# Technology and the Problem of Change

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**Bringing Real-World Problems to the Classroom**

Children in a Tennessee middle-school math class have just seen a video adventure from the Jasper Woodbury series about how architects work to solve community problems, such as designing safe places for children to play. The video ends with this challenge to the class to design a neighborhood playground:

*Narrator:* Trenton Sand and Lumber is donating 32 cubic feet of sand for the sandbox and is sending over the wood and fine gravel. Christina and Marcus just have to let them know exactly how much they'll need. Lee's Fence Company is donating 280 feet of fence. Rodriguez Hardware is contributing a sliding surface which they'll cut to any length, and swings for physically challenged children. The employees of Rodriguez want to get involved, so they're going to put up the fence and help build the playground equipment. And Christina and Marcus are getting their first jobs as architects, starting the same place Gloria did 20 years ago, designing a playground.

Students in the classroom help Christina and Marcus by designing swingsets, slides, and sandboxes, and then building models of their playground. As they work through this problem, they confront various issues of arithmetic, geometry, measurement, and other subjects. How do you draw to scale? How do you measure angles? How much pea gravel to we need? What are the safety requirements?

Assessments of students' learning showed impressive gains in their understanding of these and other geometry concepts. In addition, students improved their abilities to work with one another and to communicate their design ideas to real audiences (often composed of interested adults). One year after engaging in these activities, students remembered them vividly and talked about them with pride.

Bransford *et al*, 1999:196

The above example is one of countless radically new examples of the new technology at work (for many other examples see Bransford, *et al*, 1999, Chapter 9; Scardamalia and Bereiter, 1999; Wiggins and McTighe, 1998). While still in the minority, we now have enough on-the-ground examples to know what the new technology looks like and can do to embrace learning. At the same time we also are beginning to realize that *the more powerful technology becomes, the more indispensable good teachers are.*

The more powerful technology becomes, the more indispensable good teachers are. This would not be the case if rote learning were the goal but it is especially the case when learners must construct knowledge and meaning in order to achieve deep understanding. In this paper we identify and connect two domains of knowledge within which great advances have been made in the past decade. One has to do with technology and learning itself; the other with knowledge of the process of change. By and large, the dramatic developments in the domain of technology and learning have not been informed by knowledge of the change process. Yet they used to be intimately related.

We start with a brief portrayal of new developments on the pedagogy of technology and learning, and then we pursue the connection with what we know about how effective change takes place.

## Technology and Learning

DVD, gigabyte, virtual learning space, RAM, ROM, digital video, digital cameras, ATM, PDF, graphing calculators, computer projection systems, video streaming — all common terms to many people in the workplace and some educators. Slide projectors, overhead projectors, Gestetner machines, dicta machines, record players and other traditional technology — fond memories of the past or are they? A new language using technology vocabulary many of us are unfamiliar with today. Changing times, changing schools — a phrase that challenges what we are currently doing in many classrooms. Are we still rooted in the curriculum of the 70's or have we truly made the necessary changes to move forth and connect teaching and learning to a knowledge work society.

There is actually an increasingly clear notion of the nature of the paradigm shift underway in radically altering the nature of learning through technology. What is the changing paradigm as we enter the year 2000? The technology will necessitate that teachers change their pedagogy for learning to become relevant and meaningful for students to acquire the necessary knowledge and skills to be productive citizens in a global economy. ISTE (International Society for Technology in Education) along with the Milken Exchange on Education Technology produced a document for the U.S. Department of Education titled "National Education Technology Standards for Students". The following chart from this document is a good example of the shift in nature of the learning environment (U.S. Department of Education, 1998:2):

| Traditional Learning Environments | New Learning Environments |
| --- | --- |
| ♦ teacher centered instruction<br>♦ single sense stimulation<br>♦ single path progression<br>♦ single media | ♦ student centered instruction<br>♦ multisensory stimulation<br>♦ multipath progression<br>♦ multimedia |

| Traditional Learning Environments | New Learning Environments |
|---|---|
| ♦ isolated work | ♦ collaborative work |
| ♦ information delivery | ♦ information exchange |
| ♦ passive learning | ♦ active/exploratory/inquiry based learning |
| ♦ factual, knowledge-based | ♦ critical thinking and informed decisions |
| ♦ reactive response | ♦ proactive/planned action |
| ♦ isolated, artificial context | ♦ authentic, real-world context |

U.S. Department of Education, 1998

This same document notes that the resulting learning environments should prepare students to:

Communicate using a variety of media and formats;

- Access and exchange information in a variety of ways;
- Compile, organize, analyze, and synthesize information;
- Draw conclusions and make generalizations based on information gathered;
- Use information and select appropriate tools to solve problems;
- Know content and be able to locate additional information as needed;
- Become self-directed learners;
- Collaborate and cooperate in team efforts;
- Interact with others in ethical and appropriate ways.

Similarly, Dwyer, *et al* (1991) talk about classroom approaches of knowledge instruction and knowledge construction. Knowledge instruction is viewed as the transfer of thoughts from one who is knowledgeable to one who is not and teacher work is perceived as direct instruction. Knowledge construction views learning as a personal, reflective, and transformative process where teacher work comprises facilitating students' abilities to integrate ideas, experiences, and points of view into something new. The two approaches are not incompatible and simply position on a continuum of learning strategies. Technology plays a different role in the two approaches. In a knowledge instruction classroom, technology can be a patient tutor giving students the opportunity to repeat the learning of a concept until mastered. This is quite appropriate for some students. In a knowledge construction setting, technology becomes a tool to help students access information, communicate information and collaborate with others. In today's classrooms there is certainly the need for some knowledge instruction but a great deal of student activity might involve knowledge construction given the explosion of information. We do need to move away from students coming to school to watch teachers work.

The following table summarizes the contrast of knowledge instruction and knowledge construction (Dwyer *et al*, 1991):

| | **Knowledge Instruction** | **Knowledge Construction** |
|---|---|---|
| **Classroom Activity** | Teacher centered (didactic) | Learner centered (interactive) |
| **Teacher Role** | Fact teller (always expert) | Collaborator (sometimes learner) |
| **Student Role** | Listener (always learner) | Collaborator (sometimes expert) |
| **Instructional Emphasis** | Facts (memorization) | Relationships (inquiry and invention) |
| **Concept of Knowledge** | Accumulation of facts | Transformation of facts |

| | **Knowledge Instruction** | **Knowledge Construction** |
|---|---|---|
| **Demonstration of Success** | Quantity | Quality of understanding |
| **Assessment** | Norm referenced (multiple choice items) | Criterion referenced (portfolios and performances) |
| **Technology Use** | Drill and practice | Communication (collaboration, information access, expression) |

Dwyer *et al*, 1991

In addition to the above directional analyses there are an increasing number of examples of these technologies-in-use in sophisticated learning environments. Bransford *et al*'s (1999) chapter on 'Technology to Support Learning' provides many examples of how new technologies work in practice and with what impact. Bransford and his colleagues explore how these technologies do five things by:

**New Technologies:**

- Bring exciting curricula based on real-world problems into the classroom;
- Provide scaffolds and tools to enhance learning;
- Give students and teacher more opportunities for feedback, reflection, and revision;
- Build local and global communities that include teachers, administrators, students, parents, practising scientists, and other interested people;
- Expand opportunities for teacher learning. (Bransford, *et al*, 1999:195)

Further, detailed descriptions of radical transformation of learning are contained in Scardamalia and Bereiter's (1999) work in which they have developed Computer Supported Intentional Learning Environments (CSILE) to support schools as 'knowledge-building organizations'. Similarly, the establishment of a technology-based learning environment at River Oaks contains many concrete examples of what these exciting ideas look like in practice (Smith, 1999).

In many of the examples cited above there is evidence of impact on student learning (standardized tests as well as conceptual understanding and performance based assessment) — see Bransford, *et al* (1999); Scardamalia and Bereiter, 1999; and Smith, 1999 for details. In essence, the role of technology envisaged is one where it helps transform learning by helping to answer the question, "What kind of education will best prepare students for life in a knowledge society?" (Scardamalia & Bereiter, 1999:275)

## Technology and the Problem of Change

The problem, then, is not the absence of concrete examples of what these new learning ideas look like in practice (although this too is continually expanding). The more difficult problem is that teaching in a knowledge-building community represents a very sophisticated change for teachers and all those who work with them.

Fortunately, knowledge about the change process has also been becoming more sophisticated (for this body of knowledge see Fullan, 1991; 1993; 1999; and Fullan and Hargreaves' trilogy (1996-1999). In this short paper we address three key aspects of this knowledge: the teacher as learner, organizational learning, and program coherence.

**Teachers as Learners**

Many years ago we asked the question 'What kinds of changes would teachers experience if they were to implement a new learning approach?" (Fullan, 1991) We suggested three aspects:

- New materials;
- New behaviors/practices;
- New beliefs/understandings.

We observed that the (mere) use of new materials (curricular, technology, etc.) was important but was only the tip of the implementation iceberg. The more difficult parts related to whether teachers (a) developed new skills, behaviors, and practices associated with the change; and (b) acquired new beliefs and understandings about the change. In other words, change involved *a process of redoing and rethinking*. Given the dramatic distance from current to new practice represented by new technologies (or more accurately, new pedagogies) this change process, involving millions of teachers is obviously an enormous challenge.

As we have studied the implementation process we have discovered that virtually all teachers go through an 'implementation dip' during the first stages (of redoing and rethinking) even when there is good support. In any case, we know a fair amount about what to expect and how to support teachers during this period of change. It is also clear what kinds of professional development will be helpful. Clearly, one-shot workshops, no matter how good, will not (cannot) have much of a carryover effect. There needs to be continuous assistance *during initial implementation*. Good professional development provides follow-up. There are many examples around of 'teacher development centers' in which model examples of practice are demonstrated and in which teachers can learn from and receive network or 'hands-on' support to apply the ideas.

There is no doubt that the kinds of pedagogical changes generated by the partnering of cognitive science and technology have profound implications for the way teachers will teach and the way they need to think about and understand teaching and learning. Scardamalia and Bereiter (1999) capture this nicely:

> In our experience, the teachers who remain continually fascinated and involved are ones who have a dual interest. They are interested in advancing their understanding of history, geology, biology, cultural anthropology, and so forth; and each year they experience some advances themselves as they work with students on problems in those areas. But they are also interested in understanding the process of understanding itself. The students' efforts (and their own as well) to explain phenomena, to grasp theories, and to overcome naïve conceptions are an endless source of insights into that distinctively human phenomenon, the pursuit of understanding.
>
> An interest in understanding how understanding grows does not seem to be a feature of most people's curiosity. It is an acquired interest, and one that teacher education programs ought to be passionately dedicated to developing. Without it, we find, teachers tend to remain detached from students' knowledge-building efforts to reduce knowledge-building activities to merely another set of schoolwork routines. (p. 287)

**Organizational Learning**

Unfortunately, good professional development by itself is not very effective. Studies of change have also enabled us to understand that the culture of the school makes a huge difference. Put one way, imagine one or two teachers who are involved in a highly motivating professional learning series involving technology. Picture the teachers returning to a negative work culture. In this situation, the culture wins every time. For this reason, a general aspect of supporting change involves developing 'collaborative work cultures' within a school (or 'professional learning communities'). We, and others, have worked on this issue for some time and now have strong evidence that collaborative cultures make a difference in both teacher and student learning; we have also been working on how to develop professional learning communities through what we call 'reculturing' (Fullan, 1999).

In brief, research shows that schools that only restructure (change the curriculum, add new roles, reorganize) make no difference in teaching and learning. However, schools that reculture (as well as restructure) do make a difference if they (a) focus on student learning; (b) link knowledge of student learning to changes in instructional practices; and (c) work together to assess teachers and school leadership to make improvement. Out of this work we have concluded that teachers must become 'more assessment literate'. Assessment literacy is the capacity to examine student work and student performance data and make critical sense of this information; and to develop instructional and school improvement plans to make the kinds of changes to get better results — doing all of this on a continuous basis. Technology, of course, (as in the above examples) is absolutely crucial to this entire process.

Schools, in other words, must become *learning organizations*. We now know what these schools look like in practice (we return in the conclusion to the question of how to develop such schools). Incidentally, this finding also reveals the limitation of teacher networks. We, ourselves, value teacher networks (electronically supported) but their limitation is that they only stimulate individual learnings across the network. They do not connect the individual learnings to reculturing the whole school — without the latter new ideas will falter and disappear (for a positive example see Smith's (1998) report on River Oaks).

**Program Coherence**

A third change learning is that teachers and schools are inundated with a continuous torrent of fragmented and unconnected policies, innovations and other demands. The natural tendency in our complex systems is toward non-linearity and piecemeal reform (see Fullan, 1999). Innovations in technology so far have been part of the problem not the solution, that is, the vast majority of attempts to introduce technology have come in the form of new machines and software, one-shot workshops at best, and generally the episodic infusion of new monies for technology unconnected to the curriculum let alone to whole school improvement.

The most effective schools are not the ones that take on the sheer most number of innovations (which actually adds to overload and non-linearity) but the ones that work on program coherence, connectedness, synergy and the like (Fullan, 1999; King & Newmann, 1999).

The good news is that not only can pedagogically driven technologies powerfully address the program coherence question, they are absolutely essential for this task.

Although this has been an all too brief summary of change knowledge, two things should be clear. First, the combination of teacher learning through assisted professional development, organizational learning through the development of collaborative cultures, and program coherence are essential. No one or two of these will make an impact. Second, these changes in combination are exceedingly deep and complex to achieve.

## Still, The Problem of Change

There are two additional perplexing problems about educational reform. The first problem is what we will call 'the pathways' dilemma. Even if we have an idea of what the destination would look like, and even if we know the requirements of change (good professional development, organizational learning cultures, program coherence), this is not the same as knowing how to get there in one's own situation. Put differently, to know that organizational learning cultures are essential, and even to know what they look like, tells you very little about *how* to establish them. Research tells us the impact of learning cultures 'once they are up and running' but does not say much, if anything, about the pathways of developing a learning culture' if you don't have one. This is why we have said 'steer clear of false certainty' (Hargreaves & Fullan, 1999). There is no substitute for working diligently on local strategies for change based on one's own context and informal (not determined by) visions of what the new order should be and what change knowledge one needs in setting out on the journey.

The second perplexing problem is how to 'go to scale'. If we can point to a handful of successful examples, how do we propel them into 100 or more examples? We do not have space to address this issue in depth but we are gaining an appreciation of the problem of scale (see Fullan, in press). Essentially, if we do not improve the quality of the reform infrastructure (policies and agencies of pressure and support) it is not possible to achieve reform on a large scale. Even on a small scale, innovative examples which are established in given instances *will not last* if the infrastructure is not supporting them. Put another way, it is possible to create an innovative school which is highly successful for a few years; it is not possible to *sustain* innovations in the face of a neutral or non-supportive infrastructure.

In addressing the infrastructure from a technology perspective, the Milken Exchange has developed a valuable framework of seven dimensions (along with indicators of implementation) including: learners, learning environments, professional competency, system capacity, community connections, technology capacity and community (Lemke, & Coughlin, 1998). There remains, of course, the very difficult task of 'implementing the framework' itself, but the agenda is well established.

These are exciting times in pursuing the new pedagogies and the new technologies. For the first time we can think of the education profession as engaged in the business of scientific breakthroughs about learning. What we have attempted to establish in this paper is that the phenomena about learning potential will not be realized unless we learn how to incorporate the knowledge of the change process, and the critical role of the teacher as learner and schools and networks as learning communities.

To achieve any significant breakthroughs it is going to require that we marry the professional new examples of technology-based pedagogies with grounded knowledge in the complexities of bringing about reform on a large scale. The content of reform in technology and learning, and knowledge of the change process must feed on each other if substantial impact is to be achieved.

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