

Twenty-First Century Teaching and Learning for Rural and Underserved School Districts: Catalyzing Innovation Through a Service Delivery Technology Platform

Hiller A. Spires, Eric Wiebe, and Phil Emer
Friday Institute for Educational Innovation
North Carolina State University
United States
hiller_spires@ncsu.edu

Andy Rindos
IBM Corporation
Research Triangle Park
United States

Abstract: The William and Ida Friday Institute (FI) for Educational Innovation, in collaboration with its education, government, and corporate partners, has developed a service delivery technology platform that will launch the research and outreach efforts of its 21st Century Teaching and Learning Initiative. FI is designed to capitalize on North Carolina State University's long history of committed engagement in the public, private and nonprofit sectors of the state and its leadership role in economic development. This paper will consider the role of the Institute's innovative service delivery technology platform in promoting 21st century skills for teachers and students in rural and underserved school districts in North Carolina. Specifically, we will address 1) the development of the model using a set of cross-sector partners, 2) the plan for implementation with targeted rural educational districts, 3) a multidisciplinary research agenda, and 4) the anticipated challenges of such an innovative endeavor.

In his recent work, "The World is Flat: A Brief History of the Twenty-First Century," Thomas Friedman makes a compelling case for preparing students with the skills needed to excel in the global knowledge society. Friedman claims that as a result of about ten events and forces that started in the 1990's and converged in 2000, the world has flattened—that the playing field in terms of intellectual capital and work has leveled. This phenomenon, he asserts, has profound implications for our economic, work and social future. The combination of the IT revolution and the fact that the economies and political systems of countries like China, India, and Russia opened up to the free market has helped flatten the world. A flat world calls for a new educational system—one that aggressively takes advantage of globalization and harnesses cross-sector talent to transform our educational system. The Friday Institute for Educational Innovation was created to be a catalyst for broad-based educational change.

The Friday Institute (FI) is located in a state-of-the-art, 33,000-square foot facility on North Carolina State University's Centennial Campus, adjacent to Wake County's Centennial Campus Middle School. As a research and outreach arm of the College of Education, the FI is meeting the demands of the global knowledge society with its mission to *advance education through innovation in teaching, learning, and leadership*. The FI is designed to capitalize on NC State's long history of committed engagement in university/business partnerships and its leadership role in economic development—both in urban and rural regions of the state. The Institute will capitalize on a Shared University Research (SUR) grant from IBM entitled Next Generation Education for Pervasive, Technology-Rich Learning Environments to address issues facing teachers in rural North Carolina.

Acknowledging an Educational Crisis in North Carolina

Low high school graduation rates coupled with high teacher turnover present an impending education crisis in North Carolina. In 2004, North Carolina was ranked 43rd in percentage of students who graduated from high school. Out of 100 ninth graders, 61% graduate from high school four years later; only 41% enter college and only 19% go on to

receive a college degree (National Center for Education Statistics, 2004; National Center for Public Policy in Higher Education, 2004). The challenges facing North Carolina students are exacerbated by the fact that one third of new teachers will leave the profession in three years and almost 40% will leave in five years (N.C. Center for Public Policy Research, 2004). This disturbing profile is even more pronounced in North Carolina's rural schools. Specifically, in the northeastern corridor of the state many counties are performing far below the state average on the ABCs End-of-Grade tests (Education First NC School Report Cards, 2004). For example, in Hertford county 43% of 6th Graders scored below grade level on reading (compared to 20% at the state level) and in Halifax county less than 19% of high school students scored at or above grade level in geometry (compared to 67% at the state level). The challenges of the education system in these communities reach far beyond low test scores to include low numbers of fully licensed teachers. Case in point, in Northampton county only 51% of high school teachers are fully licensed (compared to 82% at the state level) and in Vance county only 75% of elementary school teachers and 54% of middle school teachers are fully licensed (compared to 90% and 79% at the state level).

Previous research has shown that the unique environment of rural communities provides both assets and challenges to educators. Rural schools characteristically offer two conditions that have long been thought to be desirable for the educational and developmental well-being of students—namely, small enrollments and a strong sense of community (Coleman & Hoffer, 1987). Among the challenges of rural education are those whose underlying cause is geographical isolation from larger population and cultural centers. These include the delivery of advanced courses and other specialized programs; the recruitment and retention of highly qualified teachers and administrators; adaptation to changes in the content and delivery of education through professional development; and the need to accomplish all of the above outcomes under conditions not normally conducive to economies of scale or other efficient operations (Carter, 1999; Schwartzbeck, Redfield, Morris, & Hammer, 2003).

By their very nature, rural counties do not have ready access to many resources available in more urbanized locales. Education in Rural Communities (2004) reports that “the pool of educators is smaller, finding teachers for specialty subjects is more difficult, public school choice options are limited, and subgroups are small. The ability to implement educational reform is often limited by small economies, insufficient and inequitable funding, and districts that encompass large geographies.” On top of challenges such as these, rural economies are again in transition. Just as small family farms began to disappear decades ago, so too are the small manufacturing businesses. A recent report, *Pulling Together: The Rural Circumstance* finds that today, agriculture employs less than one in ten rural workers, and rural manufacturing now only provides jobs for 17% of the rural workforce. Especially germane to our project, the *Pulling Together* report notes that advances in telecommunications are enabling other types of services such as telemarketing and data processing to move to rural areas, albeit many of these jobs pay low wages. With respect to the challenges facing rural educators, changes in rural economies, and the possibilities that new information and communication technologies offer, the Friday Institute along with its business and government partners is well-positioned to assist rural educators to meet the challenges of the 21st century.

Looking to the Future with the 21st Century Teaching and Learning Initiative

The Friday Institute is partnering with the NC Center for 21st Century Skills, the NC Department of Public Instruction, and others to coordinate resources and to design a program of professional development for teachers and administrators that will be built upon a customized, interactive service delivery platform. The platform will enable virtualization of and on-demand access to a suite of tools, resources, and content that will help districts build capacity to meet 21st century demands. Key to the development of this project will be involving the school districts as co-developers of the online resources. Our aim is that rural educators will be able to access the most current information on best practices, communicate with others in their district, across districts and at the Friday Institute, and participate in the development of innovative instructional technologies and approaches for rural educational settings.

Skills that are needed by our students if they are to be successful in the 21st century will be infused throughout these professional development activities. The Partnership for 21st Century Skills, formed in 2002 with the support of the US Department of Education and composed of leading business, technology and education organizations, has identified five content and skill areas that represent the essential knowledge for the 21st century: 1) global awareness; 2) civic engagement; 3) financial, economic and business literacy; 4) learning skills that encompass problem solving, critical thinking, and self-directional skills; and information and communication technology

literacy skills. Since 2002, the Partnership for 21st Century Skills has emerged as the leading advocacy organization focused on infusing 21st century skills into education; in April 2005, Governor Mike Easley announced that North Carolina would develop the first state-level 21st Century Skills Center. Through the affiliated 21st Century Teaching and Learning Initiative, the Friday Institute will partner with North Carolina's 21st Century Skills Center to help lead a nation-wide movement toward a new model for teaching and learning.

In addition to the 21st century skills outlined above, key to a successful economic future in a global society is the production of more scientists and engineers. The Business Roundtable (2005) in its report, *Tapping America's Potential: The Education for Innovation Initiative* states, "Our goal is to double the number of science, technology and engineering graduates with bachelor's degrees by 2015" (p. 1). Mathematics and science are the disciplines that form the building blocks for developing future engineers. The number of engineering degrees awarded in the US is down 20 percent from the peak year of 1985. Although US fourth graders score well against international competition, they fall near the bottom or dead last by 12th grade in mathematics and science, respectively. The US is not developing its workforce with skills in expert thinking and complex communications to meet the needs of the 21st century, global, knowledge-based economy (Levy & Murnane, 2004). Nor is the nation making strategic human-capacity investments to develop a nation of workers and citizens fluent in the use of advanced technologies. Compared to South Korea, China, and Ireland, the United States is falling behind in terms of aligning education and business expectations.

Corporate America is already feeling the impact of the serious shortage in US graduates in engineering, math, and science, and is creating programs to appropriately address university curriculum (e.g., IBM Academic Initiative). However, industry also recognizes that any solution must address the pipeline at the K-12 level, and that outreach by Colleges of Education (including research institutes such as the Friday Institute) represent an important mechanism by which university technical strengths and deliverables can be brought to bear to address the needs and challenges of K-12 education.

A Case in Innovation: Service Delivery Technology Platform for Educators in Rural and Underserved School Districts

For northeastern North Carolina, the world (in Friedman's terms) is not flat. As mentioned previously, this area of North Carolina is confronted with challenges in the area of teacher quality and retention coupled with low high school graduation rates. As part of our 21st Century Teaching and Learning Initiative, we are creating a technology-based service platform that will enable targeted rural areas to have access to 21st century tools and content (i.e., "become flat.")

The Friday Institute platform leverages work in remote services computing that is currently being pursued by the Department of Computer Science and the Information Technology Division at NC State. Through an IBM Shared University Research (SUR) grant, the Friday Institute received 30 BladeCenter servers to explore how a centralized computing cluster, the Virtual Computer Lab, coupled with an extended services-oriented architecture (SOA) could be better used to serve K-12 education in North Carolina. Supporting middleware and applications (Tivoli, WebSphere, etc.) have been provided by the IBM Academic Initiative. Initially, the investigators are establishing a proof-of-concept that demonstrates how this SOA architecture can better support faculty and students at the Friday Institute and the College of Education at NCSU. The intent is to determine first how resources, including computing power, applications, content and scientific tools can be shared in a distributed environment. This SOA model will be applied beyond the NCSU campus to facilitate collaboration among Friday Institute staff and researchers and schools throughout North Carolina. The goal is to centralize the management of the resources at the FI and NCSU while minimizing operational and maintenance requirements at outlying schools throughout the state. This will allow the students and teachers to focus on teaching and learning rather than on managing the complexity of the technologies.

Remote Services Supporting Instruction

The initial application of the services delivery platform was the development of a video-repository. Over the last few years, the use of video has exploded in both research and instructional applications. On the research side,

investigators are filming hours of footage in classrooms examining instructional practice and student learning. On a smaller scale, footage is also being produced of individuals or small groups of students working or being interviewed. A vast majority of this video footage is kept on tape or transferred to CDs and DVDs. This local management of video footage is cumbersome to manage and difficult to share. Faculty also want to be able to use similar types of footage in instructional settings. The solution is a video database, called VBase, that uses open source tools (Linux, Apache, MySQL and PHP) on IBM Blade Servers to allow video to be archived and easily accessible in a secure manner from any location over the Internet. The design of VBase, was led by stakeholder focus groups to ensure that it meets their research and instructional needs. For rural schools, VBase will provide access to video in any computer at school or home. For example, teachers can search the database for relevant clips and then provide links to streaming versions on web pages for use in the classroom. Equally important, VBase will provide access to training materials and video-based tutorials related to professional development such as best classroom practices and the use of technology in the classrooms.

Another remote service under development is an extension of an ongoing project on the NC State campus. The project, called the Virtual Computing Lab, is a web-based service, built on commercially available and/or open source technologies for the scheduling and provisioning of remote access to a set of high-end computational resources residing on IBM BladeCenters. These resources are loaded on demand with predefined application sets geared to instructional computing and made available via a remote desktop client. While the application software on the Blades run under either Linux or Windows XP operating systems, these applications can be made available via Windows, Mac OS, or Linux desktops. Using remote desktop application software, a student or faculty member can run the BladeServer as a personal computer on their desktop, making use of applications on the BladeServer and having access to shared content, such as video content, via common networked file storage. The VCL, developed by Department of Computer Science and ITD at NC State, provides remote access to applications that are typically only available through computer labs due to high costs and licensing requirements. Through a Web-based portal, students and faculty can reserve a virtual lab machine – an IBM Blade Server is loaded “on-demand” with an operating system and the requested application. The server and software resources are “released” back into the available pool after the project is completed.

In partnership with IBM, the Department of Computer Science and ITD, the FI will extend the VCL model to initially support scientific probeware and data visualization applications for teachers and students. The VCL model reduces computer management in the classroom and labs by only requiring a minimum number of core applications on all computer with more specialized applications loaded via the VCL. This leaves the management and support of these applications and host computer hardware at a central site back at NCSU. This model means that scarce resources invested in specialized software can be shared across a school or schools (contingent on licensing restrictions) without the effort of loading and unloading it from computers. Instead, the software is run off a CPU back at NCSU but available from any computer with the minimum prerequisite network and software capabilities.

Bringing VBase and the VCL together into a SOA provides a platform for delivering instruction and for supporting the teachers leading the instruction. VBase provides tools for teachers to manage and organize video for use in the classroom with (or without) VCL delivered applications. It can also provide video-based professional development and technical support for instruction that makes use of VCL delivered applications.

In addition to the VCL and VBase platforms, the FI has also implemented the Nortel Multimedia Communication Server (MCS)TM, a SIP-based videoconferencing and real-time collaboration system. The SIP protocol means that communications can be set up with a wide variety of devices, including: webcams, telephones, whiteboarding, chat, in addition to high-end H.323 videoconferencing systems. Centralized IBM servers at the FI provide all of the management tools, requiring a minimum amount of hardware and setup at remote sites.

Scientific Probeware

The FI has initiated a pilot project with Granville County, Northampton County, and Roanoke Rapids City schools in NC to investigate the integration of technology-based instruments in the middle school science classroom. All of these school systems are in the northeast rural corridor of the state.

Use of data collection sensors, called probeware, provides new methods for students to learn about mathematics, science and the environment. Probeware refers to educational hardware and software used for real-time data

acquisition, display, and analysis with a computer or calculator (The Probeware Group, 2003). By connecting probes to a computer running suitable software, students can observe data displayed in a variety of formats as it is being collected. When used in an inquiry-based learning context, this capacity can significantly enhance learning. Over 40 kinds of probes are used in education, although temperature, light, and distance probes are most common. Software used with probes can represent the data in both numeric and visual forms, including graphs. There is great educational value in having students see the display change in “real time”, that is as soon as the physical input changes. In this way, learners quickly associate the physical change with the way the representation changes. More recent advances in probeware include the ability to run “virtual labs” with tools such as Vernier’s Logger Pro™. With these tools, measurements can be taken directly from a video of an experimental phenomenon. For example, X and Y measurements of a video model rocket launch could be investigated in a study of forces acting on the rocket.

With this pilot project, the research team will investigate novel ways of providing teacher support for the use of probeware in the classroom. The probeware focus provides an opportunity to work with technology that has a local component (probes connected to computers), but can use computer software delivered by the VCL. When virtual labs are used, video can be managed by the VBase video distribution system. Support for teachers will range from face-to-face training at the Friday Institute and rural schools, synchronous support and training using the MCS collaboration system, and asynchronous support through a Friday Institute portal. All these approaches will be used as part of an evaluation of best practices for teacher support. Integrating probeware and video technology through the services platform manages the complexity for teachers and students by providing transparent access to distributed resources that are centrally managed through the FI.

A Multidisciplinary Research Agenda

Research assessing the efficacy of the SOA approach of supporting K-12 instruction demands a multidisciplinary approach that includes the combined expertise of educational researchers specializing in pre-service and in-service teacher education along with computer scientists and engineers. HCI and software usability research methodologies are being incorporated into the design process of creating effective and affordable IT infrastructure for rural school systems. The specific research questions to be addressed through this project: 1) How can local, PC-centric and remote, server-centric services work together to support instructional and administrative functions in a rural school system; 2) How can communication technologies best be deployed to support this computing infrastructure?; and 3) How does the technology infrastructure used to support a rural school system integrate with the FI technology platform? Additionally, we will require ongoing feedback from the teachers to assess the quality of the applications in the classroom. The anticipated outcomes of the proposed project are that teachers and students will have on-demand access to content and tools that they otherwise would not be able to access. Access to the latest ideas in science and mathematics is essential to promote student engagement and achievement, which in turn contributes to the pipeline for future scientists and engineers (Dede, Korte, Nelson, Valdex, & Ward, 2005).

Framing the Challenges of Educational Innovation

Taking innovation seriously in the academic arena requires a shift in organizational culture in terms of work processes as well as reward structures. Even though the term educational innovation is used broadly, most innovations are rarely adopted and diffused (Rogers, 1995). University researchers may easily underestimate the enormity of the invasive nature of innovations and may often apply “inappropriate change strategies instead of looking to the guidance from the history of innovation diffusion” (Szabo, 2002, p. 1478). As the multidisciplinary research team implements the service delivery technology platform applications in rural and underserved school districts, we will work to bring new understandings to the adoption and diffusion process of innovation. We understand the complexities of integrating new technologies into educational settings and will document the adoption and diffusion process and how we negotiated the site-specific challenges to implementation.

Peter Drucker notes that every organization needs one core competence: innovation (Harvard Business Review, 1995). The 21st century global knowledge economy requires a new paradigm for the research university, not simply adjustments to the 19th and 20th century models. Clearly, global and economic forces are placing a premium on technological skills that in turn force educational institutions to step up to the challenge of producing a literate and technical workforce. At the same time, the egalitarian nature of society in the US demands equal educational opportunities for everyone, principally those for whom equity, access and quality is a challenge. Lastly, and simply, technology is driving the pace for change. The inexorable pressure of these forces—the global economy, democratic

society, and technology--makes it clear that educators must find news to make the mark. In fact, these forces make the field of education the most vital resource the US has to stay competitive and to fulfill its social goals. But the rules are changing, and the metrics for measuring the value of the educational "product" are also changing. More and more, there seems to be a demand for results. Through its design of invention the Friday Institute will take up the mantle of innovation, with its inherent challenges and complexities, and continue to engage cross-sector partners to produce dramatic results in education. If we take Friedman's clarion call seriously, we must not settle for less than educational transformation—our economic, social and cultural future depends on it.

References

Business Roundtable (2005). *Tapping America's Potential: The Education for Innovation Initiative*. Retrieved October 11, 2005, from <http://www.businessroundtable.org/pdf/20050803001TAPfinalnb.pdf>

Carter, C.S. (1999). *Education and development in poor rural communities: An interdisciplinary agenda*. Charleston, WV: ERIC Clearinghouse on Rural Education and Small Schools.

Coleman, J.S. & Hoffer, T. (1987). *Public and private high schools: The impact of communities*. New York: Basic Books.

Dede, C, Korte, S., Nelson, R., Valdex, G., Ward, D. (2005). *Transforming learning for the 21st century: An economic imperative*. Naperville, IL: Learning Point Associates,

Drucker, P.F. (1995). The information executives truly need. *Harvard Business Review*. Retrieved October 11, 2005 from http://harvardbusinessonline.hbsp.harvard.edu/b02/en/common/item_detail.jhtml?id=95104

Education First NC School Report Cards (2004). Retrieved October 10, 2005, from the website <http://www.ncreportcards.org/src/main.jsp?pYear=2003-2004>

Friedman, T. (2005). *The world is flat: A brief history of the twenty-first century*. New York, NY: Farrar, Straus & Giroux.

Levy, F. & Murnane, R. J. (2004). *The New Division of Labor*. Princeton, New Jersey: Princeton University Press.

National Center for Educational Statistics (2003). *Public high school dropout and completers for the common core of data*. Retrieved October 11, 2005 from <http://nces.ed.gov/pubs2004/2004310.pdf>

National Center for Public Policy in Higher Education (2004). Retrieved October, 11, 2005 from <http://www.highereducation.org/index.shtml>

N.C. Center for Public Policy Research (2004). *Shortage of Teachers an Impending Crisis- State Action Needed*. Retrieved October 11, 2005 from <http://www.nccppr.org/Teachersshortage.pdf>

North Central Regional Educational Laboratory. *Education in Rural Communities*. Retrieved October 9, 2005, from <http://www.ncrel.org/policy/feature/ruraleducation.htm>

North Central Regional Educational Laboratory (2003). *Pulling Together: The Rural Circumstance*. Retrieved October 9, 2005, from <http://www.ncrel.org/rural/PullingTogether.pdf>

Partnership for 21st Century Skills. *A Policymaker's Guide to 21st century Skills*. Retrieved October 11, 2005, from http://www.21stcenturyskills.org/images/stories/otherdocs/P21_Policy_Paper.pdf

The Probeware Group (2003). *Probeware: A definition: The Concord Consortium*. URL http://www.concord.org/work/software/ccprobeware/probeware_overview.pdf

Rogers, E. M. (1995). *Diffusion of Innovations*. Free Press: New York.

Schwartzbeck, T.D., Redfield, Morris, & Hammer (2003). *Declining counties, declining school enrollments*. Arlington, VA: American Association of School Administrators

Szabo, M. (2002). Educational reform as innovation diffusion. *Proceedings of Informing Science & Information Technology Education Conference*, (pp.1465-1480). Cork, Ireland. Retrieved December 17, 2003 <http://ecommerce.lebow.drexel.edu/eli/2002Proceedings/papers/Szabo154Educa.pdf>