TOWARDS IMPLEMENTING TECHNOLOGIES IN EDUCATION: EXPLORING THE PEDAGOGY AND PEOPLE OF GOOD INNOVATIONS

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ABSTRACT
With the amount of research and research journals available on the subject, it may seem like we have established many 'facts' and 'truths' about technology and pedagogy. More realistically, the 'truth' is that we are only just beginning to learn within and about the young field of educational technology (understanding the adoption, use, and impact of technologies such as computers in education). One important question we now face relates to understanding what makes a good technological innovation in education. Drawing on past and present research, it is crucial to re-examine the roles of *pedagogy and people* (innovators, educators, and learners) in technology innovations. In this paper, I describe both processes in detail. I conclude with implications for research and practice.

WHAT DO WE KNOW ABOUT GOOD TECHNOLOGY INNOVATIONS FOR EDUCATION?
With the amount of research and research journals available on the subject, it may seem like we have established many 'facts' and 'truths' about technology and pedagogy. We have evidence that technology helps motivate certain children, particularly those with special needs (Bamberger, 1999; Englert, Zhao, & Ferdig, 1998). Technology provides students access to places and information they may not have had access to before (Hall, 1999). Students more productively navigate complex, ill-structured domains when they use tools such as hypermedia and multimedia (Spiro, Coulson, Feltovich, & Anderson, 1988). Add the available research to the enormous amount of time and money designated each year for technology implementation, and an outsider might be convinced we have gained many 'facts' and 'truths' about the role of technology in education.

More realistically, the 'truth' is that we are only just beginning to learn within and about the young field of educational technology (understanding the adoption, use, and impact of technologies such as computers in education). As can be expected, we have ten questions for every one answer. Why do certain teachers adopt technology quickly while others refuse to implement it? What are the benefits and constraints of teaching and learning online? Do media such as computers directly impact a students' educational development or is it merely the instructional design afforded by the medium? How much Internet access should students be given? Do technologies fundamentally change a teacher's practice or merely make it more efficient?

All of these questions can potentially be encapsulated by (and are superimposed within) the caricatured battle currently waged in the field of educational technology. One side of the divide consists of technology-driven educators soap-boxing the classroom-changing benefits of computer implementation. The other side is made up of technology critics voicing the concerns and warnings of yet another unjustified panacea for education. Although this dividing line is obviously more blurred and the differences more complex than portrayed in this story, the ideologies undergirding each side are very real in the academic literature and the policy decisions in our schools (Agostino, 1999; Berrien, 1998; Cuban, 1986; Oppenheimer, 1997; Reeves, 1999). Technology, whether seen simply as devices with a central processing unit (CPU) or most recently as the Internet and multimedia, is seemingly under scrutiny for some inherent abilities to help teachers teach, help learners learn, and to fundamentally change the social and educational context of classrooms.

Rather than taking sides in this debate (labeled a futile approach by Thomas Reeves in a keynote address at EdMedia '99 (Reeves, 1999), we return to our original question—what do we really know about good technology innovations in education? Many would define 'good innovation' as one that improves performance, successfully meets a pre-defined plan, or one that solves an educational problem. For instance, a good innovation would use technology to help students become better readers. Or, a good innovation would increase SAT scores after continued computer use.

It is crucial for designers and developers to understand two main building blocks upon which 'good' innovations are created: *Good Pedagogy & Good People*. A good innovation is one where *technology and pedagogy are not*

separated.   A good innovation also engages *a process that enhances the relationships among innovator, educator, and learner*.

The main purpose in defining a good innovation is to ensure a deep and complete enough analysis so that: a) cognitive changes, whether they exist or not, can be explained in relation to the person using the technology in a curriculum, rather than explaining it as an intrinsic quality of the technology itself; b) stronger and more definitive claims can be made about the instance of implementation; and c) educators are provided with more comprehensive information about what and how to train future teachers or in-service teachers learning technology.

GOOD PEDAGOGY
What do we really know about technology and education? We know that *a good technology innovation is one that is integrated with academic content and good pedagogical practice*.   Technology research provides evidence that even without the interaction of more knowledgeable others, prior pedagogical goals, or a strong teaching program, children *may* construct their own curriculum and their own purpose for classroom technologies (Webb, 1996). However, technology use in the classroom is not necessarily an end in and of itself (except, perhaps, in the case of an instructor teaching a computer course), nor should it be left up to chance as to whether the student uses it as a medium in learning. In most cases of chance, instructors and students leave the machines to gather dust (Kinzer & Risko, 1998; Miller & Olson, 1994; Webb, 1996). In other scenarios, technology plans without pedagogical considerations result in mindless technology 'checklists' devoid of any strong ties to curriculum (i.e., keyboarding, word processing, and desktop publishing skills learned by the end of the third grade) (Berrien, 1998).

What does it mean, then, to create an innovation steeped in academic content and practice? Mainly it entails tying it to learning theory to create authentic and engaging activities for students. From a social constructivist perspective, this means:
1) The innovation must be imbued with authentic, interesting, and challenging academic content (at the high end of the students' Zone of Proximal Development).
2) Participants must have a sense of ownership.
3) There must be opportunities for active participation, collaboration and social interaction.
4) The curriculum and technological tools must provide chances for the creation of artifacts in a variety of ways.
5) Publication, reflection, and feedback play a key role throughout the project.

Authentic, Interesting, and Challenging Content.   Authentic content refers to content that is meaningful, worthwhile, feasible, and anchored in a real-world problem (Newman, Secada, & Wehlage, 1995; Blumenfeld, Krajcik, Marx, & Soloway, 1994; Englert et al., 1998; Krajcik, 1994; Scardamalia & Bereiter, 1991). Albanese states that this type of learning is an instructional methodology characterized by the use of problems as a context for students to learn problem-solving skills and acquire knowledge about the topic they are studying (Albanese & Mitchell, 1993). Kolodner (Kolodner, 1997) adds that students learn in these situations "by having rich experiences that motivate the need to learn and that give them a chance to apply what they are learning" (p.61).

It is important to have authentic, real-world problems because they are interesting and meaningful to the students and thus engaging. "Designers of successful classroom interventions must make sure that they are engaging enough to seduce children into the world of learning…Once ensnared, it may be possible to guide students toward the intrinsic rewards that follow from self-initiated disciplined inquiry" (Brown, 1992, p. 173). Interesting problems, in turn, create significant missions for the students to fulfill; learning occurs in the context of carrying out that mission (Kolodner, 1997).

Along with being authentic and interesting, content that is supported by technology must be challenging to the students. A main tenet of Vygotsky's theory is the importance of aiming instruction at the upper boundaries of a child's 'Zone of Proximal Development' or 'ZPD' (Brown & Ferrara, 1985). The ZPD is defined as:
the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers. (Vygotsky, 1978, p.86)

In other words, if instruction is too easy for the student, they will lose interest; if it is too hard, they will become frustrated. The goal is to use content that is at the high end of their ZPD, where learning takes place with adult guidance or collaboration with more knowledgeable or more capable others. The child still acts as the agent in the learning activities, but knowledge emerges from the social interactions between the child and the adult or

more knowledgeable other (Scardamalia & Bereiter, 1991). These other participants scaffold the learning such that the individual constructs knowledge at a level unreachable by him or herself alone.

A Sense of Ownership. The active construction of knowledge means that the student learns to take on a self-regulating role in the learning process. This active construction has become the forefront of many education mission statements, specifically stating: "the self-regulated learner must have a healthy self-concept with a strong understanding that they, alone, are in control of their learning, mastery of tasks, and attainment of goals" (Sandford & Richardson, 1997). The emphasis is on student control of their learning, where opportunities for that ownership are available in the design as well as the solution of the project or problem.

Active Participation, Collaboration, and Social Interaction. Closely tied to the idea of the Zone of Proximal Development is the notion that good innovations must provide opportunities for active participation, collaboration and social interaction. Active participation has seemingly become a catch phrase in any learning theory that opposes itself to "traditional didactic approaches to education, which seem to be based on an assumption of direct transfer of knowledge from teacher to student, without an intervening constructive process" (Scardamalia & Bereiter, 1991, p. 38). In other words, knowledge is not transmitted from the expert to a passive learner; rather, learning is an enculturation process where knowledge is actively constructed within the student's ZPD with the help of more capable others (Brown, Collins, & Duguid, 1989; Rogoff, 1994). This active participation takes place as students talk, write, relate, and apply among other things, and is present in both the design of the problem as well as the design of the solution (Chickering & Gamson, 1987; Kolodner, 1997).

Regardless of who or whom is the more capable other, technology can support the active construction of knowledge and eventually the taking over of the self-regulating adult role in the social learning relationship. Innovations that espouse active learning, collaboration, and social interaction also offer opportunities for new types of relationships between teachers and students—least of which is the proverbial move from 'sage on the stage' to the 'guide on the side' (Batson, 1993). Finally, as "learning occurs through centripetal participation in the learning curriculum of the ambient community" (Lave & Wenger, 1991), innovations become promising tools insomuch as they provide space for the creation of learning communities. Those communities, places where students can try out ideas and challenge the ideas of others, are both supported through and emergent from interactions with technology such as computers (Krajcik, 1994; Resnick, Rusk, & Cooke, 1999).

The Creation of Artifacts. Good innovations must offer a variety of opportunities for the creation of real solutions and artifacts in response to those problems. Michael Cole (Cole, 1996) states: "an artifact is an aspect of the material world that has been modified over the history of its incorporation into goal-directed human action" (p. 117). In social constructivist thought, these artifacts are integral and inseparable components of human functioning (Engestrom, 1991; Prawat, 1996). The creation of those artifacts allows students to learn concepts, apply information, and represent knowledge in a variety of ways (Blumenfeld et al., 1994). Those artifacts, in turn, represent students' understanding of the problem, resulting solutions, and emergent states of knowledge (Krajcik, 1994).

Publication, Reflection, and Feedback. Students having a chance to *publish, reflect, and receive feedback* on their efforts is essential to a social constructivist model of learning because of what Rom Harré (Harré, 1984; Harré, Clarke, & DeCarlo, 1985) has called the 'Vygotsky Space.' His representation helps clarify how learners "move from using new meanings or strategies publicly and in interaction with others to individually appropriating and transforming these concepts and strategies into newly invented ways of thinking" (Gavelek & Raphael, 1996). The Vygotsky Space defines and describes four recursive processes within the individual-social and public-private dimensions: appropriation, transformation, publication, and conventionalization.

Publication is the process in which student knowledge, understandings and strategies are made public so that others can respond. Artifact creation and the opportunity for publication are important ingredients in good innovations for three reasons. First, through publications, teachers and researchers "can infer the process by which students transform meanings and strategies appropriated within the social domain, making those strategies their own" (Gavelek & Raphael, 1996) p. 188). Second, publishing makes material accessible to subsequent reflection and analysis, allowing students to revisit and revise their artifacts, thus enriching the learning experience (Bruner, 1996; Krajcik, 1994; Olson, 1994; Olson, 1998).

A third reason publication is important refers back to the need for a good innovation to consist of challenging, academic content at the high end of the Zone of Proximal Development. Assistance from a more capable or more knowledgeable other in the ZPD is referred to as scaffolding (Wood, Bruner, & Ross, 1976). "Scaffolding characterizes the social interaction that occurs among students and teachers that precedes

internalization of the knowledge, skills, and dispositions useful for all learners" (Roehler & Cantlon, 1996). Publication offers the opportunity for feedback; feedback, in turn, scaffolds a learner in their quests for knowledge construction, knowledge integration (Linn, 1991), higher-order thinking, and self-regulatory behavior.

GOOD PEOPLE

What do we really know about technology and education? We know that *a good technology innovation is one that views implementation as a process catering to the relationships between innovator, educator, and learner.* In the last section, I presented research that demonstrated evidence of the necessary but potentially reciprocal relationship between technology innovation and pedagogy. That first requisite highlights technology innovations as tangible hardware or programmed software that act (at least in one manner) as cognitive tools. They scaffold and support students' learning and student learning environments when they are permeated with good pedagogy. However, a good innovation is also a process of creation, implementation, and use by innovator (developer), educator, and student. A good innovation is consequently defined in relationship to *what it is* as well as *how it is implemented*.

Technology innovation is more than just a hardware and/or software product—it is also a process. That process is not just a matter of the amount of time it takes to develop the product; rather, it is also a matter of how the product is implemented (developed, put into practice, taught, etc.) over time. That process can best be defined as a collection of relationships between the members involved in the innovation, namely students, teachers, and developers. Therefore, a good innovation, in addition to requiring good pedagogy, also requires good people. (Saying 'good' to describe 'good people' makes it sound like I'm referring to some aspect of their character. Instead, I am describing the way in which they provided legitimate opportunities for growth in a learning community.)

What does it mean to have an innovation that is implemented by good people? It means having:
1) Innovators who recognize the dialogic nature of innovation implementation.
2) Innovators who interact with teachers and students in genuine ways.
3) Innovators and teachers who understand the flexible nature of both teaching and technology.
4) Innovators who provide opportunities for legitimate participation.

The Dialogic Nature of Implementation. There has been much debate in the field of educational technology regarding the relationship between technology innovations and established practice (Bromley, 1997; Bruce & Hogan, 1998; Bruce, Peyton, & Batson, 1993). One side views technology innovations as having the power to fundamentally transform existing practice (Fishman & Pea, 1994; Papert, 1987). The other side contends that teachers' beliefs, school bureaucracy, and other established practices retard, sometimes even negate, the potential impact of technology innovations (Cohen, 1987; Cuban, 1986).

Good innovations require developers who understand that technology implementation is a bi-directional dialogic interaction between innovation and established practice (Cziko, 1995; Hawkins, 1987; Zhao et al., 2000; Zhao, Mishra, Worthington, & Ferdig, 1999). "In this view, neither innovation nor existence is considered the independent variable. Instead, both are independent and dependent variables, causing changes in each other simultaneously" (Zhao, Worthington, & Ferdig, 1998, p.2). This dialogic interaction can be thought of as a 'negotiation' or 'improvisational dance' between the teacher and developer, with each bringing something special to the relationship (Cliff & Miller, 1997). The teacher brings knowledge of pedagogy, academic content, and pedagogical content knowledge (i.e., how to teach, an understanding of mathematics, and how to teach that understanding of mathematics). That knowledge helps developers create innovations imbued with good pedagogy. The innovator brings cognitive tools that support teaching and learning as well as a more complex understanding of the potential uses of technology. The concept of negotiation reminds both groups that they are entering into a dance, with the intended outcome being a recursive, dynamic creation of technology that supports pedagogy and pedagogy that is fundamentally changed by virtue of its integration with technology.

It may sound like 'technology as innovation process' refers to the time and effort it takes to carry out a project. Or, it may appear that a good innovation requires nothing more than knowledgeable people experienced with teaching and technology. Both of those, of course, are essential. However, the process lives or dies depending upon the relationships between the people. Even when knowledgeable people work together, it might fail because the relationships among them are not educationally legitimate interactions. Legitimate interactions, as described above, are those that are dialogic, genuine, and reveal the flexible nature of both teaching and technology.

Genuine Interaction.   With some innovations, the technology expert (developer or innovator) is also the classroom teacher. However, in numerous cases, the developer or innovator comes from outside of the classroom.   This could include technology coordinators, volunteers from local businesses, or educational researchers examining the effectiveness of new technologies and innovations.   External specialists can be extremely important to the success of innovations, especially if the teacher is uncomfortable with technology to begin with (Chaney-Cullen & Duffy, 1999). However, additional responsibilities are placed on the technology expert from outside of the classroom in implementing a good innovation. Namely, *developers must understand the significance of genuine interaction with teachers and students*. If an expert is to help implement the innovation in the classroom, he or she faces a challenge the teacher does not originally have: when the teacher is the innovator, students have already developed a rapport with the person integrating the technology. This rapport is important for innovators entering the classroom because building connections with students helps to develop a community or culture of learning to which the innovation is to be introduced (Rowe, 2000). As described in social constructivist pedagogy, this community promotes learning as students participate in shared endeavors with others (Brown, 1994; Rogoff, 1994).

In order to enter into the dialogic interaction and negotiation of implementation, technology experts must also develop a relationship with the teacher(s) in the classroom. Most in-service technology training models, generally in the form of short-term after school programs, fail to provide teachers with the opportunities or the knowledge they need to successfully implement technology into their curriculum (Murray, 1995). Murray (1995) describes four characteristics of good technology developers and innovators including: a) being peers of who they are training; b) being effective teachers who can translate technical information to learners of different levels including novice; c) being patient tutors without succumbing to taking over the keyboard; and d) being available to answer questions promptly.

Genuine interaction with teachers and students is a necessity of a good innovation because: a) the developer acts as the more knowledgeable other in the learner's Zone of Proximal Development, thus supporting good pedagogy; b) interaction facilitates collaboration and social interaction, which helps to sustain the community of learners; and c) interaction fosters rapport between the members of the innovation. By building rapport, technology experts enter into a more dynamic and comfortable 'improvisational dance' with the existing participants and practices of the classroom. The role of the technology developer or innovator is highlighted as someone who supports teacher and student learning by actively participating with the classroom participants in the innovation rather than consulting at a distance.

The Flexible Nature of Teaching and Technology.   An important component of the implementation and negotiation process is genuine interaction between the participants. This genuine interaction builds rapport and helps the members develop shared understandings of the knowledge, skills, and dispositions they bring to the dance. For a developer, one important understanding is the *flexible nature of teaching*. Learning, from a social constructivist perspective, is always improvisational and adapting to immediate, constantly fluctuating circumstances. Therefore, teaching requires continual learning, adaptation, improvisation, and instant decision-making (Becker & Riel, 1999; Engestrom & Middleton, 1996).

Teachers require innovations that are adaptable enough to meet these changing demands of the classroom. Part of this need can be alleviated when developers help teachers understand *the flexible nature of technology*. In other words, PowerPoint to one teacher is a presentation tool at meeting; to another teacher, it is a way for students to tell a story. One teacher might use a video camera to record and then reflect on her teaching; for another teacher, the camera provides a way for students to reflect on their learning. Teachers and developers need to understand that even with technologies designed for specific purposes, users will create their own rationale and functions for its use. This chameleon-like flexibility of technology, once appreciated, is a very useful feature, especially for teachers who might be limited by the amount of technology they have access to. (As described in the next section, it is also important in assessing the impact of the innovation.)

However, developers can also design the implementation to facilitate and support the flexible nature of teaching. This design, called component architecture, focuses on producing reusable and context independent software units (Zhao, Mishra, & Ferdig, 2000).   Specifically on the web, a designer can implement multiple, interchangeable modules to meet the educational goals of the teacher, rather than developing thousands of lines of code each time a new need arises. These products use server-side software (i.e. mail, video, and web servers, etc.) and client-side plug-ins (i.e. JavaScript, Java applets, Shockwave, etc.) to offer an integrated suite of multi-functional tools for teachers and students. However, all of the tools are small modules in and of themselves. Chatrooms, space for writing notes and papers, diagram and mapping instruments, and classroom videos are all separate components that can be exchanged, combined, or separated when a new educational need arises.

A major benefit of this approach for developers is the opportunity to easily and inexpensively create flexible and pedagogically sound software by adapting 'modules' to different purposes and applications. Many of the components necessary for web-based learning environments are available pre-packaged and free over the Internet. The component architecture design also facilitates the negotiation process between the developer and teacher. If a teacher finds a component that does not fit her pedagogy, she can easily replace it with another without having to throw out the entire innovation (Ferdig, Mishra & Zhao, 2004). Furthermore, the teacher can play a more significant role in choosing the modules because she no longer has to know how to program in order to make the components work.

A good innovation requires *developers and teachers who understand the flexible nature of teaching and technology*. For developers (and teachers), this understanding entails realizing that users create their own functions and reasons for using any given technology. Developers can also facilitate the process of negotiation by creating technology innovations that are based on interchangeable components. In doing so, they also help *teachers appreciate the flexible nature of technology*.

Opportunities for legitimate participation. If an innovation is to work for all participants, it must *provide opportunities for legitimate participation*. Legitimate peripheral participation, a term coined by Lave and Wenger (1991), means offering chances to co-participate in the practices of the ambient community, with the end goal being full participation in that community. "Moving toward full participation in practice involves not just a greater commitment of time, intensified effort, more and broader responsibilities within the community, and more difficult and risky tasks, but, more significantly, an increasing sense of identity as a master practitioner" (Lave & Wenger, 1991, p.111). The goal of legitimate peripheral participation is to allow students to act as practitioners in the practice they are being enculturated into.

DISCUSSION

I began this discussion by asking, "What do we know about good technology innovations for education?" It seems like we know a lot, considering both the research available (research articles, journals, books, etc.) and the amount of money (in the form of grants and bonds) that is allocated for technology implementation in our schools. Yet, the truth of the matter is that we know very little about the young field of educational technology. I am referring to both 'realizing the potential of' and knowledge in the form of strong claims about its use. Evidence to support that assertion has been documented from three different areas: 1) articles, books, journals, and research calling for *more* research to justify the implementation of technology in the schools; 2) calls for *different* approaches to research on technology, specifically that which is more comprehensive; and 3) arguments that abound in the field (and have for some time) regarding the role of technology in education.

Perhaps an answer to the initial question is that we know, or at least are beginning to know, more about what makes a good innovation. This is an important question for our field because it helps establish and reiterate what we know, which in turn sheds light on what we still need to learn. Through a critical review of the literature, I explored how good pedagogy and good people are important components of a good innovation. Are both necessary, though? There are times when well-designed software helps someone teach because of the built-in pedagogy steeped into the design of the tool. There are other times when a knowledgeable person can take a technology and make it pedagogically sound 'on the fly.' In both cases, one drives the other. We can support teachers with pedagogically sound technology; and we can learn from teachers who make technology pedagogically sound. Therefore, they are definitely required, but they tend to be responsible to one another. One will always require the other; good pedagogy is part of a process and the process includes teaching with good pedagogy.

CONCLUSION

Good technology innovations are those that are imbued with strong pedagogy and opportunities for growth in the learning community. Teachers and developers must learn to appreciate the flexibility of teaching, as well as the ways in which the flexibility of technology can reciprocally support the initial pedagogy and instruction. These understandings are supported by the design of innovations that are adaptable (as set-forth by the idea of component-based architectures) and part of a dialogic interaction that promotes mutual growth, change, and advancement of the technology and the corresponding pedagogical goals.

The field of educational technology has made important advancements regarding understanding the pedagogy and people behind technology innovations. As evidenced by the research discussed and presented here, active participation in authentic tasks using technology, along with people who understand how to legitimately bring people into the learning community, afford greater opportunities for gains in multiple domains. However, like

many others, I highlight the call for more research related to understanding these technology innovations. We do not have the evidence we need to justify the expansion of technology in the schools.

Future research needs to continue to broaden the relatively new field of educational technology. We do not have the accounts we need of the emotional and social responses of students to new educational technologies. We need to know more about the importance of joining multiple psychologies to understand technology integration. The task of technology-focused, educational psychologists and teachers, then, is not only to establish more structured research and teaching agendas, but also to expand the diversity within those inquiries.

More importantly within this research call, if a teacher or educator wanted to assess a technology prior to its use, pedagogy and personnel would be pre-requisites for answering the question, "Is this a good innovation?" We change the meaning of the question dramatically, however, if we ask "Is this innovation good?" rather than "Is this a good innovation?" The latter question directs us toward criteria for evaluating 'goodness' from within the world of innovations (as innovations go, is this a good one?), but the former question forces us to look outside of the world of innovations—to appeal to some external standard for goodness. Instead of understanding what is important in the creation of a good innovation, we ask what results demonstrate that the innovation was good or successful. This question essentially examines the consequences, the outcomes or the performance of the implementation. Unfortunately, the *performance of the technology* in the classroom is the one we know the least about.

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