Networked Systems for Schools That Learn

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There are many goals for the use of technology in schools, including preparing students for tomorrow's workplace and contributing to economic competitiveness. However, foremost among the goals for using technology in schools is the improvement of schooling itself. Advances in digital media and network technologies provide opportunities and expectations for school improvement. To that end, the U.S. Department of Education states as a primary goal that: "Digital content and networked applications will transform teaching and learning" [4]. Expectations for improvement in teaching and learning are fueled by dramatic increases in the levels of technology in our nation's schools [8]. The percent of schools with Internet access increased from 35% in 1994 to 95% in 1999.

Hope for improvement, however, is tempered by the recognition that even with these substantial increases in access to technology the impact on public education has been limited. After a year-long process of review and hearings, the Web-based Education Commission summarized the impact of Internet-based technology on education as: "Across America, people told us that the Internet offers one of the most promising opportunities in education ever. And yet they were troubled by their inability to harness its potential advantages" [7]. Referring to an earlier wave of technology and its expectations for school reform, Larry Cuban provided a one-line synopsis: "Computers meet classroom; classroom wins." This epithet of computer-assisted instruction indicates that even with substantial investment and great efforts, the role of computer-assisted instruction was at best marginal. Current investments in wiring schools and bringing Internet access to teachers and students face the same challenge of actually making a difference in the ways schools work, teachers teach, and students learn.

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The substantial investment to place technology in schools and the apparent limited return on investment mirrors the productivity paradox ascribed to business from the 1960s into the 1990s. In a comment that parallels the line from Larry Cuban about computers in schools, Nobel Laureate economist Robert Solow characterized the results of technology in industry: "We see the computer age everywhere except in the productivity statistics." More recent analyses of productivity show that in the late 1990s technology was substantially contributing to productivity. Brynjolfsson and Hitt [1] summarized the recent research by declaring: "Computers are pulling their weight." The research shows, however, that just investing in technology does not improve productivity. Some firms with high investments in technology demonstrate gains, while others with equal investments do not. A study funded by IBM [2] with collaborators from academia and business publishing associated the contributions of technology to productivity gains with a focus on customers, business process transformation, and organizational learning.

The schoolhouse seems to be one of the few places in society where investments in networked technology have not changed the way people work, nor brought measurable improvements. What will it take for digital and network technologies to enable the type of work practice change and productivity in schools that we have seen in industry? Our vision is not to see schools as a type of industry with a process model for children's development, but rather to find the creative transformation of work and empowerment of administrators, teachers, and students that comes from radically new and powerful tools.

Many of the technology implementations we see in schools today are beneficial, but substantial school improvement will not occur because of one technology-using elementary school teacher, a few middle school projects, or even an entire school with advanced uses of technology. Similar to enterprise resource planning (ERP), customer relationship planning (CRM), and supply chain management (SCM) systems in business, schools need enterprise wide networked systems that implement school processes in ways that contribute to student learning outcomes. As educators and developers, our ability to develop these systems is quite primitive, but new network-based learning systems are coming into use that offer the possibility of integrating curriculum experiences and student information systems as well as changing the metaphor of the Internet from library to workspace. We will call these integrating and process-oriented systems networked learning systems (NLS). These systems consist of a program or set of programs that operates over a network and supports users as they undertake tasks or participate in processes related to learning. This article presents a framework for understanding how these new tools may fit with an agenda for educational improvement.

Learning Organizations

In *The Fifth Discipline* [5], one of the seminal management books of the last 75 years, Peter Senge described new ways of working and communicating for organizations to achieve competitive advantage in challenging times. The term "learning organization" was coined to emphasize the need for organizations to get smarter about their work by learning from experience. Just as we know individuals get smarter (becoming better at understanding conditions, solving problems, and judging solutions) through experience, feedback, and discipline (ways of thinking about their experiences and

feedback), so too do organizations. Senge's book described five disciplines that facilitate organizational learning. The five disciplines are:

- *Personal mastery*. Empowerment through the realization of a personal vision.
- *Mental models*. Reflection and inquiry that make tacit knowledge visible and shared.
- *Shared vision*. Establishing and nourishing a common purpose.
- *Team learning*. Enabling teams to think, learn, and mobilize for change.
- *Systems thinking*. Understanding how interdependency and "change processes" lead to solutions to complex problems.

The five disciplines have been applied in many business settings. In Senge's most recent book, *Schools That Learn* [6], the disciplines are applied against the challenges of schools. Senge's approach helps educators and policy makers see the school as a learning community, not just as students learning the school curriculum, but as an organization or community that needs to get smarter about how it works, takes on challenges, and mobilizes for school improvement. Senge references the role that technology such as email or conferencing can play in facilitating the actions of communication and sharing, but he does not address how technology can be systematically used to change ways of thinking and working.

Using NLS to Support Learning Organizations

How can schools change the way they work and realize productivity gains similar in magnitude to those realized by businesses? We believe Senge's approach can guide schools toward answering this question, and that advances in networked technologies empower schools to implement the five disciplines of learning communities in ways not possible heretofore. Here, we illustrate how one such system, Shadow netWorkspace (SNS) [3], supports ways of working that enact the five disciplines. The sidebar provides brief descriptions of other applications that bring NLS functionality to schools.

SNS is a Web-based work environment developed specifically to support K–12 schools. Much like a personal computer's desktop, SNS provides a personal workspace for organizing, storing, and accessing files, and an environment for running applications. SNS also provides the ability to create groups, and for each group to have a "group desktop" for file sharing, communication, and collaboration. Because it is Web-based, teachers and students can access their workspaces from any computer that can access the Web, and partners (parents or mentors) unable to participate in schools because of time or distance, can participate in the Internet-based workspace. SNS is freely available to all users, designed to be installed at individual school locations, and comes with an open source (GNU) public license and application programming interface (API) so others can develop applications for it and participate in enhancing and supporting it. Although schools are conservative organizations and have traditionally been reluctant to implement open source software, recent events are making open source software more viable for schools. The events include the prominence of support by organizations such as IBM, new organizations, such as the Open Source Educational Foundation (OSEF), and endorsements from groups such as the President's Information Technology Advisory Committee.

SNS is both an information space for organizing, storing, and accessing files, and a social space in which users have roles that structure interaction, such as teacher, student, or parent. SNS also supports groups for sharing, communicating, and collaborating. The next sections illustrate how SNS supports activities that help build a learning community, and instantiates the five disciplines of personal mastery, mental models, shared vision, team learning, and systems thinking.

Personal mastery. Community members must have a personal identity that both empowers them to achieve to a high level of personal satisfaction and represents them in the community in a way coherent with their own self-image. For example, programmers in the open source community are empowered with tools (licenses, source code, Web-based information, and sharing) and invest their time and resources to create powerful programs. These programmers want to share their work freely with others who can benefit or learn from it. If the programs were made available anonymously, there would be far less drive to mastery, creation, and sharing. SNS provides each member of the community with an identity and an extensive section for presenting a profile. SNS also provides substantial customizability for the desktop and organization of files. Users in all roles can create groups, invite members to participate, invoke chat or other communication tools, and share their work in multiple ways. As the name "netWorkspace" signifies, core to the design of SNS is a work environment that is resourced, connected, and customizable, where one can accomplish various types of work. The workspace facilitates students having a meaningful identity in school that is associated with their accomplishments, so they will see themselves as a part of the school community.

Mental models. Mental models are guides to behavior. Much like the set of expectations we have for going to a restaurant causes us to take a seat, order food, and pay for it before leaving, our expectations and models for how the world works and how we will work within it guide our actions and the sense we make of the actions of others. Senge argues that we need to articulate (visibly represent) our mental models as well as the models of those with whom we work. Reflecting on our own models is how we will change them to best fit the situation. Inquiring into the models of others is how we come to understand their actions as goals and intentions, not simply behaviors. Central to the processes of reflection and inquiry are ways of making these assumptions visible, so they can be examined and communicated. A way of thinking about this idea that especially fits schools is to think of making learning visible. Making learning visible challenges the learner to represent what they know, and enables the teacher or learning partner to not only see an answer but to see the underpinnings that generate that answer. Much like asking a student in mathematics to show their work of calculating an answer, we want students to show their work in all forms of learning. Figure 1 illustrates a document created with the online document editor that allows students to represent their work, get feedback from others, and demonstrate progress in their thinking and understanding.

SNS supports making learning visible by providing online tools for creating multimedia content, providing a special viewer application for examining media, and facilitating the sharing of most document types; allowing users to organize and store documents so iterative steps toward a final production can be maintained and shared; and supporting multiple reviewer types (including teachers, other students, parents, mentors from inside and outside of the local community) so that the teacher does not have to be the only source of review and feedback. One of the key barriers to exam-

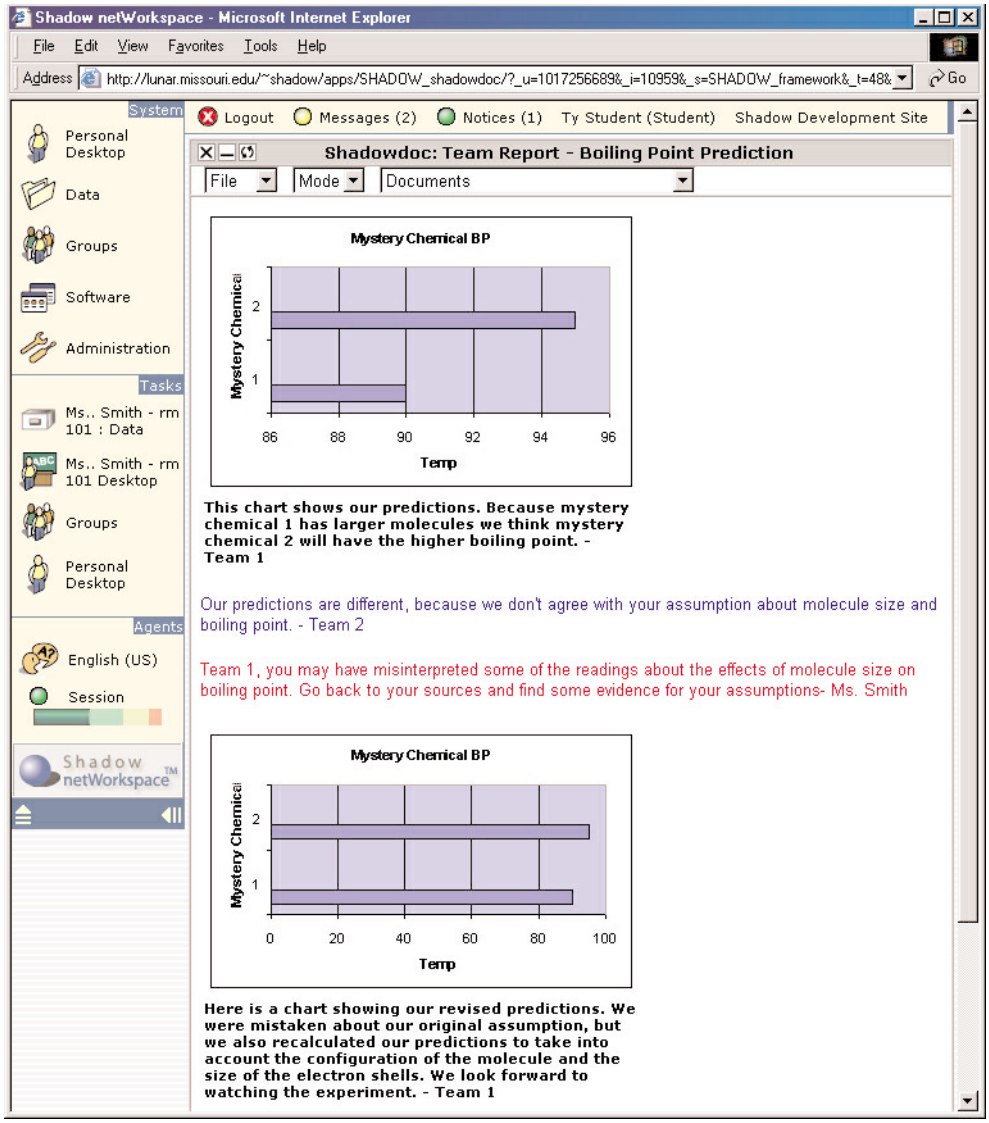

Figure 1. Making learning visible through a collaborative online document.

ining mental models or making learning visible is the lack of time and the pressure to cover subject matter. Since the student's workspace is available wherever they have an Internet computer or appliance, teachers can create teaching materials for asynchronous teaching and learning. It may be unreasonable to expect many teachers to create many materials, but teachers and other members of the extended school community could collaborate to develop instructional materials, and have a common and easily accessible platform for implementation.

Shared vision. The articulation and sharing of mental models provide individuals with the opportunity to discover other individuals with similar mental models and personal visions. This discovery can lead to the aggregation of individuals into groups

and the identification and shaping of a shared vision. This shared vision serves to motivate individuals and foster commitment to learning and action (team learning). Key to building a shared vision is participation and inclusion of all the stakeholders in the learning community. By providing a social context for participation (members have roles with appropriate rights and authority), easily available grouping techniques, and an easy-to-use interface, SNS supports the participation of all appropriate members, and facilitates their interaction and sharing.

Team learning. How can members of a community interact and mobilize to achieve common goals so that the collective effort is greater than what could be accomplished by isolated individuals? SNS makes it easy for schools to establish classes with teachers, but also allows any member to create workgroups or review groups. Each type of group has different rights. For example, in a class group, students cannot throw a document created by the teacher into the trash, whereas in workgroups all members have equal rights and responsibilities regarding the managing and editing of files. Workgroups can be set up for the purpose of a group of students working on a team project, teachers collaborating on curriculum development, or students forming a chess club. Review groups allow an individual to organize a set of work for review by others. Review groups could be set up for the purpose of an electronic portfolio, a science fair exhibit, or having a teacher, student, guidance counselor, truant officer, and parent collaboratively review a student's work over time. To date, SNS provides the three group types described above, but other group types could be developed based upon new definitions of roles and rights. Figure 2 shows the desktop for a class group. The desktop is designed to support many of the processes of the class, such as providing documents or data to the class members, enabling messages, building a group calendar, and notifying members of new homework.

Within a group, members can invoke discussion boards or chat sessions whenever appropriate. The user experience is that of easy and flexible group formation, various communication tools, and file sharing and security. Just as the name "netWorkspace" communicates an environment for personal mastery, it represents customizable work environments for teams and groups. The groups and types of groups in a learning community can change as the need for new types of social interaction emerge over time.

Systems thinking. Senge calls systems thinking the fifth discipline (the name of his book) to highlight its importance in bringing the other disciplines to bear on knowledge creation and learning. While there is much to be understood about systems thinking, the practice of systems thinking starts with a simple concept called "feedback." Feedback provides the information needed to recognize causality, see patterns, and understand the interrelationship of phenomena. If NLS become places where much of the important work of schools is done or represented, then representations of this work can be viewed, reviewed, and monitored for patterns and relationships. While it is certainly possible to build an NLS that represents unimportant or noncritical aspects of the work of schools, and build elaborate systems models that will lead to no substantial improvement in schools, the challenging and creative work of systems thinking is drilling down to the essentials and core focus of the enterprise. The report from IBM directs information systems in business to bring value to customers; similarly in schools, NLS must focus on students and student work. Neither SNS nor any other NLS we have examined claims much progress in providing the

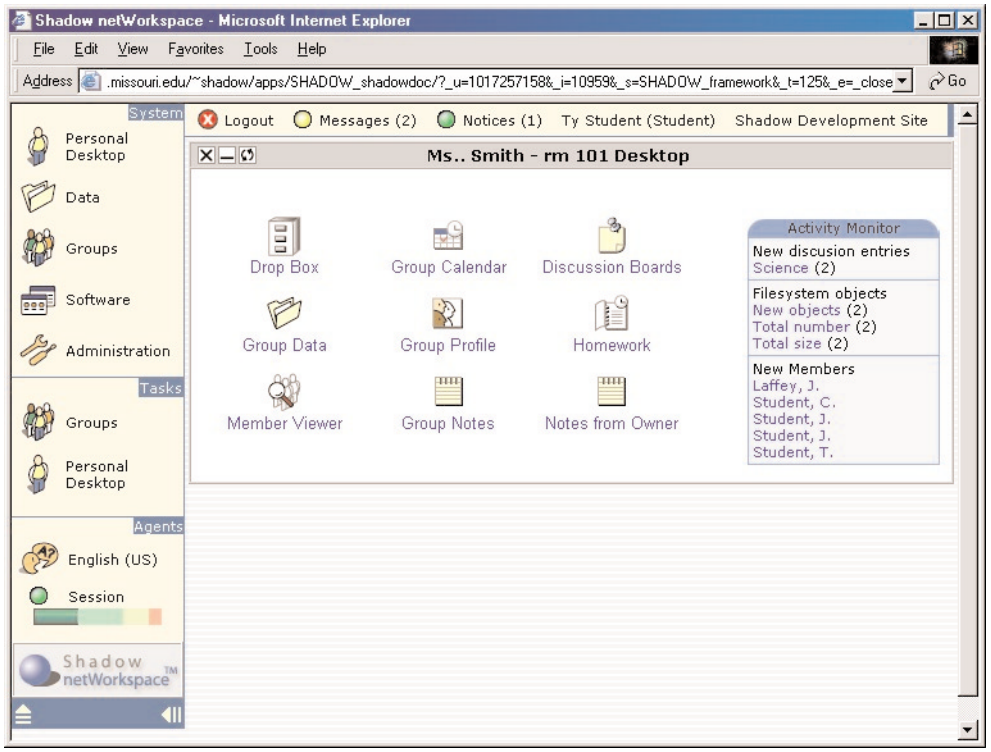

Figure 2. Desktop for a class group.

core feedback needed for school improvement. One of the goals of NLS developers who have created open source licenses for their work is to build communities of users so the shared experiences of school communities can provide feedback to NLS development, which in turn can lead to systems that improve over time and experience.

Conclusion

Networked learning systems hold great potential and promise for school improvement. The rapid deployment of technology into schools, along with the relentless advancement of technology for digital representation and network services, call for ways of thinking that will turn schools into true learning organizations. The work undertaken in the business community focuses our attention on turning schools into learning organizations that not only work to support student learning, but also work to improve their ways of working. NLS can be a substantial contributor to helping schools become learning organizations.

Systems like Shadow netWorkspace are early and somewhat primitive instances of the environments we envision for schools as learning organizations. These systems must advance through evolutionary and learning processes of their own. Schools must adopt NLS and begin the process of fundamental change to management, organizational structures, and human resource allocation that these systems will enable. The vision of NLS in schools has been impeded by limitations in access to technology and in bandwidth. However, we are already seeing instances of schools in which every

child has a laptop, and it is not hard to imagine a future where in many schools every child has some form of PDA. Similarly, wireless connections and Internet2 connections into schools foreshadow ubiquitous high bandwidth. Our implementations of NLS and our ways of thinking about schools need to advance, so that as ubiquitous access becomes a reality, we will have schools that can learn to bring these new network services to bear on improved teaching and learning.

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A Selection of NLS

www.class.com

Class.com is a for-profit corporation that provides online course support structures. Their system can enable a complete independent study virtual school via a standard Web-browser.

www.lightspan.com

Lightspan offers a free portal that provides separate channels for teachers, school leaders, parents, and students. Your School Online, Global Schoolhouse, and Your Class Online provide free Web site creation and hosting for schools and classes with bookmarks, announcements, and classroom conferencing using CU-seeme software.

k12planet.com

A for-profit project by Chancery Software that provides "an Internet-connected information and communication tool that gives parents, students, and teachers secure access to individual student data directly from a school's student information system."

www.powerschool.com

A for-profit Web-based "student information system" that provides support for scheduling, grades, and attendance, as well as discipline logs, meal management, parental access, creation of transcripts, progress reports, rankings, and report cards.

web.mit.edu/oki/

The Open Knowledge Initiative is a collaboration among a number of higher education institutions led by MIT. OKI seeks to build a learning management system that can integrate with a variety of campus enterprise systems.

www.Luvit.com

Luvit provides "a flexible and interactive way of distributing knowledge." Luvit's main product LUVIT Education Centre 3.1 is claimed to be the only e-Learning platform in the world to be certified for Microsoft Windows 2000 server.

www.webct.com/

WebCT is a provider of integrated e-learning systems for higher education. WebCT's solutions combine pedagogical tools with content management capabilities, options for personalization, customization, and integration with an institution's existing campus infrastructure.

www.blackboard.com

Blackboard's flagship product, Blackboard 5, supports course management, customizable institution-wide portals, and online campus communities similar to WebCT.

www.vlei.com/

Virtual-U is a soon to be open-source project designed to provide a framework for online collaborative education. VU is a course management system with integrated collaboration tools and user authentication and customization.

www.LearnLoop.org

LL is an open-source, Web-based, groupware environment for collaborative learning. Learnloop's modular design helps learning organizations design a custom interactive Web space.

sns.internetschools.org

Shadow netWorkspace is an open source, Web-based, collaborative work environment designed and developed specifically to support K–12 schools. SNS facilitates distribution of information through community interaction and knowledge representation tools.