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GUEST EDITORIAL

Bringing Cognitive Science into Education, and Back Again: The Value of Interdisciplinary Research

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Most fields reach a stage when the basic science has developed to a point where it can be naturally expanded to real-world applications. Much of cognitive science has reached that level of maturity. The signs that the time is ripe for more cognitive scientists to make their mark on educational practice are abundant. Some signs are conceptual. We have developed over the past half century a basic understanding of many cognitive processes. Some signs are more tangible, such as a growing number of organizations, journals, conferences, publications, and, in particular, funding opportunities that focus on the application of cognitive theory to educational practice.

About 15 years ago, the notion of applying cognitive science to educational practice was budding, as evidenced by some government funding, such as ONR, and funding from private agencies such as the Mellon Foundation and the McDonnell foundation's *Cognitive Studies for Educational Practice* (CSEP) program. Since that time, the trend to fund cognitive-based educational projects has grown. Currently, both the National Science Foundation and the Institute of Education Sciences (and others) fund a number of programs that center on projects that apply cognitive theory to educational problems. A prime example is the *Cognitive and Student Learning* (CASL) research program, featured in the 2006 March and May issues of the APS Observer. This program explicitly encourages researchers to test cognitive principles in educational settings.

But, what business does a cognitive scientist have in the classroom? Usually, none. A great deal of expertise is required to venture out into classroom settings. The hard knocks of classroom research can be avoided by training from those who have already been there, and this type of training is usually not provided in typical cognitive science programs. More importantly, the cognitive scientist shouldn't go at it alone because cognitive theory by itself has generally proven insufficient to cover the host of variables that come into play when considering socially dynamic settings. Very rarely does a cognitive theory apply directly to classroom. And

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trickle down cognitive science has generally failed. Cognitive principles and theories often fall short in the classroom because they fail to consider the complex variables that come into play, outside the learner's mind.

A more optimal scenario is when cognitive scientists team up with educational researchers or learning scientists to explore educational problems from both perspectives. Cognitive theories and principles have a great deal to offer the world of education. However, it is the marriage of approaches and theories across multiple disciplines that is more likely to have a long lasting impact on educational practice. Interdisciplinary collaborations are most likely to make progress both in the classroom as well as refining our theoretical understanding of cognition. This is nothing new to cognitive science – interdisciplinary research is perhaps the heart of it. However, more typically the integration of various fields in cognitive science research is geared toward answering theoretical questions about human cognition. The other side of cognitive science, the application of what we know about human cognition to theoretical and applied questions raised in other fields, is somewhat less common. Central to this editorial, is the application of cognitive science to educational practice.

A claim might be made that the application of cognitive science to education is a different field from cognitive science. For example, perhaps that is the domain of *learning sciences.* On the other hand, learning sciences seems to be somewhat different; that is, it seems to describe the researcher in education who may or may not take a cognitive perspective, not the cognitive scientist who adopts an educational perspective.

This may be splitting hairs. Nonetheless, one question I've been asking myself, since it was suggested that I write this editorial, is how applications of cognitive science to the real world differ from other fields, such as human factors, applied cognitive psychology, Human Computer Interaction (HCI), Artificial Intelligence (AI), or the learning sciences? There is certainly crossover and a member of the Cognitive Science Society is quite likely to be found at one of the respective conferences for those areas. But, is there a factor that distinguishes cognitive science from other fields of research? Perhaps one factor is that research in cognitive science is theoretically guided and motivated. However, many or most fields of research are theoretically guided. Another obvious distinguishing factor is that cognitive science is about cognition and cognitive science research should feed back to our theoretical understanding of some aspect of human cognition. Essentially, if you're not about cognitive theory, you're not in Cognitive Science. However, there is not only a heavy emphasis on theory in cognitive science, but also on instantiated, well specified, and usually computational models of cognition. Thus, taking cognitive science into the real world should not only be theoretically motivated, but also test some aspect of a theory or model. In turn, the results in the real world should optimally provide a feedback loop, back into theory. Ideally, we should engage in a reciprocal, synergistic process between the applied and theoretical worlds. If the goal of a cognitive scientist is solely to better understand cognition, then testing theory in the real world should feed back to theory.

Are there exemplars of this ideal? I think clearly there are and two early cognitive theorists come quickly to mind, John Anderson and Walter Kintsch. Both were leading researchers in the field of cognitive psychology early in their careers (e.g., Anderson, 1983; Kintsch & van Dijk, 1978). Both developed well-respected cognitive models and have conducted basic empirical research to test and further develop those models (e.g., Anderson & Lebiere, 1998; Kintsch, 1998). And, both have worked to answer questions toward improving educational

practice (e.g., Anderson, Douglass, & Qin, 2004; Caccamise, Franzke, Eckhoff, E. Kintsch, & W. Kintsch, in press). Moreover, both have remained theoretically bound, taking lessons learned from educational research back to the lab and their theories.

If you have a theory about learning, memory, knowledge acquisition, language, comprehension, communication, social interactions (and the list goes on), a strong test of that theory is how it survives outside your lab. One of my own goals in research has been to conduct basic research (e.g., McNamara & Healy, 2000; McNamara, Kintsch, Songer, & Kintsch 1996; McNamara & McDaniel, 2004) and also to apply principles of cognitive science to educational problems (e.g., Graesser, McNamara, Louwerse, & Cai, 2004; McNamara, 2004; McNamara, Levinstein, & Boonthum, 2004) and when possible in educational settings (e.g., O'Reilly, Taylor, & McNamara, in press; Taylor, O'Reilly, Rowe, & McNamara, in press). My own philosophy has been that if a certain theory doesn't successfully apply in the real world, there is some probability that it may not be viable as a theoretical framework. Taking ideas out into real world settings, and in particular, messy classrooms, is an excellent venue for observing ideas in action (or not). I'm not, by any means, undermining the importance of laboratory research – we absolutely must have a clear understanding of phenomena under *controlled* conditions before testing theoretically inspired predictions in the real world, and particularly in the classroom. And, I frankly prefer laboratory research because that's what I'm trained to do. But, thinking about and testing strong, well substantiated ideas and theories in less controlled conditions helps to understand the limitations and parameters that might be missed in the lab. Also, problems that occur in the real world can help to understand the parameters of cognitive principles and sometimes, the limitations of cognitive theory.

Will this journal, Cognitive Science, publish your results if you do test your theories and cognitive models in an educational platform? If the past were predictive of the future, the answer may be discouraging. One of my graduate students, Courtney Bell, dutifully counted the number of prior publications in Cognitive Science since 1978 that were applied to education, or potentially applicable. The numbers were low, ranging from 9 to 48, depending on the strictness of the criteria. My best guess is that one principle reason for this low count is because the Cognitive Science Journal is not viewed as a typical outlet for such publications. Although one purpose of this editorial may be to move toward changing that trend, it may be a hard sell to publish a paper in Cognitive Science that is simply an application of an existing theory in a classroom. Also, it's not clear that an application paper would have maximum impact if it were published in Cognitive Science. Nonetheless, it may be encouraging that the majority of the publications in Cognitive Science that we identified as regarding educationally relevant topics were published in the last 5 years (i.e., about 60% of the 48). So, as we move towards a better understanding of cognition, viewing it from multiple angles and in multiple settings may become more integral to the field of Cognitive Science. It's time perhaps that we in cognitive science widen the doors to research in applied settings.

In any case, if you have theories or questions that might relate to education, if you are interested in thinking outside the lab, now is clearly a good time to consider collaborative ventures that involve testing cognitive science in education. The need is clearly there. And, for now, there is some funding. There are clear signs that the time is ripe for cognitive scientists to think about how they can impact the educational world. In my opinion, this approach is fruitful and there's a wide array of problems remaining to be solved.

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