similar experiments have been done in many other fields – various sports, medicine, computer programming, weaving, music. In all of them the same kind of evidence shows up indicating vast knowledge of patterns relevant to the activity. But not just any patterns will do. Given textbook physics problems involving pulleys, inclined planes, and the like, novices as well as experts can sort the problems into meaningful categories; but the categories of the novices are based on surface features – pulley problems in one category, inclined plane problems in another, and so on – whereas the categories of the experts are based on the laws of physics that are applicable.

Principled pattern knowledge evidently lies behind a great deal of what we commonly attribute to mental abilities and intuition. The novice physician looks at a patient and sees a dumpy person with thin, oily hair; the skilled internist looks at the same person and sees a familiar pattern of thyroid deficiency. The novice editor sees a 40-word sentence and breaks it into two disjointed sentences. The expert editor sees a 25-word noun clause and changes it to a free modifier, thus rendering the 40-word sentence easy to read. The star quarterback or infielder decides in a split second on a play so brilliant that it takes the sportscaster a minute and a half to explain its rationale. Could the player actually have thought all that out? Of course not. It was a matter of recognizing a principled pattern – principled in the sense that it encapsulated the principles elaborated by the sportscaster.

The lesson in this, however, is not that we should be teaching students tens of thousands of patterns. If there is a place for pattern training at all (which there may well be) it will be at advanced stages of mastering very specific jobs or problem domains. Experts do not generally learn patterns directly but as a byproduct of striving to achieve goals in their domains. Their pattern knowledge is principled by virtue of their pursuing principled goals, trying to get to the bottom of things, reflecting on their mistakes, making use of principles to understand what they are doing and the phenomena they encounter (Bereiter & Scardamalia, 1993).

A better way of approaching the educational implications of pattern knowledge may be the following: With experience, everybody acquires pattern knowledge. That is just how our brains work. They are pattern-learning devices (Margolis, 1987). The only question, therefore, is what kind of patterns will be learned? Will they be patterns that support resourceful, principled action and that keep being elaborated and enriched as experience grows or will they be patterns bound to surface appearances, limited in their potential for growth, and supporting mindless, stereotyped behavior? Schooling should be able to do something about this, even though most pattern learning will take place outside school.