

# Preparing People for Rapidly Changing Environments

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The October 2006 issue of the *Journal of Engineering Education* describes a landmark set of activities called the National Engineering Education Research Colloquies (NEERC) that explored how rapid changes in the world require new ways to educate future generations of engineers. The argument is not simply that we need more engineers than we have had in the past; instead we need a *transformation* in how we educate future engineers [1].

Many people in the learning sciences have also been exploring the need for educational transformations, and it seems clear that our different research communities have a great deal to learn from one another. Opportunities I have had to work with the VaNTH Bioengineering Center (VaNTH.org; [2]) convince me of the immense value (to me at least) of collaborations such as these.

Currently, my colleagues and I in the LIFE Center (Learning in Informal and Formal Environments (LIFE-SLC.org)) are finding it useful to juxtapose several research literatures that include: (a) expertise and its development [3–5]; (b) transfer and its implications for assessment [6–7]; (c) change and innovation [8–11]; and (d) design strategies for promoting and managing change [12–14]. The act of juxtaposing these different literatures has generated a number of interesting questions. I discuss five that I hope are useful to raise.

## I. HOW IS OUR WORLD CHANGING?

An answer to this question is not simply that we now face global competition and hence have to work harder to educate more people. My reading of the innovation literature [8–11] suggests that the major factor to address is the increasing rate of change.

Not so many years ago, companies could come up with an innovative idea for a product or service and gradually refine it for 25 years or more. People could develop particular kinds of expertise and be successful for a lifetime. This made it possible for educational institutions (e.g., community colleges, four-year institutions) to teach job-specific skills and knowledge and know that most of this would still be useful in the workplace.

Today, innovation cycles are often very short and educational systems are often insufficiently nimble. As educators, we may end up training students in specifics that are no longer useful once they reach the workplace. Some suggest that preparing people for change requires that we rethink our characterizations of “expertise”.

## II. RETHINKING CHARACTERISTICS OF EXPERTISE

It is often stated that experts are able to solve problems by applying previously learned (e.g., schematized) skills and knowledge in new settings. This is true, in part. If we encounter a problem that seems similar to previously solved problems, we are much more efficient at solving it [4, 15]. Nevertheless, people who function in rapidly changing environments must learn to navigate in situations where they are at the edges of their existing knowledge. Following the seminal work of Hatano and colleagues, a number of researchers are beginning to explore the idea of “adaptive expertise” as a concept worthy of in-depth study [16–24].

Many of the early studies of expertise [4]—while extremely useful—did not focus on the thinking and behaviors of experts when they encountered novel (for them) problems and innovations. The early studies of expertise tended to compare experts with novices, and the experts were often given problems that—because of their previous experiences—were well schematized and hence relatively routine.

Ericsson’s work on world-class experts in chess and other domains [25] provides an illuminating picture of the constant innovation and restructuring needed to be successful at high levels. As they developed their expertise, Ericsson’s experts resisted premature automatization of skills and procedures and continually pushed themselves to new heights. In contrast, others reached a plateau and failed to make further major advances. Ericsson does not refer to his world-class experts as adaptive experts, but I think it is a useful term for describing them; it highlights the process of intentionally seeking new challenges and insights rather than resting on one’s laurels.

The term adaptive expertise also seems useful for characterizing people who are not necessarily world-class in their fields but are still highly adaptive and innovative [26]. The value of exploring different expressions of expertise is illustrated by opportunities to interview leaders in technically-sophisticated workplaces. They have told us that, over time, employees often become so efficient in their jobs that they can do the work required of them in less time than their eight-hour workday. Some reinvest their spare time by pushing themselves to learn more and find ways to improve [19]. Others seem content to use their spare time in ways that are relaxing but less productive for their company. Both groups are experts at their particular jobs—but they seem to behave in different ways.

## III. NEW UNITS OF ANALYSIS?

Should we assume that some of the workers noted above are simply more motivated and adaptive than the others? Many theorists (see [24] for examples) wisely emphasize the need to consider

“people in social-cultural contexts” as the unit of analysis that we as a field need to explore.

The idea is that all of us function within a variety of settings that include social-cultural supports and barriers. These are often invisible but can have major effects. For example, it is possible that a worker who rests on his laurels during extra company time (see above) may exhibit a very different attitude and behavior in different social and organizational settings—especially those that provide strong peer support for contributing to teams.

Similar sets of social constraints affect students. Researchers in the LIFE center find that a student may look only mildly proficient in school (e.g., chemistry class), yet may spring to life in informal settings where there are opportunities to choose one’s own tasks that have real consequences for the lives of family and friends (e.g., making perfumes that are tailored for particular people in their lives [27]). In addition, many students innovate in informal settings in order to pursue their chosen activities, yet may not seem innovative in school [28, 29].

Examples such as these suggest the need to study adaptive people and adaptive organizations. The two go hand-in-glove, and social-cultural analyses are important for understanding human action in settings that range from schools to workplaces to after-school [24, 30].

#### IV. HOW CAN WE HELP PEOPLE BECOME MORE ADAPTIVE AND INNOVATIVE?

How can we help people move along trajectories toward adaptive expertise? It will not be sufficient to simply have people memorize statements about different kinds of expertise. Still, knowledge and its organization is important for flexibility, and one fruitful strategy is to explore “mid-level” knowledge organizations (perhaps systems theory and systems design) that can help people tie together their knowledge in ways that support future flexibility.

Students also need to experience processes of inquiry and innovation—including the struggles and doubts. *Then* it can be helpful to make their experiences explicit by putting names to what they went through, and helping them refine their innovations by connecting them to expert knowledge [31–33]. The hard part of being adaptive and innovative is that it often forces us to change ourselves, our environments, or both. These changes can evoke strong emotions and take us away from our momentary efficiencies and comfort zones by forcing us to unlearn old skills, tolerate momentary chaos and ambiguity in order to move forward, and—at least occasionally (and perhaps frequently)—be in positions where we must take risks and be wrong [33].

Different configurations of social and organizational supports and hindrances affect the motivation and risk-taking that often accompanies innovation. Helping students learn to see how their thoughts, emotions and behaviors are influenced by particular kinds of organizational and cultural settings seems to be extremely important. They will then be in a much better position to thoughtfully design effective environments that can help them and their colleagues do their best work [12–14].

#### V. NEW METRICS FOR SUCCESS?

Exploring ways to prepare people for fast-changing environments also suggests the value of expanding our views of metrics for

success. For example, several studies show that typical “one-shot” assessments of peoples’ abilities to directly apply previously acquired skills and knowledge is often too blunt an instrument to show signs of being on a trajectory toward adaptive expertise [31–33].

It is also useful to think about new metrics for judging our *teaching successes*. One might be as follows: If students are unable to show at least some examples of innovative ideas and procedures that add to our knowledge as teachers, we may be too constraining in how we teach.

In engineering, many opportunities exist beginning in the early years of the program to assign students projects that help them work—often collaboratively and *ideally with clients* under faculty guidance—to develop innovations that are truly useful (e.g., see Olin College, <http://www.olin.edu/on.asp>). These do not have to be patentable innovations, of course; they merely need to be new for the students involved in the classes [10]. Helping students explicitly articulate the processes and struggles that led to their outcomes should help prepare them to function more effectively in new environments [33].

Another metric for successful course design might involve a greater emphasis on the degree to which we truly prepare students for future learning. As an illustration, O’Mahony and colleagues [34] redesigned workplace courses for engineers to learn about new kinds of materials such as composites. The people in any particular course often came from many different parts of the company and did not know one another. One of the most positive outcomes of course was the chance to form new social networks that they could utilize later in the workplace (e.g., people knew whom to contact for more information). During the course, these networks were established by giving people chances to work collaboratively on job-relevant problems to see how their particular sets of skills and knowledge complimented one another.

To make this collaboration happen, new approaches to instruction had to be developed that supplemented the older “lecture only” instruction which—while brilliantly taught—provided almost no opportunities for people to interact and learn from and about one another so that they could use technology to continue to connect later on.

Overall, it seems clear that we could also do more in our classes to prepare students for future learning. For example, we could help them learn to innovate in order to work smarter [33], and we can help them build digital suites of information, tools, and access to networks of expertise (e.g., fellow students with particular sets of skills) that they can draw upon and add to as they go through school, and then use after they graduate.

#### SUMMARY

The work of the NEERC is exemplary and this journal is doing an outstanding job of building a new, collaborative learning community. As a learning scientist, it is exciting to have the opportunity to interact with this community and work on issues that can help us all succeed.

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