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there is little reason to anticipate significant improvement in the near future.

What this means for instructional development is fairly clear. Colleges and universities, if they go the development route at all, will be forced to do so with one or, infrequently, two full-time developers. Some universities may field large teams if the specialist members take joint appointments that involve additional academic or administrative activities elsewhere in the university. This arrangement eases the purse strings but carries with it the very real danger that team development activities may suffer, particularly if joint appointees find that promotion appears to hinge on their nondevelopmental pursuits rather than on their developmental success.

I have heard one argument that calls for the training and placing of specialists in the superb teams that now exist at eight or ten of our largest universities. This strategy suggests that educational products and replicable instructional processes be developed at these sites and packaged for dissemination to other colleges and universities, where a developer-generalist would implement them. This idea preserves development roles for generalists and specialists, and makes fiscal sense—but probably would not work. Whatever the reasons are that prevent departments within the same university from sharing jointly development courses, their effects are even stronger between different colleges and universities, so that amortization of development costs over several institutions seldom occurs.

My concern in this short article is that some of our finest graduate programs in instructional technology are selling short the role of a desperately needed professional—the generalist-instructional developer. When trained *generally,* in the best sense of the word, the generalist-developer fills a vital role, whether in an individual or team setting.

To illustrate the role of the developer among a team of instructional specialists it is necessary that we examine the definition of instructional development. If we disregard for the moment differences in educational jargon, we recognize that most people view it as the over-arching set of activities whose result is the facilitation of learning. Any individual who goes by the title *instructional developer,* by definition, must be aware of and have authority over all such activities. If this seems an unrealistic role, perhaps our conception of instructional development is at fault or maybe we are suggesting that only managers or project directors qualify as instructional developers in team settings. In either case, a special set of skills is called for.

The role of the lone developer is complicated by his relative isolation from instructional specialists. He may find himself in the awkward position of doing the specialty tasks and, unfortunately, doing none of them very well. Even more tragic is the specialist-gone-developer who is so enamored with his specialty training that he tends to ignore the other important activities in development.

Unless I am being extremely inaccurate, it appears that many, perhaps most, instructional developers are not instructional developers at all. They are instructional specialists who are finding their way into an as yet generalist profession. It seems obvious that consumers of the development process are judging the potential of instructional development by the professionals we now field from specialist graduate programs. □

Point of View

Education for Innovation: Beyond '21st Century Skills'

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The Innovation Imperative

The Organization for Economic Co-operation and Development (OECD) has started referring to contemporary societies as "innovation-driven." Innovation is becoming recognized as not just a priority for individual organizations but as an imperative for whole nations and regions. At the same time, it is becoming recognized as an educational imperative. Governments can do only so much by establishing innovation centers, providing stimulus funds, and removing barriers. Beyond that it depends on the innovativeness of the people.

Improving human capacity for innovation represents a huge educational, child rearing, and even cultural challenge. It ought to be the occasion for deep problem analysis, adventurous experimentation, and new kinds of technological support. We see some of this, but far less than the situation seems to demand.

We propose an *international design lab* to advance the social and technological innovations needed to provide an effective alternative to the currently dominant "21st Century Skills" movement.

No one seriously advocates innovation for its own sake, of course. In current usage, "innovation" stands for a whole cluster of endeavors. These include knowledge creation, problem solving, invention, discovery, imaginative expression, and entrepreneurship. Together they constitute the

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creative aspect of progress, progress achieved through the production and application of new knowledge and not limited to the economic sphere but inherent in the whole contemporary effort to improve the human condition through creativity. When we use the terms "innovation" and "education for innovation," we reference this larger conception, which we believe is the one that needs to inform educational policies.

21st Century Students: Learners of Testable Skills, or Thinkers of Significant Thoughts?

The models guiding education's response to the 21st Century innovation challenge date from the early 1950s. This was an in-between period in education. John Dewey had published his last major work in 1949, and the wave of innovations in science education inspired by Sputnik had not yet begun. The gap was filled by statistics and measurement specialists, with factor analysis as the most influential technology. Factor analysts identified a set of testable mental abilities, which many educators relabeled as thinking skills and set about trying to teach.

In the days of Dewey, Whitehead, and Russell, "teach children to think" meant help children develop into serious, productive thinkers. A statement appearing frequently on the Web and attributed to Bertrand Russell expresses the classical view:

> *When you want to teach children to think, you begin by treating them seriously when they are little, giving them responsibilities, talking to them candidly, providing privacy and solitude for them, and making them readers and thinkers of significant thoughts from the beginning. That's if you want to teach them to think.*

There is no mention of skill here. The classical view regarded learning to think as a matter of what in contemporary parlance would be called a mindset—a way of relating to the world of ideas. The explicit treatment of thinking as learnable skilled behavior can perhaps be dated from 1947 and the publication of the first in a series of curriculum materials titled *Learning to Think,* authored by T. G. Thurstone, whose career up to that point had been in mental test development. The itemization of thinking skills received a major boost in the 1950s from the publication of Bloom's *Taxonomy of Educational Objectives,* which proposed a ladder of skills, with Knowledge as the lowest rung and Evaluation as the highest. During the same period, J. P. Guilford published a series of factor analytic studies that defined a matrix of more than a hundred mental abilities for educators to grapple with as learning objectives. By 1987, B. Z. Presseisen summarized school policies and practices in terms that stand in sharp contrast to the terms used by Russell:

> *The most basic premise in the current thinking skills movement is the notion that students CAN learn to think better if schools concentrate on teaching them HOW to do so.*

There is no disputing the value of creativity, problem-solving ability, critical thinking, and other such traits, but when these personal attributes are designated as "skills," serious questions arise concerning teachability and transfer. It is certainly possible to raise test scores by direct means, such as strategy instruction and practice exercies, and less certainly by indirect means, such as project-based learning. But it has not been demonstrated that such test score gains have any real-life significance, and a century of research on transfer of learning gives little reason for optimism. What is worse is that activities devoted to "21st Century skills" may actually lower educational quality. They constitute additions to the curriculum that, besides overloading it, may actually disrupt the pursuit of understanding.

One can find examples on the Web of teachers proudly using a checklist of skills to be covered in subject-matter lessons, with special activities designed to exercise those skills. If carried too far, this cannot help but produce fragmentation and disruption of the coherent building up of complex concepts. Equally important from the standpoint of education for innovation, the 1950s style of thinking militates against the discovery of new competencies arising from new possibilities and new challenges.

The 1950s style of thinking presupposes that learning goals are to be set in advance by experts and stakeholders, after which means of testing and teaching them are to be worked out empirically. That way of thinking, which is still to be found explicitly in some "21st Century skills" approaches, may have been appropriate during a period of relative stability but is radically out of synchrony with today's world.

Learning to Innovate by Innovating: Enculturation into Knowledge-Creating Communities

What alternative is there as a means of educating for innovation, other than naming, testing, and attempting to teach relevant skills? The time-honored fallback is *learning by doing.* It is the way we pick up most of our everyday skills and knowledge. It is also the mainstay of doctoral study in research universities, where students do research or design things that are not merely novel but that advance the state of the art or knowledge in their field. Of course, the "doing" must faithfully capture the essence of the targeted competency. You do not learn to be a pastry chef by making mud pies. Unfortunately, "learning by doing" has become a cliché tied to concrete actions involving concrete objects. To understand learning to innovate by innovating, it is essential to recognize that *working with ideas is also learning by doing*.

In order to actually "do" research, students must venture beyond potted experiments designed to teach control of variables and operate in what we have termed "design mode"—tackling ill-structured authentic and complex "why?" questions, identifying promising possibilities, and carrying out research to find better ways.

Social and technological innovations are required to support sustained creative work with ideas and to help student communities self-organize around goals of advancing their collective state of knowledge. Such technology needs to be maximally supportive of knowledge creation, with feedback that empowers students and teachers. Bertrand Russell, as quoted above, called for enculturating students into the society of "thinkers of significant thoughts." The 21st Century challenge is to ensure that students become

creators of significant thoughts themselves. The creative role of dialogue is widely recognized in the knowledge-creation literature as an essential component. Technology must support students in knowledge-creating dialogue throughout their educational interactions and overcome the loss of continuity that results form separate and only loosely connected discourses scattered across wikis, blogs, text messages, online forums, and multiple devices.

Black-box intelligent technologies and learning analytics need to shift from charting and directing skills acquisition to enabling students to do the thinking. Assessment must become internal to the collaborative knowledge-creating process.

Beyond these innovation challenges, the main obstacles to doing genuine knowledge creation at lower educational levels are two beliefs: a belief that knowledge creation, which generally amounts to some form of theory building, lies beyond young students' abilities and interests, and explicit or implicit adherence to a traditional principle that reduces to "learn first, innovate later."

We have devoted most of our past 35 years of research to showing that these beliefs are wrong-headed. There is some truth in them, but not enough to justify turning our backs on an approach that characterized knowledge-creating organizations and that made research universities engines of progress in the modern world.

Children can invent, tackle authentic problems, and produce explanations that account for facts. They can modify or replace their ideas on the basis of new information. This does not make them Curies, Edisons, or Einsteins, but it does mean they differ only in degree from scientists, inventors, designers, and scholars who earn their livings as knowledge creators.

"Innovate from the start, learn in the process" is a viable alternative to the learn-first rule, and one that is more in the spirit of an "innovation-driven" society. An educational approach that embodies this alternative principle and that makes innovation, in its most inclusive sense, the heart of the curriculum goes by the name of "Knowledge Building." In Knowledge Building the emphasis shifts from personal knowledge acquisition to the production of public knowledge. We suggest that Knowledge Building can serve as the platform for designing educational methods that bring all the varied meanings of "innovation" into the educational program: knowledge creation, problem-solving invention, discovery, creative expression, and entrepreneurship.

Highly compatible with Knowledge Building are most of what bear labels such as "constructionism" and "design thinking." While Knowledge Building is compatible with a number of activities intended to modernize schools, simply adding activities, regardless of how powerful they may be, to the current structure will not produce the level of change needed. For that we need to reshape schools into knowledge-creating enterprises, occupying the same multifarious problem space as those in the world beyond the school.

New social and technological environments will play an essential role, but the focus must be on supporting sustained creative work with ideas—and supporting it so effectively that collaborative knowledge-building interactions become the norm for educational engagement. This norm must be understood and maintained by students, as they are the ones who need to generate ideas, identify the most promising, and improve them through sustained creative work.

If problem formulation and idea improvement remain the responsibility of teachers and curriculum and technology designers, this excludes students from essential parts of the innovation/knowledge-creation process.

Thus, the principal challenge in designing more powerful knowledge-building communities and technology is support for users in taking collective responsibility for knowledge advancement. Ideally there should be an unbroken continuity between schooling and adult creative knowledge work, and both the pedagogy and the technology should be designed to make such continuity possible.

Building Cultural Capacity for Innovation: An International Design Lab

"Building Cultural Capacity for Innovation" (shortened to "BCCI") is an international design, research, and development initiative to build cultural capacity for innovation in developing and developed nations, at all educational and socioeconomic levels. International partners are united by the idea that large increases in a society's innovativeness requires building cultural capacity for it, starting in early childhood, aimed at democratizing knowledge creation, and continuing through progressive development toward adult life and work in knowledge-based societies. BCCI is a research-intensive enterprise dedicated to the 21st-Century principles of *a place for everyone and knowledge for public good.* BCCI research not only tests but creates innovations.

Although different cultures and different conditions call for different practices in education and child rearing, education for innovativeness implies certain common goals. Regardless of how they go about it, societies seeking to become more innovative in today's world must develop citizens who:

- Enjoy taking risks with ideas and work at improving their own and their community's ideas.
- Carry out sustained work with ideas rather than being limited to brainstorming and other short-term efforts.
- Have distinctive personal ways of contributing to collaborative knowledge creation, adapted to their individual capabilities and dispositions.
- Are well-grounded in science and humanities and appreciate their role in a progressive society.
- Thrive on complexity and idea diversity.
- Identify personally with the worldwide effort to advance knowledge frontiers.

BCCI aims to provide a relatively clear-cut way of going beyond the teaching and assessment of "21st Century skills." By engaging students and teachers as active participants, along with researchers, engineers, and policy-makers, we aim to provide sustainable and scalable pedagogical and technological models with potential to exceed existing curriculum standards and expectations. □