Congressional Testimony of Nancy Butler Songer
Professor of Science Education and Educational Technology
The University of Michigan
www.onesky.umich.edu

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Classrooms as Laboratories: The Science of Learning Meets the Practice of Teaching

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Parents, educators, politicians, and the general public agree that the crisis in American education is severe. Despite the demands for a scientifically and technologically literate public, the challenge to provide quality K-12 science education appears particularly pronounced. Research demonstrates that between fourth and eighth grade, American students' achievement and understandings of complex science decline relative to their peers internationally (Linn, Lewis, Tsuchida and Songer, 2000). For urban students these declines are even more pronounced and, in many inner-city classrooms, the threat of failure fuels enormous pressure to perform well on high-stakes tests causing an unnatural emphasis on "teaching to the test" and other practices which research demonstrates do not result in long-term learning. As a recent issue of *Education Week* (Agron, 1998) states, "It's hard to exaggerate the education crisis in America's cities."

From my viewpoint, this crisis is particularly interesting because I believe my colleagues and I know a great deal about how to foster the learning of complex science and other higher-order thinking skills, yet our research results are not having much direct impact in today's classrooms. Researchers in reading education have made good progress impacting classroom practice, and, in general, have outperformed science and mathematics educators in realizing classroom impact from research results. The comments from a Michigan 6th grade teacher I interviewed this week summarize the current thinking of many when she stated, "even kids that can solve math problems or remember science facts have a difficult time thinking scientifically or thinking conceptually about math. They have math and science beliefs, but they really can't substantiate why they believe what they do."

What can be done to facilitate greater impact of learning research on the practices in today's classrooms? I suggest four necessary, but perhaps not sufficient, steps towards realizing large-scale impact of educational research in America's classrooms.

1. Partnership Research Centers

We need very specific kinds of long-term partnerships in order to implement this challenging agenda. First, we need more government-funded national research centers with particular focus on realizing the impact of learning research in today's educational systems, from kindergarten through college undergraduates. These centers must be guided by a leadership structure that is managed by university educational researchers, yet has district superintendents as essential co-leaders and Co-PIs. In addition, the leadership team must include discipline specialists such as chemists, biologists, mathematicians and software engineers. The inclusion of content specialists would both ensure quality content and technological resources in the K-12 programs, as well as advance the understanding of strong pedagogy at the university level thereby allowing greater direct impact of learning research on both K-12 and university-level teaching. Leadership by educational researchers is also essential in that it ensures that a quality research agenda will lead the iterative improvements and implementation, allowing us to best learn from and understand our learning outcomes, barriers, and the evolution of new ideas.

The Center for Learning Technologies in Urban Schools (LeTUS), a center I am affiliated with that is funded by the National Science Foundation, is one exemplary case of this model. Center directors include two superintendents, one each from both the Chicago and Detroit Public Schools, as well as two university researchers, one each from the partner universities of The University of Michigan and Northwestern University. Center work focuses on the direct translation of learning research into the development of tangible programs, models of professional development, and student outcomes. While this example specifically addresses impact within urban schools, different manifestations of this model might emphasize different foci and might not necessarily remain focused on a particular geographic region.

In general, my work suggests that without an infrastructure including partnership research centers with specific co-leadership both within and outside the school districts, the learning theories can not be appropriately translated into tangible products for schools.

2. Congruence between Testing, Pedagogy, and Curricula Towards Impact

We need a much higher number of educational programs that are created based on learning research as applied to classroom settings. These programs, while manifestations of what we know

about how children learn, would also strive to align with state and district curricular frameworks and high-stakes tests so as to be usable by schools that are working within these guidelines.

In terms of the learning fostered, these programs would, for example, help children of poverty in urban Detroit investigate scientific questions focusing on relevant and important scientific events. Rather than encouraging children to memorize facts about weather or animals, learning-driven programs guide children to work alongside National Hurricane Center scientists in the prediction of a live hurricane off the coast of Florida, or in the interpretation of species diversity data they have collected in their city using Palm Pilots and the software of professional African animal trackers.

The National Science Foundation supports the development and research on many quality programs of this kind in science and mathematics. However, very few of these reach large-scale impact. While my colleagues and I represent a handful of such boutique programs, my program, titled, *Kids as Global Scientists,* currently, I believe, has the largest impact of these in schools, and we have worked with only 46,000 middle school children in the past three years. Therefore, once programs such as ours have proven successful in many schools, we need much stronger mechanisms for helping these programs to become available and supported on a wide scale, so that they can impact millions of learners rather than thousands.

3. Longevity of Working Relationships, Reforms and Research

Large-scale impact requires long-term commitment from school administrators, educational researchers, and teachers. Implementing this change would require a reexamination of most current funding cycles, which provide funding for only three years at a time, a formula that disallows much opportunity to build long-term relationships or sustaining programs and research agendas.

The Interagency Education Research Initiative (IERI) is one example of a multi-agency initiative that provides several of the necessary ingredients towards the development of sustained relationships, research agendas, and research-driven classroom impact. IERI was developed to provide concrete examples of the impact of learning-focused research on the practice within schools. Comprised by an interagency team consisting of the National Science Foundation (NSF), the Department of Education's Office of Educational Research and Improvement (OERI), and the National Institute of Child Health and Human Development (NICHD), IERI serves as an important model of the kinds of funding structures needed for the challenges ahead. Our current work funded under IERI holds more promise for impact in part because of our five years of large-scale funding which allows us to build and support several dimensions of the necessary infrastructure including

relationships with teachers, a four-year coordinated curricula, and a longitudinal research agenda tracking ten cohorts of students for four years each.

Why is longevity important? Our research demonstrates that while most our teachers notice gains in student beliefs and understandings of science after utilizing our programs one or two years, our teachers state that they do not feel completely comfortable guiding scientific thinking until about the third year of implementing our programs. This is consistent with much of educational research, such as results that document that a change in teachers' beliefs precedes a change in teachers' practice. Learning research also advocates curricula programs with more time on fewer concepts so that understandings such as fostering complex scientific thinking can develop. Our program utilizes a multi-year, coordinated curricular sequence in science that supports childrens' revisiting of scientific thinking skills such as building explanations from evidence each year with increasing complexity. Similarly, the research program tracking the developing of complex thinking in science should follow students for several years through these multi-year, coordinated programs.

4. Digital Library of Working Exemplars or Other Centralized Systems of Dissemination That Encourage Classroom-Level Customizations of Similar Goals

Each run, we implement the "same" program with about 10,000 children simultaneously in about 250 classrooms coordinated across the United States. While I have not personally visited each of these classrooms, I believe I can say with confidence that each teacher implements our program in an unique way, depending on the age, learning style, level of homogeneity, type of community, state testing structure, and district and school constraints placed on that individual and classroom. Interestingly, I believe all of our teachers hold the same larger goal as we do which is to help their children learn to think scientifically about weather or biodiversity. I think we all also agree, with some slight variations, that "learning scientifically" involves a kind of thinking far beyond reading middle school science textbooks or the memorization of animal facts and includes: collecting and analyzing data, formulating questions about their evidence, generating explanations from evidence, and connecting evidence to scientific knowledge through real-time predictions.

Recognizing the need for quality, learning-based programs that "work" for a wide range of children, we need dissemination models that respect both high common standards based on learning research, and variations that allows adjustments for particularly classroom contexts and populations. As one example, while we wish all children to improve their ability to thinking critically in science,

research on learning in urban classrooms helps us understand that the professional development program needed to specifically challenge "the pedagogy of poverty" common in urban classrooms is different in important ways from the professional development program needed to foster learning within another focus population. Research also helps us understand that teachers need buy-in, and an important way to ensure this is to demonstrate the manner in which a particular program has been adapted towards the specifics of their context and learners.

One manifestation of this dissemination model that several of my colleagues are working towards is the development of a systematic digital library of working exemplars. Other countries, such as Japan, provide centralized systems for life-long teacher professional development consistent with current research findings. We need, at a minimum, a digital library of video clips, lesson plans, facilitated Internet discussions and other resources that begin to articulate and exemplify classroom manifestations of current research ideas. An even stronger version of this idea would involve the systematic development of online courses, offered through centers such as the LeTUS center mentioned above, for in-service and pre-service teachers' ongoing discussion of pedagogical practices current with educational research.

Summary

Recently, I discovered that a Detroit middle school class of 36 students was not able to participate in our science program because there were only 17 chairs in the large closet-like room used for the computer lab. As this simple example illustrates, my colleagues and I know a great deal more about fostering learning in science than is being realized in today's schools. As we embrace a global economy and a technological world, all of our children, not just those in more affluent schools and neighborhoods, need thinking skills and technological fluency to participate as productive, informed citizens. Educational programs such as ours that develop and research best means for the development of these literacies, as well as foster them early, often, and systematically over time, contribute to the understandings we need to support all our children in their quest to embrace their future and succeed. But even with the strong funding and research history we have been fortunate to achieve in the current system, these understandings will remain anecdotal and of small impact nationally without systemic changes in the infrastructure and models of dissemination needed to organize, translate, and implement them on a much larger scale.

Linn, M.C., Tsuchida, I., Lewis, C. and Songer, N.B. (2000) Beyond Fourth Grade Science: Why do US and Japanese students diverge? *Educational Researcher 29(4)*, 4-14.

Agron, J. (1998) The urban challenge. *Education Week* 17(17) 6.