

CAESL  
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## Overview

- Whenever good research is done, an educational asset is created. The question is, how shall we capture and use that asset?
- It follows that as science itself changes, the new scientific opportunities create new educational opportunities. At the same time, changes in science and in technology can create disruptive influences in education, challenging the curriculum, holding up our ideas about what it means to be educated to new light and changes in basic ways how we assess learning.

Emerging Frontiers in Education and Engagement: The View from EHR

**First Premise: Advances in science today will create disruptive technologies and knowledge that will change our approach to education. This can best be seen and explored in the process of integrating research and education in our large-scale projects such as the Centers for Learning and Teaching, science and technology centers, engineering research centers and major facilities.**

The nature of science and the ways in which scientific knowledge is advanced are changing in significant ways. This will change the infrastructure needed to support new kinds of research and the observations, modeling, simulations and data collection and manipulation required to work in a dynamic mode rather than a

static mode. As this happens, our approach to the integration of research and education must change to reflect the new capacities made possible by advances in science as well as by the capabilities in the new instrumentation and infrastructure that can be turned to educational uses as well.

The growing availability and more sophisticated access to and use of technology in both K-12 and in higher education will act as a disruptive technology in the same way that technology changes society by changing the nature of the relationships and roles played within our educational environments. It will change

- a. How knowledge is created and by whom.
- b. Who defines what is worth knowing.
- c. Who controls access to information and who interprets it?
- d. What it means to learn and what it means to teach.
- e. Who is an active participant and who simply observes?

All of this will change our ideas about learning environments and how to produce conditions that promote learning.

New tools will have profound effects on the nature of education and will require new approaches to involving students in research, new strategies for introducing contemporary scientific ideas and theories into the curriculum and new ways of thinking about public outreach and engagement. This will require significant research on how people learn when they are offered different ways of understanding the material. Among the consequences of the revolution in science that will have significant impacts on education and how we approach the curriculum, the student experience, and our ideas about what we are trying to accomplish in education are

- The convergence of the disciplines with a resultant blurring of disciplinary boundaries and the emergence of integrative fields;
- The growth of multi-disciplinary interest in the science of learning and the availability of deeper understanding of how young people learn and how adults learn;
- The capacity to model dynamic systems.

These advances will allow us to examine continuous, dynamic, simultaneous, organic, interactive, conditional, heterogeneous, irregular, nonlinear, deep, multiple processes that are difficult to understand. The result will be a revolution in STEM education!

**Second premise: EHR supports a research domain that is complex, interdisciplinary and focused on several scales, from the individual learner to change at the institutional level and within large educational systems. New computer systems will change the nature of the questions that can be asked.**

Cyberinfrastructure can be used to see into the classroom and to examine the pathways by which individual students explore ideas and acquire mastery of material. It is now possible, for example, to follow the development of sophistication and expertise in a field or a profession through assessments and monitoring/tracking systems embedded in educational cyberspace. The challenges of an educational context open up new areas of research for the designers of CI and shape ideas about new cybertools and often generate new research questions. It also permits investigators to deal with the enormous data sets created by multimedia observations of classrooms, individual student learning and scientific observations. The domain of education and learning research will change dramatically. As we

have seen in the case of many other areas supported by NSF, EHR is seeing the beginning of an era of "Big Data Science" which will change our understanding of how learning takes place and how to foster deeper understanding in science, technology, engineering and mathematics.

These fundamental changes in how science is done, the instrumentation and infrastructure that supports new forms of scientific experimentation and new interpretations and applications of this capacity in educational contexts there will be a significant impact on education: the curriculum, the preparation of teachers; the role of faculty; and, the organization of schools, colleges and universities.

Let's take a look at what is happening as you continue to develop CAESL.

**Issue #1: What will it mean to be educated in the 21<sup>st</sup> century and how do we have to change our approach to education to reflect these new realities?**

### **The qualities of an educated person**

*A key attribute of an educated person is an on-going love of learning and a curiosity about the world. A love of Learning can develop in many ways and at many different times, stimulated by an inspiring teacher, by a sense of purpose and personal responsibility, by the experience of generating new knowledge, in short by any means that offers the opportunity to be taken seriously by people we respect.*

*Educated people can find creative and adaptive solutions to newly emerging problems as well as old ones that are ever with us. To*

prepare our students for life and work in the 21<sup>st</sup> century, we must provide opportunities for them to learn in the same way that professionals/experts learn. This can be fostered by exploring fields of study in the same way that these fields are actually advanced through discovery, integration, interpretation and application of knowledge. Education must look beyond the classroom to the challenges of the community, the complexities of the workplace and the major issues in the world.<sup>1</sup>

*Educated people understand how we know what we know and how to construct a warranted foundation for the claims we make about what is true. To create environments where authentic learning can occur that develops in the same way that our understanding of disciplines and intellectual challenges develops, we must set up new contexts that are not bounded by disciplinary or institutional imperatives, where the scholarly interests of faculty and students are integrated with the realities and urgencies of society and where learning can have consequences for both students and the community (i.e. engaged learning) and/or the fields they study (i.e. undergraduate experiences of research and discovery).*

*Education carries with it the expectation that educated people use their knowledge and acquire new understanding in a responsible way, mindful of the effects of their actions on others. They have a moral imagination<sup>2</sup>. Engaged learning exposes students to essential dimensions of the responsible use of power*

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<sup>1</sup> This idea is derived from an article by Elizabeth Zinser (2004). Making the Case for Liberal Education. *Change Magazine* Winter 2004 p. 38-41.

<sup>2</sup> The concept of *moral imagination* comes from the work of Martha Nussbaum (2004) Liberal Education and Global Community. *Change Magazine* Winter 2004 p. 42-47. It refers to the capacity "to view with sympathy the situation of people who live at a distance or who look different from ourselves." (p. 42) It allows us to take seriously the lives of other people and to be concerned about their well-being.

than comes from the generation and application of knowledge. This can prepare students to live and work in a complex and changing world characterized by many different cultural spaces and many significant challenges and uncertainties.

*Educated people are not trapped in their own place and time.* Education must encompass the exploration and understanding of the enduring questions that have been traditionally thought important and how we have thought about those issues in the past as well as an exploration of the future.

**Here are some questions that are on our minds at NSF and are probably on your minds also. If not, perhaps you will find this list interesting.**

- Must we define a single vision of what it means to be educated or are there many legitimate and significant ways to be and become educated?
- How much of an education is about *doing*? How much is about *being* and *becoming*?
- How do experts learn and can we draw our students into an authentic pursuit of knowledge that develops in the same way that professionals advance their fields and professional practice? At what age can this begin? Was Bruner right when he claimed that we can teach a subject authentically to students of any age?
- Does formal coursework get in the way of the kind of learning we can envision? If so, what are we learning about other ways to foster the knowledge/skills/inclinations of an

educated person? What does this mean for the informal science community?

- What are the differences that distinguish learning about a subject, becoming an expert in a subject and learning to use the patterns of thinking of a subject as a well-educated person?
- If education includes the capacity to understand how we know what we know and how knowing varies across disciplines, how can we ensure that students learn to appreciate and draw upon these differences.
- If access to information and the opportunity to learn are no longer the exclusive purview of academic institutions, what is the distinctive role of higher education today? Is it to exercise moral authority and lead students into a deeper consideration of meaning, purpose and value of knowledge and learning?
- If we acknowledge that it is possible to make straight A's and still flunk life, what does success mean? Is it the ability to find adaptive solutions to ever-changing problems for which there are no well-tested, research-based answers.
- Does everything need to be taught or are there many ways for people to learn? How do we validate these other ways of learning and knowing?
- If we cannot easily change faculty culture or rewards, how can we introduce changes to support our vision of education within the realities of faculty expectations and interests?

- What will motivate a broader group of people to experiment with change?
- What is the world of our students today? How much of their experience is shaped by institutions like schools and colleges and how much is shaped by their own choices and the circumstances of their lives? What is the nature of that experience and what do they learn from it?

**Issue #2: What are the qualities of a well-educated person? How can we measure those qualities?**

In my opinion, education is best thought about as a way of developing the human imagination and cultivating habits of the mind and heart that lead to new understanding---rather than a specific set of arts and sciences disciplines. Martha Nussbaum calls this "the moral imagination," "the capacity to transcend divisions created by distance, cultural difference and mistrust." (Nussbaum 2004. p. 42) These are capacities much needed today. We all know that knowledge has consequences. An approach to learning and teaching at any age that can foster both moral imagination and the development of a deep sense of responsibility for living a life of compassion, respect and concern for the lives and truths of others can guide those consequences down responsible paths.

Recently, Jeffrey Nesteruk captured the essence of the elements that make such learning possible in an essay in The Chronicle of Higher Education (Nesteruk 2004). In reflecting back on why he was so drawn to the explorations of life and meaning that are fostered by liberal education, Nesteruk concluded that his inclinations were shaped in a small town life that made him "comfortably incomplete." His bonds with family,

friends, neighborhood and community gave him affirmation and an "ample share of recognition" while leaving him psychologically safe enough to reflect upon his young life and long for broader and more challenging horizons.

From this musing upon his own early life, Nesteruk draws out the difference between *bridging*, a process that is outward looking, encompassing a world beyond our own time and place and *bonding*, a condition that forges relationships. If these bonds are diverse enough, we feel connected, yet open to new discoveries. If our bonds are too homogeneous, we may form exclusive identities, seek membership in homogeneous groups and develop a resistance to the lives and insights of others unlike ourselves. At its best, bonding gives us a sense of connection and confidence and a place from which to venture out to explore new ideas, meet new people and learn new things through experience that may not be compatible with what we already "know." These explorations can force us to break old connections and forge new ones. Like resetting a bone, this can be painful. Many of us would prefer to avoid such disruption of our lives and purposes.

What does all of this mean for us as educators? The sense of support and identity that Nesteruk (2004) had is more elusive nowadays—for us as well as for our students and colleagues. As Nesteruk (2004) put it

"Psychic comfort is difficult to come by in a world where families are less stable, neighborhoods less cohesive, communities less certain of their futures. And the incompleteness [students] confront is more daunting in that it stems from more radical differences than [Nesteruk] had to negotiate...The bridges...have further to span."

The often-intolerable tensions that shape the lives of most of us today drive many to seek release through the wrong kind of certainties. Some accept an "absolute relativism" best expressed in the language of the young as "whatever," said in a dismissing tone of voice. "They accept all, but insist on nothing. They make choices without judgments. They are incomplete, but not comfortably so."(Nesteruk 2004).

The other poor choice is the way of fundamentalism, either secular or religious. Those who take this way "eliminate conflicts not by accepting differences but by avoiding them. In the classes they take, the teams they join, the fraternities and sororities they pledge, they seek others like themselves. They feign completeness, but their deeper discomfort is never far from the surface." They settle for living in "a world of diminished aspirations" both for themselves and for others.

As educators, we encounter both of these patterns in the lives of our students and their families and in the communities we live in. You may be tempted by these paths of least resistance yourselves.

What is the antidote for this dis-ease?

An education for today must seek to foster "richer social networks" forged by linking learning to life in new ways. This is the reason we must seek civic engagement and embrace a curriculum and a philosophy of education that offer a more expansive and humane vision of what it means to be educated. Our intentions as educators must be to produce a new interpretation of learning in which broad education and deepened understanding about civic responsibility and international justice, about human

capacity and world cultures is expressed through an approach to education that

- Develops the intellect and the capacity and inclination for lifelong learning;
- Shapes ethical judgment and the capacity for insight and concern for others, the world we live in, and the future we will bequeath to our children and their children;
- Fosters an increased understanding and openness to other cultures, languages and societies and the connections that bind us together as fellow travelers on an increasingly connected globe;
- Builds an understanding of the effect of the human presence on the land and the effects of the systems we build to advance our efforts as a community;
- Expands our scientific horizon and our appreciation of the influence of new technologies on our lives, both as individuals and as we live them in community with others;
- Supports our capacity to nurture democratic and global knowledge and engagement, and---hardest of all---helps us acquire the ability to reach out to our adversaries and those who seek to harm us and to understand why they act as they do.<sup>3</sup>

**Issue #3: How is the nature of knowledge changing and what will that mean for the education of both graduate students and undergraduates?** I will use my experience with science and engineering at NSF to talk about this, partly because I know more about science than I do about what is going on now in the humanities and the arts and partly because time is short.

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<sup>3</sup> Adapted from Zinser (2004)

As we enter a new era of science, there are signs that the disciplines are converging, drawn together by common mathematical and computational paradigms. As this happens, the areas of greatest interest transcend traditional academic disciplines and the structure of the academic department and draw increasingly from many disciplines. Four intellectual horizons are coming together

**Nanoscale science** that takes us down three orders of magnitude smaller than most manmade devices we use now. Engineers can now manipulate matter one atom and one molecule at a time.

**Terascale computing capability** that allows us to compute three orders of magnitude faster than before. We have crossed the boundary of  $10$  to the  $12^{\text{th}}$  power or one trillion operations per second!

At these speeds, we can model systems that take us from our familiar world of thinking and teaching to an alternative universe.

World One (the familiar)

Discrete, static, sequential, mechanistic, separable, universal, homogeneous, regular, linear, surface, single

World Two (the real world)

Continuous, dynamic, simultaneous, organic, interactive, conditional, heterogeneous, irregular, nonlinear, deep, multiple

**Cognition:** We are learning much more about how we think and learn and how our cognitive and emotional responses influence our capacity to make sound judgments.

**Proteomics and Genomics:** As we map out the human genome and explore how proteins take their shapes, and as this knowledge converges with nanoscale science and terascale computing, our understanding of who we are and how we came to be will open up new ethical and social challenges that we have barely begun to explore or understand.

This new world, created by sophisticated modeling that better represents the behavior of real things is always on the brink of disorder and chaos, according to Mitch Waldrop, author of Complexity who describes a place where new ideas are forever nibbling away at the edges of the status quo. Are we prepared for this? Can we help our students be ready for this?

The consequences of this convergence will be profound on how we practice our professions and how we prepare our students. Joe Bordogna, the Deputy Director at NSF and a visionary engineering educator captured the challenge in an article he wrote in The Bent of Tau Beta Pi last fall. He started out with a series of challenging questions that are always on our minds at NSF.

- Will our youngsters have the skills needed to thrive in a competitive global economy driven by innovation and rapid technological change?
- Will there be a robustly capable supply of knowledge workers to meet increasing demands for them in our society and workplace?

- How can we prepare our students for a world in which change and complexity are the rule, a world continuously transformed by new knowledge and technology, where differences and divisions that have not been integrated can have immediate and large-scale consequences?

Have we drawn this exciting frontier into the experiences of our students? At least at the undergraduate level, the answer is a regrettable, not much. Are our students being prepared to live in a complex world? I am not sure, but if so, it is probably because they are figuring it out on their own.

**To what extent have emerging areas of science been introduced into the undergraduate curriculum?**

The best recent examination of this question is the Bio2010 report issued by the National Research Council in 2002. The reflections of the Board of Life Sciences within the Division of Earth and Life Sciences is of substantive interest to all scientists both because the changes in the scientific disciplines are similar and because of the growing intersection of biology and chemistry. In addition, the external constraints to reform should sound familiar.

The most jolting finding of the NRC study is that the undergraduate experience in biology is lagging seriously behind "how biologists design, perform and analyze experiments." (p. 1) This gap will make it difficult to prepare our students to pursue careers in biomedical research but it also means that they often lack any appreciation for how science is actually being done today and what the convergence I talked about earlier will mean for them, whether they want to become biologists or not.

The study represents our best exploration to date of just how much the nature of scientific investigation is changing and how little this remarkable shift is reflected in what undergraduates learn and how they learn. What should all of our students know about science? Can we find ways for our students to learn science the way researchers learn science? Would students who learn science by doing science be more attracted to the field or better educated or both?

**What kind of undergraduate education can prepare students for careers in a world where intellectual, cultural and national boundaries cease to have meaning?**

I will turn to the recently released report of the **Greater Expectations Panel**, which I had the honor to chair, for answers to this question.

Greater Expectations envisions a higher order of learning that prepares our students for a complex world. The panel urged the adoption of an invigorated and practical liberal education as the most appropriate kind of learning for the 21<sup>st</sup> century.

The core concept is that our students must become intentional learners who can adapt to new environments, integrate knowledge from many sources, and continue to learn throughout their lives. The students we prepare today are standing at the beginning of a new era where the old boundaries of knowledge and people and nations and cultures no longer have the meaning they once had. Unless we dedicate ourselves to their intellectual, emotional and social maturity, they will not have the capacity for discovery, learning and true engagement that will characterize successful scholars, practitioners, leaders and citizens in years to come.

Our job is to prepare people who will lead productive, creative and responsible lives.

Not long after *Greater Expectations* was completed, I discovered the work of Robert Kegan. His book, *In Over Our Heads. The Mental Demands of Modern Life* has become my reference point for the challenges we face as educators. Kegan starts out by pointing out that the modern world "makes demands on our minds, on *how we know*, on the complexity of our consciousness. (p. 5). He talks about how our minds mature as simpler ways of organizing experience that we used in our youth become subsumed into more complex and sophisticated ways of thinking and understanding and richer and more empathetic ways of relating to other people as we mature. Slowly our "values, ideals and broad beliefs" (p. 27) take shape.

Kegan's vision of higher order learning and mental functioning is inspiring. It captures better than anything I could say why we must continue to work toward an education that is truly liberating. He explores the meaning of conflict or difference, especially really difficult differences, our changing ideas about what good leadership is and how knowledge is created.

In the mental world of tomorrow

- Conflict will take on a new meaning. The continuation of conflict tells us that we need to look again at our assumptions, to examine the strength in the arguments of others and to acknowledge and study the weaknesses in our own. As Kegan puts it, "We may have this conflict because we need it to recover our truer complexity" (p. 319) and admit into our mental spaces the things that we have chosen to exclude.

- Leadership also takes on a different character. We usually think of leaders as being the ones who “craft and communicate a coherent vision, mission or purpose” and who can “recruit people to take out membership in, ownership of or identification with that vision, mission or purpose.” (p. 322) To do this, a leader must possess considerable powers of “conception and communication” and excellent interpersonal skills. The leader for tomorrow, however, will know how to create a shared “context, in which all interested parties, the leader included, can together create a vision, mission or purpose they can collectively uphold.” (p. 322)
- Knowledge takes on a new meaning as well. We have already talked about that. Instead of freezing the action and thinking about things as still frames, we can think about them as complex, moving systems, aided in this by the remarkable advance in computing power that is reshaping our understanding of how the world works.

**What challenges face us as we seek to create coherent and meaningful educational experiences for students?**

- The economics and intellectual structures of our current institutions. In our own minds, our institutions have not changed much but, in fact, they are changing dramatically. We must understand who our students are and why they are pursuing an education. We must also understand who our faculty are. Their experiences, their motivations, their career pathways are not the same as ours were. Only 25% of the faculty joining higher education today are on a tenure track or devoted to building a traditional faculty agenda. A smaller and smaller proportion of our students will

stay within a single school district or start and complete their postsecondary education at a single institution. What will this mean for the quality and intentionality of the education they experience?

- The failure of islands of innovation to come together to create a more meaningful shared approach to K-12 education and the undergraduate experience. Students of institutional change have been thinking about this problem for many years. My favorite exemplar of this line of thought is Arthur Levine's book, Why Innovation Fails (Levine 1980). Alas, the last I knew, it was out of print.

Innovation combines the ideas of reform and change and connotes something new and different. Levine defines innovation as "any departure from the traditional practices of an organization." (p. 4) What is new in one place may not be so new at another place.

Change can be introduced at several different scales.

1. New organizations
2. Innovative enclaves within existing organizations; examples include experimental units or changes in a single course or even a whole department. Such changes are relatively easy and inexpensive to implement but they can become isolated from the mainstream. These enclaves can also become sanctuaries for dissatisfied faculty or students and a means of preventing an institution from making needed organizational changes.
3. Holistic changes within existing organizations; Change on this scale "involves the adoption of a major institutional innovation characterized by a unified and coherent purpose." (p. 5) This form is the most efficient but the hardest to get adopted and "It is risky because it

involves already established institutions with built-in resources, habits, and staff---and a staff at that usually lacking in consensus about institutional purposes." (p. 5)

4. Piecemeal changes within existing organizations); the most common form of change and easiest to adopt but unlikely to have significant impact since such changes are generally the result of political negotiations rather than a coherent plan or clear vision.
5. Peripheral changes outside of existing organizations; some institutions manage the energy behind change by routing it to a continuing education unit that can serve as a laboratory for innovation; the movement of such innovations from the edges of the organization into the core is often very difficult.

Change is most likely to occur when "there is a crisis in the environment, when people have a shared interest in change; where there is a power imbalance in the environment, when the environment has experienced structural changes, and finally when it is consistent with the zeitgeist or spirit of the times."(p. 6) A common consequence of any of these conditions is that traditional boundaries weaken or disappear, allowing isolated islands of change to coalesce. For this to happen, however, an organization must have norms, values and goals that can support innovation and experimentation with the core business of the enterprise as well as sufficient resources or else compelling enough reasons to support that experimentation.

All institutions have norms, values and goals. *Norms* are the commonly prescribed guides to conduct—means of communication, how authority is expressed, rules of membership etc. *Values* are the shared beliefs and sentiments held by people in the organization. *Goals* are the commonly accepted purpose and

direction of the organization. No two institutions are alike even if they have similar missions. Thus norms, values and goals constitute an institutional character or personality and will be closely guarded against forces of change within the organization or externally. The tools use to guard these qualities are boundaries, both structural and intellectual.

Boundaries control "the social space within the organization" and maintain a desirable pattern of constancy and stability within the larger environment, that is, the *status quo*—quoted from Kai Erikson Wayward Puritans. NY, Wiley, 1966.

An initially successful pilot project or innovation may spread throughout the organization (diffusion), be encapsulated or enclaved, be reformulated to incorporate the traditional norms, values and goals of the organization (resocialization), or terminated. (Levine, 1980, p. 15). The change will persist if it is **compatible** with the culture of the organization and **profitable**. Profitability is not just economic. It can also encompass power, prestige, peer approval, growth. (Levine 1980, p.18) as viewed from the perspective of the self-interests of the individual subunits and people involved as well as from the general perspective of the organization as a whole.

Compatibility is a measure of whether a particular innovation can function within existing institutional boundaries and whether it will maintain or challenge those boundaries. (Levine 1980, p. 19).

Innovations fail when their impact is not sufficient or declines too early and when they fail to satisfy the self-interests of the individual members of the community and its subunits.(Levine 1980, p. 157-58) Decisions about continuation or termination are highly political choices and are assessed by many different

standards imposed by different disciplines and personal self-interests.

- Our inability to define the intended consequences of an education and how to measure the competencies, knowledge and inclinations that we associate with an educated person.  
I have already spoken about what it will mean to be educated but how can we measure these things? One interesting experiment is the Collegiate Learning Assessment Project being developed by Roger Benjamin and Marc Chun of the RAND Corporation's Council for Aid to Education (Benjamin and Chun 2003). This projects focuses on the skills attributed to general education---critical thinking, analytical reasoning, and written communication. These qualities are associated with a combination of coursework and other educational experiences and are not linked to particular disciplines or subject matter. They are, as close as we can come to measuring the overall qualities of an educated person by examining not what people know (i.e. content) but what they can *do* with information. The goal of this work is not to measure how any particular student is doing but rather how an institution is doing, any kind of institution.
- Our tendency to break down the larger questions about the redesign of a liberal or professional education into the habitual spaces and expectations of the disciplines and the usual focus of a particular group or organization. It is important to decide how to teach mathematics and to agree about what mathematical competency means but it is just as important to think about how mathematics fits into a larger conception and philosophy of education.

- We do not invest enough resources in research on teaching and learning. That is, in fact, the rationale for redirecting the EHR portfolio to an emphasis on
  - A cycle of discovery, innovation and application
  - The development of portfolios of related projects
  - The study of the nature of research and evaluation and the development of a warranted foundation for our work

We introduced the Centers for Learning and Teaching to put more resources in play to address the preparation of teacher educators and to generate relevant research.

- We continue to talk to people who already agree with us. We have not found effective ways to broaden the discussion to include people who do not yet see these issues as problems that we must address or who see the problems differently.
- We produce many reports that define the problems of education and that outline recommendations for dealing with those problems, but the reports do not stimulate action on a large enough scale to make a difference. It is worth figuring out what we can do to make the process of generating such reports as well as the delivery of the reports themselves more meaningful to a larger audience. I gained some insight into this problem when I read an article by Kris Kurtenback in the most recent issue of the Kettering Foundation's Connections. It turns out that educators, policymakers and administrators talk about K-12 education very differently from parents and community members. The study, which was conducted as four focus groups in two very different communities—Portland, Oregon and Meridian, Mississippi explored how parents and citizens who do not currently have children in the schools responded

when accountability was framed as a schools issue and when it was framed as a community issue. The goal was to probe whether the framing of the issues shaped how citizens feel about their own part in promoting reform and improvement in the schools. It will surely not come as a surprise that parents and other community members found edu-speak to be arrogant and irritating and they felt no stirring of responsibility to help the schools. As Kurtenbach (2004 p. 24) put it more delicately:

“There was a noticeable, and in some focus groups palpable, difference between how people responded to the citizen-focused language compared with how they responded to the language that implied education was the business of educators and policymakers.”

Listen to the difference in how issues were framed.

### Edu-speak

- Academic standards (statements about what all students should know and be able to do by the time they leave certain grade levels) ---coupled with testing to determine whether these standards are reached--- will help to ensure that all children are achieving.
- The school is the basic unit for the delivery of instruction, and thus teachers and administrators should be the primary people held accountable.
- If a district or school continually fails to make adequate progress toward improvement, then the district and the school should be held accountable.

### Citizen-speak

- The problems of communities cannot be left to policymakers and other education leaders alone.
- There is a need to change fundamentally the relationship and understanding between communities and schools on the role public schools play in the community.
- We must shift the frame of reference from "What are you, the schools going to do?" to "What are we, as a community, going to do?"

David Mathews, tracing out the thinking of the Kettering Foundation since the publication of his small but important text, *Is There a Public for Public Schools?* in 1996, argues that our policy language, our approach to accountability and our over-emphasis on standards and content have further driven a wedge between our schools and the professionals who manage them and teach in them and the communities of which they ought to be a vital part. His point hits home to me, a denizen in our current national policy environment:

"The strategy behind the law [No Child Left Behind] seems to be to make schools more accountable by publicizing standardized test scores so citizens can judge their performance. Although most people believe in high expectations for children, favor tests, and appreciate more information about schools, they seem to have a broader notion of what makes for accountability. They may be looking for a relationship with schools that allows them an actual account of what is happening in classrooms---a face-to-face description that is responsive to all they want in the education of their children, including qualities of mind and

traits of character, as well as levels of academic performance."

In my words, we all care about what our young people know, but we also care about what kind of people they are becoming.

- We do not often base our discussions on a culture of evidence. We do not explore our assumptions or our mythologies about why things are the way they are or why they should change in ways we want to change them.
- We do not know much about why ideas and practices do or do not spread or how they spread. We need to support research on the diffusion of innovation and the challenges of implementation of new strategies.

### **What is NSF hoping to accomplish in its Centers for Learning and Teaching?**

The Centers for Learning and Teaching are a primary means by which the EHR Directorate hopes to create the capacity to

**" achieve excellence in U.S. science, technology, engineering and mathematics (STEM) education at all levels and in all settings (both formal and informal) in order to support the development of a diverse and well-prepared workforce of scientists, technicians, engineers, mathematicians and educators and a well-informed citizenry that have access to the ideas and tools of science and engineering. The purpose of these activities is to enhance the quality of life of all citizens and the health, prosperity, welfare and security of the nation<sup>4</sup>."**

**To do this, we must learn how to**

1. Prepare the **next generation of STEM professionals** and attract more Americans to STEM careers and
2. Increase **the technological and scientific literacy** of all Americans so that they can exercise responsible citizenship in an increasingly technological society and help them to acquire knowledge of science, mathematics and technology that is appropriate to the development of workforce skills and life-long career opportunities.
3. Broaden participation (**diversity**) and achievement in STEM.
4. Develop a robust research community that can conduct **rigorous research and evaluation** that will support excellence in STEM education and that **integrates research and education**.

The EHR Portfolio is supported by the concept of a cycle of discovery, innovation and application to facilitate the introduction of ideas and research findings into policy and educational practice at all levels of education, formal and informal.

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<sup>4</sup> Mission statement of the Education and Human Resources Directorate.

The primary goal of the CLT program is to create a community of practice that will generate the capacity to prepare the next generation of faculty and teachers and the teachers of these instructors.

Perhaps more important is the fact that CLTs represent an innovative design that integrates research and education in new ways into a community of practice.

This community is meant to bring together the experience of preparing for the teaching profession and the continuing professional development of faculty and teachers by setting up a cycle of innovation.

According to Wenger (1998), a community of practice incorporates three elements: mutual engagement, joint enterprise and a shared repertoire. He and Jean Lave have made the case that "learning is not about the internalization of knowledge by individuals but about the process of becoming a member of a sustained community"<sup>5</sup> that confers identity and meaning to the knowledge being gained. Seen through Arthur Levine's analysis of innovation, communities of practice lower the activation energy of change by making boundaries less formidable.

Another article in the same issue of ASTC Dimensions captured some of the attitudes that are associated with a healthy community of practice. In describing the Sky Island Institute in Texas, Colleen Blair articulated five elements that characterize

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<sup>5</sup> Elsa B. Bailey and George E. Hein (2002) "Informal Meets Formal: Museum Educators and Communities of Practice." ASTC Dimensions 9-11.

every education program that the Fort Worth Museum of Science and History puts together. As she puts it (p.6)

- We build in time for networking.
- We provide great "stuff" for participants to take home.
- We do real science and invite teachers to work alongside.
- We respect participants' knowledge and prior experience.
- We believe we will learn as much from teachers as they learn from us.

It is our hope that CLTs will be like that.

There is a clear research agenda for education researchers. We already have a reasonable theoretical framework and a research-based approach to systemic reform on the scale of a single school or campus but there are many unanswered questions about how to make changes that will really serve every student well. We need solutions to the large-scale challenges associated with educational reform.

- translating well-researched models and research-tested practices into approaches that are appropriate for a particular context, its assets, its culture, the nature of the local community and the local economy (dissemination)
- moving beyond promising pilots or small-scale projects to large scale change (scale-up)
- developing effective strategies that engage scientists and engineers in the work of reform (partnerships with the disciplines)
- creating the capacity to sustain the work over time (sustainability)

- creating a credible body of evidence upon which educational innovation and policy development can be based (a culture of evidence)

Through the work of the Centers for Learning and Teaching, we hope to move beyond rhetoric about the need for “scientifically based practice” and calls for research-based models of “what works” to a genuine collaborative community of scientists, engineers and mathematicians and science and math educators in both higher education and K-12 who together can generate the capacity to support the formulation of informed policy and effective practice while at the same time creating a new concept of what it means to be a teacher.

The Challenge: How can we use the various research-innovation-application cycles set up in the cohorts of Centers for Learning and Teaching to bridge the research to practice gap, more effectively involve higher education in the improvement of K-12 education and build a body of evidence that meets the tests of relevance, truth and utility?

**The answer is to advance our understanding of how people learn science and math and how to teach in ways that will foster understanding and challenge and inspire our students, while at the same time doing this in the rich context of a real place where the challenges of educating meet the forces of public opinion, instabilities in the school systems, financial constraints, leadership transitions, political pressures and the unintended consequences of Federal and state policies.**

SO, you see, you are important. The Centers for Learning and Teaching are our venture capital, our latest and best effort, along with our Mathematics and Science Partnerships,

- To integrate research and education,
- To draw upon all of the educational assets of our nation,
- To link our efforts to those of our colleagues abroad,
- To invent effective ways to bring together the intellectual assets and experience of K-12 and higher education and to connect those collaborations more deeply into the community
- To generate a knowledge base that is reliable, trustworthy and useful.

Now, let's get to work.

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