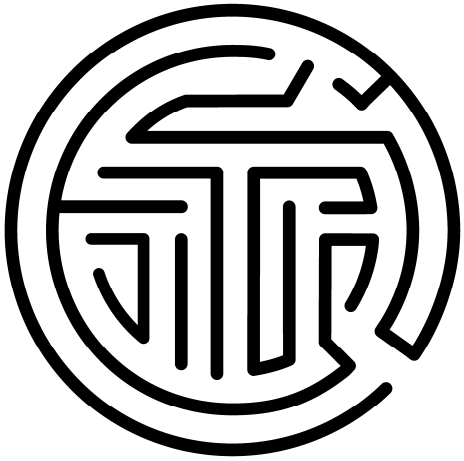

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Teachers' Domain Evaluation Report

CCT Reports
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Introduction

WGBH's Teachers' Domain (www.teachersdomain.org) is a free online collection of multimedia resources for K-12 teachers and students. According to the Boston-based station's own description, this repository contains 50 years of archival assets organized and contextualized for efficient use in schools, and features excerpts from WGBH's broadcast, video, and interactive programming. The first phase of the site focused on the Life Sciences with subsequent phases turning to the creation of additional resource areas, both in the sciences as well as other disciplines.

Before proceeding with the development of the collection, WGBH's education staff was interested in learning more about teachers' potential use of the digital resources as well as barriers to effective dissemination of the site. With support from the Ford Foundation, WGBH sought to commission additional research to supplement a Summer 2003 summative evaluation of the Life Sciences library, which involved students and teachers in two high schools. Based on the results of a formative research project the Center for Children and Technology (CCT) conducted around PBS's Digital Classroom, which was a pilot project involving seven public television stations' delivery of broadband content to local schools, WGBH invited CCT to study its online service. For over two decades CCT has been investigating the ways technology can make a difference in children's classrooms, schools and communities.

This report is the result of a five-month study; it is comprised of two components:

(1) an overview of the current knowledge base regarding how rich media resources, like Teachers' Domain, can support teaching and learning in K-12 schools; and

(2) case studies of teachers, technology coordinators and administrators' perceptions and potential use of Teachers' Domain.

Section I. Review of Rich Media Knowledge Base

Overview

While information and interactive activities delivered via media-rich websites, like teachersdomain.org, have the *potential* to help create substantive learning experiences, we know that technology by itself, as an isolated solution, seldom leads to substantial change in schools or school systems. Effective technology use is more often than not dependent on a complex number of factors that delineate the culture of a school and determine the degree to which technologies can be leveraged to support students' learning. These factors include such things as:

- Leadership and vision at multiple levels of the system
- Availability of professional development opportunities
- Availability of technology resources (both infrastructure and human) in the school and barriers of use
- School- and district-wide goals and expectations for the use of technology in the classroom context, in general and as these expectations are shaped by the climate of standardized testing

The purpose of this section of the report is to provide a description of these and other factors as they relate to the state of rich media use in K-12 classrooms throughout the United States. Researchers focusing on educational technology have conducted many studies in recent years, several of them involving large populations of teachers and students. By mining the data contained in these large-scale research studies as well as smaller examinations of rich media integration, this section of the report offers a description of the current knowledge base. We look across these studies, pulling out lessons learned, highlighting evidence of potential benefits and listing persistent challenges that schools encounter when introducing rich-media resources into classroom practice.

We have organized this section around the following questions:

- How prevalent are rich media in K-12 classrooms?
- How do educators become familiar with rich media?
- What do we know about learning from rich media?
- What conditions are necessary to support the use of rich media in classroom contexts?
- How have teachers used rich media to support learning in K-12 classrooms?

Exploring these questions allows us to examine both the complexity surrounding the integration of rich media in schools as well as the need for additional research about what role they may play in teaching and learning. After all, it is not simply the presence of multimedia and technology resources that leads to use and ultimately student learning. First, educators must have knowledge of and access to resources that provide support for using rich media in their classrooms. Second, they must be able to select high quality and relevant options from the multitude of commercial and educational resources that they are bombarded with, and third, they must have access to both the technical and instructional support in integrating these resources.

Research Methodologies

In order to investigate the questions outlined above, we undertook a comprehensive review of the literature around the use of rich media in K-12 classrooms. In addition to drawing on the findings from our own previous research, we consulted books and journals along with a number of online databases: ERIC, Education FullText, CARET (Center for Applied Research in Educational Technology), WilsonWeb, PsychINFO, Teachers College Record and ISTE's Learning and Leading with Technology.

About Rich Media

Although the field of educational technology is vast — both in its breadth within schools and its depth of scholarly study — the examination of rich media use in K-12 classrooms and schools is considerably smaller. Many studies simply do not define the kinds of resources teachers and students are using; rather; they refer to *information and communications technology* broadly or rely on the generic *use of computers*, often giving little attention to *what* educators are using or, conversely, focusing primarily on *why* they are integrating new tools into their practice and/or *how* that integration occurs (or does not occur). Consequently, before addressing the questions that comprise this review of rich media, it is necessary to delineate what *rich media* are within the context of this review.

Rich media, which is often synonymous with *rich-text media*, *multimedia* and *interactive online media,* is a term most commonly employed by web design agencies and online advertisers rather than teachers. However, as video, audio and interactive animation are becoming recognizable components of educational websites and educators continue to find ways to utilize technology in their curriculum, it is a term that is likely to become more familiar in the educational arena. Also, as cultural institutions, such as museums and libraries, continue to offer digital versions of their archival assets and other holdings, providing educators with increasingly greater access to their multimedia resources irrespective of geographical location, the notion of rich media will expand further. Drawing upon several definitions, the primary characteristics of rich media are the following:

1. Contain a combination of the following web-based technologies: streaming video and/or audio, interactive animation such as Flash, printed text and/or interactive text, photographs and/or diagrams (University of Washington, 2002; Marshall, 2002)

2. Are designed with an implicit understanding and inclusion of a cognitive framework. Various multimedia resources support this framework, working together to effectively communicate the intended message (Mayer, 2001; Doolittle, 2002; Becker, 2001; Bruce and Levin, 1997).

3. Enable users (teachers and students) to take an active role in building their own narrative, becoming producers and makers of meaning as they choose their individual/relevant learning path through the website (Reeves, 1998; Partnership for 21st Century, 2003).

How prevalent are rich media in K-12 classrooms?

There have been a number of broad quantitative studies in recent years that have attempted to survey the state of the nation's educational technology, and many have found an increase in the presence of technology infrastructure over the past decade. (U.S. Department of Education, 2002). Although none of these surveys have focused on rich media specifically, they capture data relevant to technology infrastructure, which use of rich media requires. And while technology in the nation's schools is not ubiquitous, it is no longer the lack of infrastructure that presents the primary challenge for many schools; rather it is the lack of professional development and support for the effective and meaningful integration of the available technology into school cultures and classroom practice (Grunwald 2003).

Computers

Below is a brief description of findings from several recent surveys that examine information and communications technologies:

Highlights from "Internet Access in U.S. Public Schools and Classrooms: 1994-2002." In 2002:

- 99% of public schools are connected to the Internet
- 94% of public schools are connecting to the Internet using Broadband. The largest growth in broadband adoption between 2000-2002 was in the lowest income school districts (75% - 95% or an increase of 27%)
- 92% of instructional rooms had Internet access
- 23% of public schools with Internet access used wireless connections
- 7% of public schools provided hand-held computers to students or teachers for instructional purposes
- 8% of public schools lent laptops to students

Highlights from "Computer and Internet Use by Children and Adolescents in 2001." In 2001:

- About 90% (47 million) of children between the ages of 5-17 used computers
- 59% (31 million) of children between the ages of 5-17 used the Internet.
- 72% of Internet users age 5-17 (42 percent of all youth in this age range) used the Internet to complete school assignments.
- Students report accessing the net more frequently at home than at school (78% compared to 68%).

Two additional reports, the Corporation for Public Broadcasting's "Connected to the Future: A Report on Children's Internet Use" and the Pew Internet & American Life's "The Ever-Shifting Internet Population" also provide recent data about access to information and communications technology.

Cautious interpretation of high percentages contained in these studies and others like them is often warranted as participants' experiences in Case Study 3 in the next section

demonstrate. A school may appear to have high levels of connectivity on paper when in reality teachers' encounter little or unreliable classroom access to the resources they desire. Also, issues around inequitable access, commonly known as the digital divide, persist. As the CPB survey identifies, "American children regardless of their age, income, or ethnicity, greatly increased their use of the Internet from home, school, or library over the past two years. Yet even with these growth trends, children from under-served populations still significantly lag behind more advantaged children both in home and school access." Computer and Internet access has become an important component of schoolwork, but many teachers find themselves reluctant to rely on technology-based materials because their students do not have access from home, as several participants in the Case Studies in the next section describe.

TV/Video

Because rich media are not exclusive to computer technology, but can be used in conjunction with TV monitors and video, below are highlights from two additional studies:

Excerpts from "Video in Television Use Among K-12 Teachers," (2002):

- The vast majority of teachers (91%) use video and television programming with students at least sometimes during the year making the media more popular than most other instructional technologies including the Internet. And unlike the Internet, teachers most often use video and television in actual classroom instruction to reinforce and expand the curriculum – generally with the whole class at once. Most use video or television programming once a week or less, but one out of four can be classified as frequent users (more than once a week).
- Overall, PBS is the most popular single source of content thanks to high quality instructional programming, which is considered particularly age- and educationally appropriate. In general, teachers most often access programming by purchasing either videos or DVDs, or tape programs off-air. Teachers look especially for programming that covers specific subject areas of interest, or that meets their curriculum needs.
- Teachers who use video and television experience substantial benefits, the most common being the ability of the media to stimulate class discussion, and increase student motivation. Importantly, the more frequently the media is used, the more pronounced the benefits. Teachers say programming is especially effective with special student groups including the economically disadvantaged and the learning disabled. Creating more programming for ESL students may represent an opportunity for PBS.
- The biggest barriers to increased usage include a perceived lack of time (especially among elementary teachers), the high cost of video, and a lack of awareness regarding broadcast times (program guides may be useful in this regard).
- Nearly all teachers have either classroom or school access to key television and video technologies including televisions, VCRs, and multimedia computers with Internet access. The one exception is access to DVD players, which are quickly becoming the standard in homes, but have low penetration in schools.

Highlights of an analysis prepared for the U.S. Congress Office of Technology Assessment, in which Henry Becker examined the "presence in schools of computers and related technologies and television and related video technologies and the extent to which teachers and students now use these technologies in their teaching and learning." (Becker 2001):

- While schools have continued to acquire technology, it is often being added to resources that are from an earlier generation with much less capacity for use.
- Often, in order to make the most of their still limited resources, schools place these resources together in a lab, and while making this easier for more students to use them at one time, it limits the ability to integrate the technology into the classroom curriculum.
- In terms of video use, there is a geographical distinction among use of older video technology (television and VCR use of taped programs in the classroom), which is used more often in the South and in rural communities verses newer video technology, more often used in the West and Northeast in higher spending districts.

How do educators become familiar with rich media?

In order to use rich media, teachers and curriculum specialists must first know these resources exist. Questions of awareness tend to fall under the purview of market research, however, as companies scramble to learn more about how to build brand awareness, allocate advertising dollars and sort out what makes for successful products. Likewise, companies are not the only ones concerned with the challenge of attracting educators' attention; museums, libraries and other cultural institutions also are questioning how they provide access to their resources and awareness of their roles in a learning society though (Sheppard, 2000). Nevertheless, much of the data about how educators learn about new resources is governed by rules of the marketplace: the research is either product-specific or proprietary, or both.

Computers

The few isolated studies that allude to this question while not taking it up directly suggest teachers learn about new technology-based resources from a variety of sources, including the following (CCT; CPB, 1997):

- Other educators
- Web sites
- Professional development workshops and conferences
- Search engines
- Magazine and print newsletters
- Listservs

Although there is a dearth of data around this topic, it is worth noting that the most common source of information about new educational resources is recommendations from colleagues. Fellow teachers, curriculum specialists and others within one's own building remain the primary means by which teachers learn about potential new materials. The resources themselves may be multimedia but awareness often grows out of simple word-of-both communication. Schools fundamentally remain local institutions (Culp et al, 2002).

TV/Video

To the extent that PBS is a brand, and arguably a powerful one that competes against commercial products and services, this review included research specific to awareness about public television more broadly. Although not directly tied to rich media per se, below are additional excerpts from Grunwald's "Video in Television Use Among K-12 Teachers" that are related to perception and awareness of educational resources; the 2002 survey found:

- Overall, teachers are very interested in most types of programming from PBS, but are particularly interested in PBS instructional, general audience, and professional development programming. Because teachers use television and video programming primarily to strengthen the curriculum, they react most favorably to new features

that help facilitate this (e.g., the ability to correlate content to standards, and the availability of student and teacher guides).

- Teachers strongly recommend that PBS send them advanced information with program descriptions and broadcast times, many wanting this emailed. Linking programs to specific state curriculum standards is also a very appealing new feature.
- About one in ten K-12 teachers report being members of PBS. As a group, PBS members are more likely to purchase video programming in general, and are more likely to purchase from PBS specifically. They are also more creative than non-members in their use of video programming in the classroom.

What do we know about learning from rich media?

The educational technology research community simply does not yet know enough about how rich media can support learning. Although there have been studies of discrete media, such as video, video streaming and hypertext, there is not substantial knowledge about what is possible when these media are combined (Marshall, 2002, Reeves, 1998, Smith 1998). Also, as noted above, many of the studies done to-date have not made a distinction between rich media and a more general notion of computer-related activities as future examinations of rich media are bound to do with the increase in their use. Instead, they may review of the impact of technology on student learning, teasing apart discrete skills like creativity, problem solving and critical thinking, but they treat computer-related resources broadly (Johnston and Barker, 2002).

Setting aside the need for additional research on rich media, however, below are two research summaries that offer useful information concerning what we currently know about the roles technologies can play in shaping students' learning experiences. The first is a summary of findings from previous studies of educational technology; the second, a framework for understanding multimedia applications' potential to support learning.

Summary of Findings

In 2000, the Software Information Industry Association, a trade association that resulted from a merger between the Software Publishers Association and the Information Industry Association, published its seventh edition of its report on the "Effectiveness of Technology in Schools." With an acknowledged stake in the industry's success, this report synthesizes ways that technology has had a positive impact on teaching and learning. Conducted by Interactive Educational Systems Design Inc., an independent consulting firm, the report includes the findings from 311 research reviews and reports, organizing them into three primary areas of impact: student achievement, student self-concept and attitude about learning; and interactions involving educators and students in the learning environment.

Below are excerpts from those findings related to potential rich media applications:

- In studies focusing on reading and language arts, technology has been shown to provide a learning advantage in the areas of phonological awareness (awareness of the structure of sounds in a language), vocabulary development, reading comprehension and spelling.
- Technology has been used effectively to support mathematics curricula that focus on problem solving and hands-on, constructivist, experiential activities. Students participating in such technology-supported learning experiences have demonstrated superior conceptual understanding of targeted math topics than students receiving traditional instruction.
- Studies focusing on science education suggest the benefits of simulations, microcomputer-based laboratories, video to anchor instruction to real-world

problems, and software that targets students' misconceptions.
- A learning advantage has been found when students have developed multimedia presentations on social studies topics.
- Interactive video is especially effective when the skills and concepts to be learned have a visual component and when the software incorporates a research-based instructional design.
- Offering students some control over the amount and sequence of instruction, including options for student review of material, can result in higher achievement and better student attitudes toward learning than having the software control all instructional decisions. However, low-achieving students and students with little prior content knowledge are likely to require more structure and instructional guidance than other students are. When students have a high need to learn, this may nullify the impact of the level of learner control.
- Animation and video can enhance learning when the skills or concepts to be learned involve motion or action. Also, animation accompanied by spoken narration is generally superior to animation accompanied by explanatory text.
- Content-related graphics (both static and animated) and video can help improve student attitudes and motivation in mathematics and science.
- Students using hypermedia software can benefit from an interface that includes a navigation map that shows the links among the various screens of information and the hierarchical structure of the information. It is also advisable to make the entire hyperspace to which students will eventually have access fully transparent while limiting their access to what is currently instructionally appropriate.

Framework

Apart from the findings above, all of which are tied to specific studies, Richard Mayer has examined cognitive theory to support the idea that multimedia can help people learn more effectively and meaningfully. He has explored such questions as how illustrations can affect how people learn scientific text, how people learn to solve problems from computer games and simulations and how online digital libraries can promote scientific reasoning.

In a paper entitled "Multimedia Learning: Empirical Results and Practical Applications" Peter Doolittle cites Mayer's research investigating the nature and effects of multimedia presentations on human learning, and presents the empirical results of Mayer's research in the following manner:

- **Multimedia Principle:** Students learn better from words and pictures than from words alone.
- **Spatial Contiguity Principle:** Students learn better when corresponding words and pictures are presented near rather than far from each other on the page or screen.
- **Temporal Contiguity Principle:** Students learn better when corresponding words and pictures are presented simultaneously rather than successively.
- **Coherence Principle:** Students learn better when extraneous words, pictures, and sounds are excluded rather than included.
- **Modality Principle:** Students learn better from animation and narration than from animation and on-screen text.

- **Redundancy Principle:** Student learn better from animation and narration than from animation, narration, and on-screen text.
- **Individual Differences Principles:** Design effects are stronger for low-knowledge learners than for high-knowledge learns and for high spatial learners rather than from low spatial learners.

What conditions are necessary to support the use of rich media in classroom contexts?

The presence of a reliable technological infrastructure and rich media alone do not necessarily result in sustained integration and use. A number of conditions, which dramatically shape the broader context within which teaching and learning takes place, are necessary in order to integrate rich media effectively into the classroom context. Apart from stable access, the most salient conditions that emerge from the research have to do with leadership, professional development and support, and pedagogical philosophy.

Leadership

Strong, flexible leadership — at both the building and district levels — can contribute to teachers' willingness to integrate technology into their classroom practice in meaningful ways. The extent to which administrators have a vision for technology within their schools often means they have an understanding of the changes that are necessary within the broader learning environment. In a general sense, these may pertain to curricula, administrative procedures, time and space constraints and relationships between the school and community (Benton, 2002, CCT, 2000, Fisher, Dwyer, & Yocam, 1996; Hawkins, Spielvogel, & Panush, 1997; Means, 1994; Sandholtz, Ringstaff, & Dwyer, 1997). On a practical level of integrating rich media, research indicates that school leaders recognize the importance of classroom connectivity. Rather than asking students and teachers to make use of labs, which are less easily integrated into an instructional routine, administrators seek to provide access to computers at the classroom level. This is more likely to result in teachers' professional use of the Internet as well as their directing students to conduct Internet-based research (SIIA, 2000).

Professional Development

In addition to strong, visionary leadership, research has shown that teachers who effectively use rich media have strong support systems within their schools and districts. In addition to a shared positive attitude and a commitment to providing these resources on the part of administration and school staff, support also includes school-based human infrastructure and professional development. Effective professional development includes both training on how to use the rich media tools themselves as well as how to integrate the tools into the curriculum to support student learning. Furthermore, according to another review of educational technology, "Teacher professional development and decisions about how computers are to be used in instruction may matter more than how often technology is used" (SIIA).

In a national study conducted by researchers at the Bank Street College of Education, Henry Becker examined how "expert computer-using teachers" differ from other teachers in their use of technology in their curriculum(Becker, 2000). An important finding was that these teachers worked in environments where they had both collegial and professional support; the study found that "of the 51 separate teacher environment variables examined in this study, the one with the largest difference between exemplary and other computer-using

teachers was simply the total number of teachers at their school who used computers." In addition, Becker found that 37% of exemplary teachers worked in a school where there was a school or district-based technology support staff person, compared to only 10% of other computer-using teachers. A study of Intel's Teach to the Future professional development program also has shown that teachers who have access to sustained professional development around the integration of technology, including basic software applications as well as rich media available via the Internet, have a better chance of going on to use them independently (Martin et al, 2002).

Pedagogy

Even with access to sustained professional development in a supportive environment, teachers' individual experiences influence how they use rich media. Teachers' comfort level with learning about and using new resources, as well as their ability to incorporate these resources into the classroom, all are factors of effective use. And, changes in teachers' instructional pedagogy are directly linked to the professional growth efforts in which they are engaged (Johnston and Barker, 2002). In addition, research shows that teachers who approach the use of rich media from a pedagogical perspective that embraces inquiry-based teaching, and who can incorporate rich media in the support students in their own learning, demonstrate more meaningful applications of these resources.

Larry Cuban's study *High Access and Low Use of Technologies in High School Classrooms: Explaining an Apparent Paradox* examines two highly resourced high schools in California. While he found "access to equipment and software seldom led to widespread teacher and student use," he reports teachers who used technology in meaningful ways differed from the majority of their colleagues both in the frequency with which they use computers in their classrooms and in their pedagogical approach.

Also in the Becker study cited above, "exemplary" use was defined as "an assumption that important academic outcomes will result from systematic and frequent use of computer software for activities that involve higher order thinking (such as interpreting data, reasoning, writing, solving concrete, complex, real-world problems, and conducting scientific investigations). While one finding was that these teachers employed a variety of technology in the classroom, Becker also found that using the computer for "consequential activities" was a factor of these teachers' success. Instead of using computers for skill mastery and remembering knowledge, teachers focused on using technology to support meaningful activities that had real-world relevance for students, such as writing for an audience or activities involved with occupational preparation.

In addition to the idea that constructivist pedagogies support rich media integration, some researchers have examined how the use of rich media can help facilitate an inquiry-based classroom and influence student learning. Reeves states the following about research results around pedagogical tendencies and the use of media and technology: "Longitudinal studies such as the ten year investigation of the Apple Classrooms of Tomorrow (ACOT) Project show that pedagogical innovations and positive learning results do eventually emerge from the infusion of media and technology into schools, but the process takes longer than most people imagine (Reeves, 1998).

In another study that looked at teachers who demonstrated exemplary technology use, instead of comparing exemplary technology-using teachers with other teachers, Zhao and colleagues examined narratives of grant proposals of 118 technology-using teachers to learn "what exemplary teachers do, know, and believe about using technology for teaching and learning." (Zhao, Byers, Mishra, Topper, Chen, Enfield, Ferdig, Frank, Pugh and Tan, 2001) Similar to the Becker study, these researchers found that the exemplary users tended to use a wide variety of technology. In addition, they found that teachers had positive attitudes about technology, believing that technology was an asset in teaching and demonstrated little anxiety about using technology in the classroom. "Stories from the Schools Participating in the JASON Project" defines effective teachers in a similar manner: "They all were identified in some way as leaders in their school or as particularly innovative teachers, they all mentioned that they took an experimental, hands-on approach to teaching science, and they all welcomed the challenge that JASON's changing curriculum offered." (Ba et al, 2001)

How have teachers used rich media to support learning in K-12 classrooms?

Across all disciplines, teachers have used a wide variety of rich media applications, including virtual expeditions, WebQuests, digital archives, simulations and streaming video, to support curricular goals. Increasingly, practitioners have combined the variety of technology and media resources available to them in order to create a wide variety of learning experiences for their students. For example, teachers have used a video or audio clip in conjunction with an online lesson or activity instead of simply using the clip in isolation. This reliance on a combination of interactive resources is the first characteristic of rich media we delineated above. The ways in which teachers have integrated rich media into various disciplines also has been influenced by the second characteristic of rich media: the presence of a cognitive framework, which is supported by the particular resources the teacher selects to enhance student learning.

State and national standards also have contributed to the context within which teachers have made use of rich media. While links to relevant standards have been present within many technology-based resources for many years, recent federal requirements have brought them to the forefront. Nearly all rich media resources have been obliged to incorporate standards, from the national to the local level, in order to encourage teachers who feel pressure to adhere to these standards make use of these resources. (This was evident in our interviews with teachers participating in the case studies as the next section illustrates; many teachers would not consider using rich media resources without the capability to link them to standards.)

Lastly, while there have been several national studies that have examined technology use in the classroom, this kind of large scale research has not been conducted around the use of rich media, as it is specifically defined in this review. Therefore the purpose of this section is to present smaller and more isolated studies and descriptions to provide a glimpse of rich media use in specific curricular areas.

Multidisciplinary

With the advent of rich media, many teachers have taken advantage of the opportunity they present to support work across multiple subject areas. Digital archives, as well as virtual expeditions and WebQuests have lent themselves to multidisciplinary use, due to the exploratory nature of these media.

Virtual Expeditions

Whether it is exploring different periods in time or discovering different cultures and environments, teachers have imagined an array of ways they could use rich media to enhance learning experiences within their classrooms. In "Tech Talk for Social Studies Teachers: Virtual Expeditions: Taking Your Students Around the World without Leaving the Classroom" Tim Green describes the grand promise underlying the use of virtual expeditions; he writes: "Imagine seeing the magnificent Inca ruins at Machu Picchu, hearing the howls of hyenas as they roam the Amboseli National Park in Kenya, or watching the giant sea turtles

as they float effortlessly in the water off the coast of the Galapagos Islands. Now imagine doing those things with your students, without leaving your classroom….how is it possible? The answer: virtual expeditions."

Virtual expeditions occur when teachers use a variety of technology in an attempt to create an experience for students, including mimicking an actual field trip. Green describes them as a "real-life journey that is captured and documented in images, sound, and text, with the results being transmitted primarily on the Internet." Despite the promotional tone around the discussion of this type of technology, motivation has featured prominently in many studies around the use of this type of rich media (Ba, 2002; Green, 2001). Some expeditions have provided opportunities for students to watch video and conduct research of places they have never seen. Others have included live interaction with "experts" from the field, or a live video broadcast of a place or event. All have been used as a "hook" to draw students into learning activities.

Research has demonstrated that programs that employ virtual expeditions and similar efforts have had success in capturing students' interest and introducing them to new ways of thinking and learning. Ba, et al describes several findings that emerged from a study of the JASON multimedia science curriculum on upper elementary and high school students. These findings include the following:

- Multidisciplinary components of the Jason Multimedia Science Curriculum provided coherence in students' learning through capturing their interest and providing opportunities for collaboration.

- Students appreciated the variety of experiences and access to knowledge that the multimedia components (videos, Live Broadcast, digital labs, Internet research, and other online activities) provided them; students claimed the affordances of multimedia helped them learn better.

- Students with varying literacy levels were able to access complex scientific concepts (Ba,2002).

WebQuests

The term *WebQuest* was coined nearly a decade ago by Bernie Dodge at San Diego State University, who defined it as "an inquiry-oriented activity in which some or all of the information that learners interact with comes from resources on the internet, optionally supplemented with videoconferencing." The empirical research base on the efficacy of WebQuests on student learning tends to be thin, however there are plenty descriptive and prescriptive published commentary about WebQuests and how teachers can use them effectively across all subject areas to engage students in critical thinking. Furthermore, WebQuests have been the subject of teacher professional development forums, and educators have shared WebQuest samples and assessment rubrics on many education websites and listserves. For example, Dodge has created a website that lists peer-reviewed WebQuests by subject area and grade level that teachers can use (http://webquest.org).

Teachers have chosen to incorporate WebQuests into their teaching for a variety of reasons. Tom March outlines the three main goals of using WebQuests in the classroom in an online paper entitled "Why WebQuests, an Introduction." These goals are paraphrased below:

1. *Student motivation and authenticity* — When using WebQuests students have access to real and current resources to answer a central question that asks them to understand, hypothesize or problem-solve an issue that confronts the real world. Using the Internet, students can directly access individual experts, searchable databases, current reporting, and even fringe groups to gather their insights.

2. *Developing thinking skills* — In order to engage students in higher level cognition, WebQuests use scaffolding or prompting which has been shown to facilitate more advanced thinking. Constructivism suggests that when students need to understand a more complex or sophisticated topic like those that comprise WebQuests, they need many examples with lots of information and opinions on the topic through which they will sift until they have constructed an understanding that not only connects to their own individual prior knowledge, but also builds new schema that will be refined when students encounter the topic again in the future.

3. *Cooperative learning* — In WebQuests students assume roles within a small student group and develop expertise on a particular aspect or perspective of a topic that they bring back to their teammates (March,1998).

Digital archives

As resources have been converted increasingly to online archives, teachers have had access to digital versions of primary sources such as historical accounts, literature and art. While there has been a lack of large scale research that examines teachers' use of digital archives, some small studies present a picture of how these resources have had an impact on teaching and learning. Tally and Burns describe the American Memory fellows program, which was designed to bring together teams of middle and high school educators to develop, test, and publish innovative classroom activities that use online primary-source collections from the Library of Congress. One of the goals of the program was helping teachers and students build the "information literacy" necessary to interpret these resources effectively. Tally and Burns cite previous classroom research they conducted that found "students who use primary sources exhibit more of the traits we associate with good historical thinking: they pose questions, observe details, and speculate about context — about what was going on behind the documents", while they recognize the need for teachers and students to acquire help "sorting out which online material is relevant, how to locate and evaluate useful texts, and how to apply what they have found to their questions or problems." They present the following example of how one teacher chose to construct a lesson in his classroom as a result of this program:

> "At Pleasant Valley High School in Chico, CA, social science teacher Brett Silva has set up a historical role-play for his students involving a provocative set of primary sources from the 19th century. The students are asked to mediate a

Texas land dispute between Native Americans and white settlers. The primary source documents present the issue from an Indian perspective, a white perspective, and a 19th-century Quaker perspective. Brett uses Web resources to help his students understand that human history reflects multiple points of view. He invites his students to see how the world was-and how it might have been different" (Tally and Burns, 2000).

Science

Both empirical research and descriptive cases show that there has been a realm of rich media options available to teachers that focus on specific science concepts. Science teachers have capitalized on real-time data, simulations and webcasts to help support meaningful inquiry.

In a study around the use of Unitedstreaming ™ in upper elementary Virginia classrooms Boster, Meyer et al conclude the use of video clips in science classrooms can influence student achievement when certain conditions are in-place. While Unitedstreaming™ has a stake in the success of its offering, which consists of an online digital library of video clips accompanied by support materials aligned to academic standards, they outline the following necessary conditions:

1. video clips are selected to align with the state-adopted curriculum standards in Virginia;
2. clips are used during the time span allocated for instruction related to the standards for which the video clips are aligned;
3. exam items correspond to each of the curriculum standards being taught; and
4. instructors are trained on ways to use and integrate the video clips with curriculum and instruction.

In another example, Smith and Reiser describe their experiences in designing and deploying an interactive video tool to high school classrooms in "National Geographic Unplugged: Classroom-Centered Design of Interactive Nature Films." The authors used software to create structured learning environments around selected video clips, and found that "these projects shift students away from the passive viewing of video by creating tasks requiring construction and/or interpretation of multimedia artifacts" and that "nature films also hold a wealth of "raw data" that can be observed, analyzed, and explained scientifically. Students can become multimedia researchers, decomposing these films into salient events, analyzing and drawing connections between these events, and collaborating with others to construct meaningful representations of the visual data. In a sense, students can study nature films to learn about behavior in the same ways that behavioral ecologists study animals in their natural habitats" (Smith and Reiser, 1998).

Computer-based modeling is another rich-media tool teachers have used in conjunction with online or print curriculum to support students in engaging in critical thinking in the area of science. For example, Friedman and Culp conducted a study of the Maryland Core Models Project, the intent of which was to "create an effective infrastructure to support the broad-based adoption of computer-based modeling tools and curricula that support students and teachers in engaging in systems thinking" (Friedman and Culp, 1999). In addition to teacher

professional development goals, the intent to impact student learning is summarized at the beginning of the report, "If the teacher development model, the modeling and simulation tools, and the sample curriculum units being developed are working together effectively, it should be possible to demonstrate in a sample of classes that students are engaging with and understanding certain key concepts about the nature of dynamic systems and of modeling as a methodology for exploration and analysis." Among the study's conclusions were that teachers perceived their students' use of these tools broadened the presentation possibilities of science material, deepened students' engagement with science content and put their students in charge of defining and exploring the systems they are studying.

Language Arts

Language Arts teachers have employed rich media in a number of ways in the past decade. For example, early uses of technology in Language Arts could be found in the form of computer-based phonics tools and online books that were intended to support early language learners, as well as use of the word processor for writing. Much of the research around these tools found that students who used them improved significantly in reading comprehension, spelling and vocabulary (Sivin-Kachala and Bialo, 2000).

Research in the early 1990s shows a second use of rich-media technology in Language Arts: focusing on writing among older students. For example, one writing-based project placed control of the development of rich media environments in students' hands. A multimedia composition tool developed by the Highly Interactive Computing Environments (HI-CE) Group at the University of Michigan entitled *MediaText* was created to improve student learning of content by guiding students through the development of multimedia instructional content such as stories, multimedia essays and instructional aids. Researchers found that, as a result of using *MediaText,* students' writing techniques expanded and improved (Hays, Weingard, Guzdial, Jackson, Boyle, & Soloway, 1994).

Another example of rich media integration in language arts was evident in the use of interactive storybooks for early readers. Some of these applications, even in early incarnations, included a variety of technology features that contributed to a rich media environment. Researchers at Vanderbilt University studied what they called ""Multimedia Environments that Organize and Support Text" (MOST) and described the MOST environment in the following way:

> The MOST environment includes animated video versions of children's stories, daily sessions with story sequencing and multimedia bookmaker software, story-writing activities, decoding software, "Little Read-Along" books and folktales and trade books that are thematically related to the video stories (Sharp, Kinzer, Risko, 1994).

Additional findings demonstrate gains in auditory and language skills of kindergarten students who engaged with MOST for three months as compared to students in a conventional classroom (Mayfield-Stewart et al., 1994). The research found that MOST students' stories "included more actions, obstacles and propositions; evidenced better use of tense; and were judged at a higher narrative level. The MOST students "scored significantly higher on a test of decoding in context."

Math

While research around the use of technology in mathematics education is plentiful, studies that examine the use of rich media in this subject area are practically non-existent. However, the development of research of rich media in mathematics mirrored the general trend in technology education in this subject area; while in the past the focus was around the use of isolated technology applications that concentrate on students practicing certain skills, teachers increasingly have found new ways to combine technology resources to create rich media learning environments to support this subject area. With this expansion of rich media resources in mathematics, studies that look at these new types of implementations are bound to increase.

In the early 1990s, research emerged around the use of Integrated Learning Systems (ILS), which were acquired by some school districts to support the of teaching basic skills, and around which there has been found statistically significant learning gains (Becker, 1992; Underwood, et al, 1996). ILS systems have also received criticism due to their reputation of being used for "drill and kill" activities (Clements, 2000; Batura, et al, 1999). However, according to Kulik, in "Effects of Using Instructional Technology in Elementary and Secondary Schools: What Controlled Evaluation Studies Say," traditional use of ILS has expanded to include those that are more inquiry-based. Kulik writes, "Today's ILS [programs] use color graphics, sounds, and sophisticated visual simulations, and children input their answers both by selecting objects on a screen and by typing. [They] may also incorporate constructivist approaches to learning along with more traditional methods."

While early uses of technology in math were often isolated and focused on skills, other tools were used to contribute to inquiry-based classrooms. Research in the early 1990s included a focus on the use of programming concepts, such as LOGO, in classrooms. McCoy reviewed such uses of technology in the context within a whole-classroom constructivist approach, and found that programming knowledge "[appeared] to have a positive effect on mathematical problem-solving skills of students of various ages and grades" (McCoy, 1996).

An example of use of rich media in mathematics can be found in a study conducted by the Cognition and Technology Group at Vanderbilt University that examined a program they created called "Adventures of Jasper Woodbury", a collection of video-based stories that engage students in mathematical group problem solving and critical thinking (Cognition and Development Group at Vanderbilt, 1997). According to the Vanderbilt researchers the impetus for this project included a need to "bridge the gap between natural learning environments and school learning environments." The designers were concerned with providing students learning mathematical concepts with a "common context for instruction, an authentic task, and a chance to see that school knowledge can be used to solve real problems." Researchers at Vanderbilt found that this program was effective in areas of performance on standardized tests, reducing math anxiety and increasing students' perception of mathematics as relevant to everyday life. In a later study, Hickey, et al found similar results with regard to test scores while finding lower performance on measures of computational ability, as well as an improvement in students' overall self-perceptions of math competency.

Another Vanderbilt study conducted around the Jasper program "suggests that supplementing Jasper videos with technology-based thinking tools and follow-up activities help students to apply what they've learned to new problem situations." This report describes the later use of Jasper with supplementary technology resources that were included to contribute to the problem-solving process, and found that "students who used these supplementary tools demonstrated significantly greater problem-solving skill than Jasper-only students did." The tools available to teachers are outlined as follows:

- Smart Lab — provides feedback to students about decisions they have made in the course of their work.
- Roving Reporter — [provides interviews with] various students in the learning community [who speak] about the problem-solving they have been doing…to showcase student reasoning and provide an opportunity…to react to various ideas.
- Toolbox — provides ideas for visual representations (e.g., timelines, graphs) that can be conceived of as "tools" for thinking, problem-solving and communicating.
- The Challenge — [gives] students a new problem-solving challenge…[and prompts them to] revise their work based on feedback they had just received (Barron, Vye, Zech, Schwartz, Bransford, Goldman, Pellegrino, Morris, Garrison, and Kantor, 1995).

With the growth of rich media resources, more teachers began to experiment with how to engage their students with mathematical concepts and use rich media to invite students into the information new ways. As a result, as occurred in science, the use of modeling has become more pervasive in mathematics. For example, research is underway around a project developed at Utah State University in partnership with the National Science Foundation entitled a "National Library for Virtual Manipulatives for Interactive Mathematics." This project is an attempt to develop a library of interactive, web-based virtual manipulatives for K-8 classrooms. The developers of this project describe some of the reasoning behind this resource in the following manner:

> "Learning and understanding mathematics, at every level, requires student engagement. Mathematics is not, as has been said, a spectator sport. Too much of current instruction fails to actively involve students. One way to address the problem is through the use of manipulatives, physical objects that help students visualize relationships and applications. We can now use computers to create virtual learning environments to address the same goals. Ultimately we will make all materials available at several sources on the Internet, creating a national library from which teachers may freely draw to enrich their mathematics classrooms" (Utah State University, 2003).

Section II. Teachers' Domain Case Studies

Overview

In addition to reviewing existing research studies related to the use of rich media in K-12 schools throughout the United States, we conducted a set of case studies specific to Teachers' Domain. Taking advantage of the Life Sciences prototype that already existed, we sought to gather data that would compliment the broad picture described in Section 1.

Using our network of school districts, we selected five schools to serve as case study participants, none of which had prior experience with Teachers' Domain. We selected schools that represented a wide range of demographics, e.g. urban, suburban, rural, resource-rich, resource-challenged, established technology use, etc. We also chose teachers who tended toward one of two approaches to classroom practice: 1) a traditional approach to teaching, i.e. they viewed themselves as the holder of information, organizing much of their students' class time around listening to presentations and completing teacher-directed tasks and projects; or 2) an inquiry-based approach to learning, arranging their classroom as a place where students acquired knowledge in collaboration with the teacher. Although teachers were not exclusively traditional or solely inquiry-based, but had a variation in their actual practices, this emphasis on teaching philosophy was useful. It provided us with the opportunity to learn more about how teachers, professional development specialists and technology coordinators perceived the online resource and the ways in which they would consider integrating it into their existing practice. Table 1 presents an at-a-glance view of the demographics of each case study.

Methodology

Each case study entailed a series of interviews, and for both high schools (Case Studies 3 and 4), site visits. We interviewed life science/biology (Cases 1-4) and social studies teachers (Case 5), technology coordinator/media specialists and principals/assistant principals. We also gathered some additional information via email correspondence.

Teacher interviews. We collected a range of background information from participating teachers including years teaching; prior experiences with technologies; related professional development experiences; expectations for their students; and expectations for the use of rich-media resources. We also focused on how they perceived the value of media-rich content, how they found out about these resources, what they believed the applications would enable them to do that they would not have previously been able to do and the kinds of supports they felt were necessary (particularly supports they thought their colleagues would need). Where appropriate, we distinguished between teachers who regularly used technology — established users — and those who were slower to adapt their current practice to accommodate new resources. We conducted two separate interviews: one to gather general information and one to collect feedback regarding Teachers' Domain.

Administrator/professional development specialist interviews. We collected data from district- and building-level administrators (e.g., district technology coordinators, media center coordinators, principals), focusing on their perceptions of how rich-media resources were

being used in their schools and the kinds of professional development programs they envisioned to support their use, as well as their school's vision for technology integration. We investigated their experiences with other technology initiatives, including those related to standardized testing, and explored what particular educational challenges or opportunities they see rich media addressing. We also explored how they learned about rich-media resources and what variables contribute to their awareness prior to potential use throughout their schools.

	Case Study 1	Case Study 2	Case Study 3	Case Study 4	Case Study 5
Grade Level	Middle School	Middle School	High School	High School	Middle School
Setting	Urban	Rural (Military Base)	Urban	Suburban	Rural
Location	Northeast	South	Northeast	Northeast	Southwest
Student Population	470	724	1,500	1,286	1,020
Free/Reduced Lunch	30%	50%	>90%	<1%	85%
Ethnicity / First Language Spoken at Home	78% White 16% African-Am/Black 4% Hispanic 1% Asian	45% African-Am/Black 40% White 13% Hispanic 1% Asian	65% Spanish 34% English 1% Arabic	79% White 12% Hispanic 6% African-Am/Black 3% American Indian, Alaskan, Asian or Pacific Islander	93% Hispanic 2.8% Native-Am 2.5% White 1.2% African-Am/Black .5% Asian
Pedagogy	Traditional	Inquiry-based	Traditional	Mix of Traditional and Inquiry-based	Inquiry-based
Student Access to Technology	Lab, Media Center, Classrooms, Home	Individual Student Laptops	6 Labs, Media Center, Classrooms, Home (80%)	2 Labs, Home (100%)	2 Labs, Classrooms, Home (30%)
Case Study Focus	Science	Science	Life Sciences	Life Sciences	Social Studies

Middle School
Traditional Science

Setting and Demographics

The first cast study school was a sixth through eighth-grade middle school located in Levittown, Pennsylvania, with an enrollment of approximately 470 students and 34 teachers. The ethnicity of the majority of students was White (78%), with 16% African American, 4% Hispanic and 1% Asian. The assistant principal reported that the school is "not located in a bedroom community" and characterized the school as being in a "low income economic area." According to the Pennsylvania Department of Education, approximately 30% of the students received free or reduced-price lunch. The school had a 93.9% attendance rate.

The district was undergoing some administrative restructuring; there had been a change in superintendent and some of the central office staff had shifted positions. Because of these changes, and because it was a "contract year," the assistant principal said that at the building level they were "just trying to find the best possible way for students to survive."

Participating teachers had been teaching science for 10 and 11 years, respectively, and both said that they were "very comfortable with technology" although neither said they would call themselves an expert. The assistant principal was a former science teacher and district technology coordinator. He said he considered himself an expert in technology, and had helped wire schools, set up labs and was on the steering committee for the Jason Project, a national multimedia science program, and subsequently brought it to the middle school.

Technology Vision

The school community viewed itself as dedicated to using technology, and to continuing to improve technology and rich-media resources for students and teachers. This was due in part to the assistant principal, who had a great deal of technology experience and who brought nearly all the technology to the school in the three years he had been there. He had implemented the Jason Project, and planned to remain involved in the program as well as continue to improve the technology resources in the school. His current goal, his "wish list," was to provide the school with fiber optic wiring. School administrators reported they were working with the district to achieve this but had some budgetary constraints. He said that with regard to his school's technology use "we try to keep cutting edge as far as utilizing what is out there. It helps that this is also the view of the administration" because they were supportive of new technology acquisitions. However, according to the computer teacher, there was no discussion among the administration to develop a specific plan to evaluate teachers' use of technology. When asked about his system for tracking technology use in the school, the assistant principal said that he "visits classrooms and checks in on the teachers to see what they are doing."

Regarding the school's attitude toward using technology, one teacher responded that they were "definitely trying their best to increase the amount of technology that is available." The other reported that both the school and district were very supportive "because they are always trying to get computers into the classroom." Neither of the participating teachers said they needed more support in terms of technology integration, and both expressed satisfaction with the job the administration was doing with technology.

Technology Infrastructure

Participants reported that the school had gone through a fairly significant building of technology infrastructure in recent years, much of it the result of the principal and assistant principal, both of whom felt this was a priority. In addition, technology proficiency was a requirement for incoming teachers.

The school had one computer lab with thirty-two computers, and a media center with nine computers, all of which were connected to the Internet. In addition, there were five computers in all of the science classrooms (and ten in various other classrooms) that were connected to the Internet for student use. There was also a computer with broadband access in the "team room" for teachers to use. All participating science teachers reported that because of access, they more frequently used technology than others within the school.

There was a technology teacher at the school who taught a technology class to students as a "special" class, an elective that lasted one academic quarter. According to the assistant principal, technical support was one of the school's biggest challenges; there were fourteen schools in the district that were served by a district-wide technical support team of three people. Consequently, participants reported doing a lot of "in-house trouble shooting."

While the technology hardware resources had increased over the past few years there was still not a significant amount of professional development around the use of these resources, according to participants. The assistant principal said this was not emphasized as a priority; instead, he reported that if teachers requested professional development "we send them to conferences." One teacher said she vaguely recalled attending a workshop on web-based learning. The other teacher, who is the science chair, reported that basic technology training, including Microsoft Word, Publisher and PowerPoint, is offered on workshop days. Participants reported that there was no support offered to help teachers integrate technology into their curriculum.

School Culture and Pedagogy

While the school's philosophy about teaching and learning had at its core an adherence to standards and a focus on assessment, teachers were given some amount of leeway in terms of how they achieved those objectives in their classroom. Use of technology reflected this: teachers used a variety of technology and media resources, but were required to demonstrate how these resources supported relevant standards.

The school placed an emphasis on evaluation techniques and required teachers not only to use rubrics as teaching guidelines but also to use them with their students. In addition, the school required teaching materials to be aligned to the state and national standards. The assistant principal said that alignment to standards was one of the reasons why they liked the Jason Project. One teacher said that she did not like "teaching to the test but that they don't have a choice, we need to teach what they are going to ask the kids on the test."

In addition to the Jason Project, and in line with the school's focus on evaluation, another school-wide technology initiative was implemented to help improve student assessment. Because teachers were required to use rubrics in all of their work, the administration provided them with access to a website (out of Chicago Public Schools) that contained nine hundred completed rubrics that they are free to use.

According to the assistant principal, teachers were encouraged to use technology in their classroom at least twice a week, but because "they are allowed a lot of academic freedom, some chose to give lectures and others to do WebQuests." There was no formal technology implementation plan, as it was the philosophy of the administration that if the infrastructure were present, then teachers would be motivated to use it.

Two of the participants reported that encouraging students to "think critically" was one of the most important benefits of using technology in the classroom; one teacher connected this to the variety of "real science data" from different resources around the world students were exposed to and asked to analyze. The assistant principal said that technology encouraged critical thinking particularly with regard to "analyzing the validity of the wide array of resources on the Internet." Another teacher said that technology was just another resource for learning and that in teaching "you have to use every resource available."

Resources and Rich-Text Media

While a great deal of energy at the school was geared toward the acquisition of technology hardware, there was not a concerted effort to provide the staff with training around how to use these resources.

Some of the school's technology acquisitions were made through grants but most were purchased through their building's budget. This school had department teams that met with their department chairs to express their curricular and technology needs. The department chairs then met with the assistant principal and principal and they collectively made decisions about new resources. Most new resources that they became aware of were a result of word-of-mouth at these meetings: a teacher would mentioned something to a department chair and that person would bring it to the administration.

One teacher reported that in addition to going online and "surfing around" for new resources, she received website recommendations from the librarian. She commented

that a challenge for her when looking for new resources was to match hands-on and interactive resources with those that aligned to the standards, and said that while she tried to look for interactive activities, alignment to standards had to be her first priority in making selections. Another teacher said that she learned about new resources from reading magazines or books. She said she evaluated them to find out "how relevant and how doable they are — whether or not the kids will get it; if it offers something extra or a better way of teaching something."

The assistant principal, who was a former science teacher, said he used "a lot of PBS stuff" in his curriculum. He said he thought that his teachers used similar resources, but did not know for certain.

Response to Teachers' Domain

Strengths

- *Strong, credible content*. Participants remarked about the high quality of the materials and information contained in Teachers' Domain and how important PBS's reputation is as a resource they could trust. As one teacher commented, "I really liked the credibility of the site – and knowing that all of the other resources that you connect to through the site are also credible (such as *NOVA*)." The assistant principal explained, "It is a matter of planning and time management in lesson design. Hopefully, I will be seeing some of the video streaming and the lesson plans when I get around to the evaluation cycle in the spring with my younger teachers — very powerful lessons can be pulled from this site as a resource."

- *Stand-alone opportunity to supplement in-class activities*. One teacher reported she could use Teachers' Domain to set up her class in a new way. She said she sometimes had difficulty figuring out how to enable students to use technology resources independently because of only five computers in the classroom, and she was thrilled that Teachers' Domain was so structured and had such high quality that she could let the students make use of it without her direct instruction. She said, "I have five computers in my classroom and with something like this I could set up a station and kids could rotate and use this site while I am doing another activity with the rest of the class."

- *Relevance to standards*. Consistent with the school's emphasis on assessment, participants perceived Teachers' Domain as a resource that could help teachers evaluate student learning and said they liked that there were links to state standards.

- *Easy to use*. Teachers reported that the online resources were very user friendly, especially the length of the video clips. For example, one teacher, who had used PBS programming, like *Bill Nye* and *NOVA*, which she had taped from a broadcast, said she liked the idea that the clips were already created. She said this was an aspect would save her a great deal of time.

Challenges and Suggestions

- *Technical difficulties viewing videos*. Both teachers reported having problems watching the videos, which they said was very frustrating. They explained how they have Quicktime on their computers and were uncertain why they encountered difficulties. They attributed the problem to the site's status — as a work-in-progress — but they were not discouraged from praising the site's quality and declaring that they would try again at a later date.

- *Content too advanced for middle-schoolers*. One teacher raised concerns about the sophistication of the resources and questioned whether it was grade-level appropriate. She said, "I wish that the printed resources had pictures or were more kid-friendly – for teachers it was fine but kids might lose interest reading it." She said she though the text was too "heavy" and said she anticipated using it for her research rather than with directly with students.

- *Professional development needed*. Participants expressed an interest in teacher training around the use and integration of the Teachers' Domain resources. As one participant stated, "There should be professional development for teachers around how to integrate this into their teaching. It is very user-friendly and the majority of them would be able to explore it on their own but not everyone would feel comfortable fitting it in. Also teachers might need help creating and customizing folders."

- *Interactive activities may not support independent student work*. Participants said that, although they valued the interactive activities contained in Teachers' Domain, they were not certain they could leave students to do them without teacher supervision because the "right answer" was not revealed. Specifically, the media coordinator pointed out how one of the interactive activities "told students when they had something wrong but didn't tell them what was the right answer."

- *Additional content would be helpful*. One of the teachers said she was unable to find materials relevant to the unit she was doing at the time of the case study; she said: "I would like to see more specific things on the different invertebrate groups – it doesn't have the one main topic where it talks about invertebrate groups of the body systems – these things are in there but not in a general category.

Summary

In general, Case Study 1 participants expressed an enthusiasm for Teachers' Domain and said they planned to use it along with the other resources they had acquired once they worked through the issues with the videos and Quicktime. They said they were happy to have a new set of materials, and found their credibility — because they came from a high quality source that they could trust (PBS) — significant. At the same time, this was a traditional school and teachers did not identify Teachers' Domain primarily as something that would change the way that they taught.

Instead, they reported that it could support the kind of teaching and learning that already was going on in their classrooms. There were, however, two potential ways that Teachers' Domain could alter their practice: One teacher said she thought some of her students could use the online resource independently while she did another lesson with other students; another teacher said professional development could help build confidence about integrating this type of resource into the classroom, giving teachers the confidence to experiment and explore.

Case Study 2

Middle School
Inquiry-based Science

Setting and Demographics

The second case study school was a sixth through eighth-grade middle school located on the military base in Fort Benning, Georgia, with an enrollment of 724 students and 46 teachers. The population of students at the school tended to reflect the general military population, and there was a wide range of both ethnic and socioeconomic diversity. Forty-five percent of the student population was African American, 40% was White, 13% was Hispanic and 1% was Asian.

The district was administered by the Department of Defense Education Activity (DoDEA), which was a civilian agency of the U.S. Department of Defense. It operated 222 public schools in 20 districts located in 13 foreign countries, seven states, Guam, and Puerto Rico. DODEA schools did not receive funding from the U.S. Department of Education, nor did they adhere to U.S. Department of education national or state standards. They had developed their own set of standards, which, according to one of the participating teachers, were very similar to the Georgia state standards.

Participants had quite a few years of experience among them. The three participating science teachers taught seventh-grade science for 30, 17 and 15 years, respectively. The educational technologist taught social studies and language arts for 24 years before assuming her current position six years ago. The media specialist had been in her position for 25 years. The assistant principal had been at this school for four years, and had taught in the district for 10 years before that.

Technology Vision

The entire school community at Faith had a commitment to continuing to improve technology resources and professional development around those resources. The administration and teachers viewed the presence of two different staff positions within the technology department as essential; one for teaching technology content and the other for helping with integration. The media coordinator, responsible for professional development around integration, said of the school's philosophy: "Integration is our biggest asset and we utilize the technology to further the curriculum. Technology will not help test scores if you don't use it to further the curriculum."

The participants also discussed "student preparedness" as an important benefit of using technology. They said they felt their students would be better prepared in high school and beyond because of their experience with technology at the middle school, both in terms of gaining technology skills as well as, according to the media coordinator, having "a broader view of the world." She reported, "It prepares them for real life and has attached them to the world — they think much more globally.

We are learning about bioethics and cloning. This is something they couldn't learn from a textbook because the information is all on the Internet."

The assistant principal said that technology enabled the community to become involved in the school. She said, "I think that it makes the whole community involved because everyone can go on the website and see the curriculum of what their child is learning." She also reported that the Internet helped develop students' research skills; she said, "They learn how to research and how to put together different types of writing…they are able to attain more throughout the year than if they didn't have [access to] the Internet."

Technology Infrastructure

The school had a significant amount of technology hardware. Participants repeatedly expressed how "lucky" or "appreciative" they felt in terms of the technology hardware and support that was available to them. They said they recognized not all schools had these resources, and felt that most teachers within the school took advantage of their situation, incorporating technology into their teaching on a regular basis.

Every eighth-grade student had his or her own laptop computer. Each seventh-grade classroom had a wireless lab, and the school was in the process of acquiring a wireless lab for each sixth-grade classroom. There was a library/media center that had one computer hooked up to a T1 line. The school did not see a need for more computers in the library as most students simply brought their own laptops into the library to work or conduct research. The sixth grade used computers in their classrooms or the single computer in the library. The school had data projectors in each classroom, and also had several digital video cameras for teacher use. Due to the popularity of digital cameras among the teachers, the school was considering purchasing several more.

The staff reported they were somewhat hesitant to assign homework that would require using the computer, as they said their students' access at home greatly varied due to the extreme range in household income. One participant said, "We have the kid of a general and also the kid of a private in the same class, and while the military has a program where each enlisted person can get a computer they don't all take advantage of that."

In addition to hardware, the school had an established system of technology support: there were two full time technology support staff members based in the school. One, a technology coordinator, provided technical support (training on new software, building web pages, troubleshooting with the laptops) and the other, a media coordinator, provided help with technology instruction and integration (providing new resources, teaching students and providing professional development around use of technology in the classroom). Both of these staff members kept offices in the media center and were "on call" throughout the day for both teachers and students in addition to scheduling training sessions. They also were responsible for bringing technology resource needs to the attention of the administration.

Regarding the classroom teaching staff, as part of their certification (or re-certification) all Georgia teachers participated in a program called InTech, a fifty-hour class that provided basic technical training within the context of "student-centered" classroom integration. Participating teachers said that the amount of time spent on technology varied. One said that she used it twice a week and more frequently when they were involved with a project such as the Jason Project. Another said that her students used it more at the beginning and end of units, which supported their initial research of the topic as well as their final projects.

Concerning the challenges of using technology, most staff spoke about the occasional network crashes. The technology coordinator explained, "Because almost all of our students are on a wireless network sometimes we have 400 or 500 kids going on at one time, and it is difficult to keep up without breaking down and keep things up and running."

School Culture and Pedagogy

The educational philosophy at the school was inquiry-based and the administration provided teachers with the latitude to cover their curriculum the way they saw fit. Teachers' use of technology, both the wireless labs as well as their integration methods, reflected this philosophy. Teachers used technology to support and enhance projects and provided structured support for their students to explore the resources independently.

Participating teachers and coordinators reported that they used a project-based and interdisciplinary curriculum. They said they used a multitude of resources and both group and independent student work. One teacher reported, "I don't use a textbook – almost everything I get is from other sources – the Internet, or other resource books or projects." Another said that she was constantly updating her curriculum and never taught the same lesson two years in a row. While the participating teachers were science teachers, they said they included different disciplines in their teaching. One teacher said that her students were working on a cross-disciplinary project of building a "cell city" and that it included both math and science.

Regarding the need to align to standards, one teacher said "I can't be bothered with alignment to standards. I understand what is in the standards and what I am teaching is in there." Another said that while alignment to standards was important, if she found a good resource she would determine what specific standards it would address.

The media coordinator reported that the library was often filled with students who had brought their wireless laptops into the library to work independently or in small groups on PowerPoint, WebQuests or other projects for their classes. Presentation was an emphasized skill among students, and the media coordinator said that students were often in the library working on presentations for various class projects. However, she was quick to point out that the skill of presentation was important with or without technology, saying, "What makes a good presentation also applies to

non-technology presentations and we use technology (PowerPoint) to help teach them the right way. Also, I think that our children will just happen to have an edge because they will have used technology when they go on to different schools."

Teachers reported that they did not have strict teaching requirements placed upon them by the administration, including around use of technology. One teacher said that the principal is "pleased when I use it, but he never said that he wants to see it." The assistant principal commented, "I would rather give the teachers the freedom to explore than restrain them with standards, and that the standards are so broad and each teacher has their own resources that they like to use." She explained that when the school first obtained their wireless laptops there was a related program that "could generate worksheets and a test" but that after the first year none of the teachers were using it because they preferred their own resources. She said she felt that technology should be incorporated whenever it was appropriate within the curriculum, and thought that the school provided a good balance, putting enough of an emphasis on it "so the kids see it is important" but not requiring students to use it "just for the sake of using it."

Participants said they viewed technology as more current and student-centered than textbooks. One teacher remarked, "I don't want my kids spitting back information. I want them to think. And if you only use a textbook then you are more likely to get the parrot thing. But when they have to gather information and synthesize it I am hoping that they are better learners…. If they are active learners they are apt to take it more seriously." Another teacher said textbooks became outdated easily but there is always current information online. She reported, "If you plug into the NASA site it is so much more involved than reading a textbook from 1975…. I don't want my kids to know facts but gain skills and technology helps with this." Another teacher said that technology helped her students gain skills and become critical learners, and said, "They find garbage [on the Internet] and we talk about that and why it is garbage. It is an avenue to teach them life skills."

Some of the teachers spoke about what they wanted to explore with technology. One teacher said, "I would love to get into real live research, researching with other schools or something, even experts, because I am trying to demonstrate real-world applications." She said she did an air quality unit in the spring and hoped to incorporate this type of project at that time. However, often teachers reported the need to balance their use of technology with other resources. One commented, "I don't let the technology run my classroom, it depends on what makes sense."

Resources and Rich-Text Media

Overall, participants reported that technology afforded them a more student-centered curriculum than simply using a textbook and, as far as locating new technology resources, teachers said they often read and surfed the Internet to find quality materials. One teacher said she did not have much time to read Science magazines, and she thought it was faster to surf the Internet when she was at home. Participants felt criteria for selecting resources included whether a resource was user-friendly, kid-appropriate, which meant it was understandable to students at specific

grade levels, interactive and accurate. In addition, teachers reported wanting resources that would support their curriculum. Both coordinators reported they attended the state technology conference annually as well as various other conferences, and were also on an educational technology listserve through DoDEA. The media coordinator said that she provided the teachers with lists of recommended websites.

The teachers and administrators were responsible for making the case for new resources to the PTO, which provided some financial support for technology at the school. According to the school's website, this support came in the amount of "over $20,000 per year." DoDEA provided some resources, at the request of the superintendent or principal, but the budget fluctuated greatly and according to the assistant principal "has been extremely tight the past couple of years."

Teachers frequently reported that the text of online resources presented a challenge for their students. One said that it was sometimes difficult to find appropriate online resources because of the low reading ability of some of her students. She commented, "Technology is great but if the child cannot comprehend on the screen it is no good." Another commented about some of the websites she visited that "the narratives are over their heads, but if you can get the interactive stuff they relate better to that."

Different resources that teachers said they used included the Jason Project (the school has been involved with this national science program for several years), Discovery.com, Google, NASA, Windows on Science, Brain Geography and Cells Alive.

Participating teachers said they occasionally used video to convey information but more often used the television than the Internet to show video. According to the staff, it often was difficult to get video to work because of the restrictions placed upon them because they were on a military base. They said that there were stricter network security barriers on the base than other schools and sometimes they could not access certain resources like streaming video. Most teachers reported using their data projectors with their computers, "to model what I want them to do at the outset of a lesson" before they assigned their students independent tasks with their own laptops.

Response to Teachers' Domain

Strengths

- *Multimedia components are strong*. Participants reported how beneficial it was that Teachers' Domain brought together disparate resources, such as audio, video and text, which they normally would have to take the time to collect themselves. One teacher said, "There are a couple of other resources out there that are similarly geared toward schools and teachers…but I think that the snippets of videos and interactives – that is unique. I don't believe other resources have that, especially Flash. This is much richer."

- *Supports student-centered teaching*. Participating teachers identified Teachers' Domain as a resource consistent with their teaching philosophy. As one teacher remarked about how she planned to integrate it into her classroom, "This resource — with the information and the pictures and videos — it would allow for really good interaction with students and teachers – and interactive teaching is what it is all about." Another teacher explained, "It would change the ways that teachers have students work – especially at this school because our students have individual laptops so the teacher could say go to the Mitosis site and then create your own illustration, or explain back to me how this happened, etc. For a one-computer classroom there would probably be a little more difficulty. I would see it used as an interactive student instruction time."

- *Pre-sifted collection of quality resources*. Participants said they thought the site offered high-quality resources without the time-consuming process of going through search engine results. As one teacher explained, "Anytime that I have a site that will pull up quality stuff, I appreciate it. Google pulls up so much trash…and this [Teachers Domain] I can actually use." Another teacher offered the following description, "All of the information I did view was quality information. I could use it for myself – even if I had to [adapt it down] for the kids, it was knowledge for me."

- *Age-appropriate organization*. One teacher said that the arrangement of the materials fit with the middle school needs. She said, "I thought it was extremely professional, targeted directly into the curriculum at different levels. You had a sixth through eighth, which is what a middle school is, so middle school teachers wouldn't have to go down to elementary. I liked the way that it was set up."

- *Standards-based*. Participants remarked on the value of having materials that are aligned to standards. One teacher reported, "I liked how it is connected to the standards – even though we have DODEA [standards], and they are not exactly the same, but they are pretty much in line with one another."

Challenges and Suggestions

- *Current topics in science would be an enhancement*. One teacher explained how part of curriculum involved covering current events in science, which she did not think was included in Teachers' Domain. She said, "I wish there was newer technology — something on cloning or stem cells or gene therapy or other biotechnology topics."

- *Expanded registration options would be more responsive to multi-discipline teachers*. One teacher reported, "During the registration it didn't give me the option to choose integrated – I teach life, earth and physical." She said she felt pigeonholed by having to choose a single subject area when she filled completed the profile to register for Teachers' Domain. She said she felt that she was missing access to more resources because of this.

- *Increased customization would be beneficial*. One teacher described a desire for greater control of the resources used by individual students; she said, "I would like to see that some lessons are created that could go for the individual child and at the end of the lesson there is a knowledge check or a self check that the teacher or student could see the right answer, or if they were wrong and why. The teachers would like to see that - and if they could then keep track of that - different ways of assessment in addition to the test."

- *Content too advanced*. One teacher explained, "I wasn't sure if the printable versions were for students or teachers, wasn't sure of the goal. It was high school or even college level interpretation. The reading level was too high for seventh-graders."

- *Technology skills required*. One participant thought use of Teachers' Domain required a certain savvy with technology. She said, "What I found difficult [was] you do have to have some computer ease in order to maneuver throughout the site. Someone could not just come in who did not have computer confidence, I would be intimidated if I didn't have some computer skills." Likewise, another teacher said, "It could be a little more user friendly for a novice. There is too much text; more graphics would help. A description of how to go from one thing to another or getting a video would be helpful for a novice teacher."

Summary

The Case Study 2 participants were quick to compare Teacher' Domain to other similar resources they had used in their teaching, and said Teachers' Domain surpassed these other resources in quality. The teachers said they were accustomed to using resources in creative ways: they had more experience with a variety of technology resources than more traditional teachers, and were very excited to find one that brought several different types of technology together in one place. They said they could see the online materials enhancing their teaching practice because of the way they could facilitate both small-group and independent student work. Taking note of what they perceived as the high quality of the resources, they wondered whether the materials would be too advanced for their students, although one teacher in particular expressed a confidence in being able to adapt them to her students' abilities. The media coordinator, who was responsible for providing teachers with resources, explained how she was going to introduce Teachers' Domain to teachers throughout the school. In fact, she said she thought she was not permitted to share the site until it was complete. When she discovered she was free to use and discuss it without further delay, she expressed relief as she already had shared it "quietly" with a couple of practitioners.

Case Study 3

High School
Traditional Science

Setting and Demographics

Located in Union City, New Jersey, the third case study school was a four-year high school that had approximately 1,500 students in a building designed to hold roughly 900 students. The demographics of the school suggested a student body that was disadvantaged: 27.5% of all children live below the poverty line (US Bureau of the Census, 2000) and over 90% were eligible for free of reduced-price lunch. Because Spanish was predominantly the first language spoken in students' homes (65% Spanish, 34% English and 1% Arabic), the school offered and placed significant emphasis on its ESL and bilingual programs (New Jersey Department of Education).

To meet the needs of its diverse population, the school's emphasis was in two areas: preparing students for continued academic studies on a collegiate level equipping students with the necessary skills to succeed in technology-related and vocational careers. Upon graduation, the percentage of seniors in the class of 2002 reported they intended to pursue the following experiences: 41% four-year college/university; 21% two-year college; 7% other post-secondary school; 8% military; and 23% full-time employment. Regarding classroom instruction, the school followed a block schedule — five 80-minute instructional blocks — with the length of the total instructional time lasting 6 hours and 40 minutes. The average class size was 15 and the student attendance rate was 94.8% (New Jersey Department of Education). The Science Department was comprised of 11 teachers.

Case study participants included two Biology teachers, one Physics teacher, who also was the head of the Science Department, and the director of the Media Center. Respectively, they were an experienced group, having 26, 13, 34 and 35 years of experience as educators.

Technology Vision

For over a decade, information and communications technologies have played a significant role in the school's approach to teaching and learning. As the Director of the Media Center summarized, "Union City has always been on the forefront of technology. We were one of the first high schools to really push the influence of computers in everyday life…. Technology is in the fabric of our life here." This was evident both at the faculty level — all grading and scheduling was done electronically — as well as at the student level. For example, many teachers expected their students to produce digital portfolios of their work, though not necessarily for all subject areas, and one participant said, "Our kids almost take technology for granted." In order to equip teachers with the skills they needed to integrate technology into their classroom practice, the school offered professional development opportunities throughout the school year and during the summer. As a

result, a high percentage of teachers were regular users. As one teacher commented, "You can't ignore computers in today's world."

Teachers reported they felt supported by the school's administration though they acknowledged that financial constraints had decreased the availability of resources. Despite diminished funds, the school had recently installed a ClassLink network to extend the connectivity students and teachers had to information, school materials and individual class projects and assignments. In keeping with the school's mission to give all students "the opportunity to fulfill their potential and to be the best they can be," the school's administration acknowledged that technology could both prepare students for college and give them a marketable skill. As one participant said of several of the extracurricular technology-rich programs, "It's a way out, to get employment."

Technology Infrastructure

Since the early 1990s, the school had been engaged in a number of high-profile technology initiatives and was identified by the Clinton Administration as a model for technology integration. In terms of sheer numbers, the student-to-computer ratio was 3.2:1 in the 2000-01 school year though this was only one indicator of the commitment the district had to making technology available to students and teachers. From Union City On-line, a program supported through a grant from the National Science Foundation, to Project Hiller, a recruitment initiative that placed laptops in the hands of both 100 incoming freshmen and 65 of the 120 teachers in the school, and from A+ Certification, a CISCO training program, to Teen Tech, a work program that employed students to do technology troubleshooting and support throughout the high school's building, the school had a wide range of programmatic efforts that sought to create what the school described as a "technology-rich atmosphere." The school also has a BTV Department, which was a combination of Business Education, Technology (formerly known as the Industrial Arts department), and the Vocational (formerly known as the Home Economics Department). The school's website described the BTV Department as a place where "young people are taught the fundamental academic skills necessary to work in the rapidly changing technological world. Many of our programs offer students unmatched educational opportunities through the integration of school-based and work-based learning."

Though staff at the school reported that many of the students — as high as 80% — had access to some kind of computer at home, even if it were not a "high-end machine," the school's Media Center was an active multi-purpose space that provided students with a reliable place to go online and conduct research. In addition to over 10,000 books, magazines and audio/visual materials, the Media Center offered its student body daily access to 45 networked computers from 7:30AM till 4PM. Additionally, the school's Business Department had four computer labs, each with a minimum of 22 workstations with Internet access and loaded with a suite of business software. There also were two other labs with 20-30 computers each.

At the classroom level, participants reported that there were two to four networked computers in each science lab, which were designed to accommodate 24 students overall. In actuality, participating teachers' biology classes ranged from 15 students in Advanced Placement Bio to 31 students in Stand-Alone Bio. Teachers reported that their students tended to use classroom computers occasionally to "type up assignments" while there home and Media Center use was much more frequent. Teachers also said they had access to Proxima projectors they could use to connect to one of their classroom's computers, allowing them to give whole-class presentations. Although individual departments and the Media Center each had several Proximas faculty could check out, teachers reported finding an available one and setting it up in their classroom often was both very challenging and time-consuming. As the Media Center director said about the demand for projectors, "Teachers are always using them. We don't have enough." He described how the "ideal situation" would be for every teacher to have a laptop and every classroom to have a built-in projector. Teachers echoed this sentiment and said having reliable access to a projector would give them significantly more freedom to integrate visual material into their lessons on a weekly or even daily basis. Also, echoing this sentiment another teacher said, "It would be lovely if every kid had access to a computer [in the classroom]. For the most part, we don't have that."

In order to maintain the infrastructure necessary to operate both classroom-level and cross-school technology-related programs, the school employed three full-time staff: a technician, a technology coordinator and the director of the Media Center. The latter's responsibilities included technical support as well as instructional guidance for classroom technology integration.

School Culture and Pedagogy

Formaly, the school described its curriculum as constantly evolving, "utilizing the recommendations of national models as a basis" and the recently updated State of New Jersey Core Curriculum Content Standards. These standards covered seven main academic domains as well as workplace readiness areas. For those students seeking higher learning degrees, the school offered Advanced Placement courses in Biology, Calculus, Chemistry, United States History, Spanish Language, Spanish Literature and English Literature. Science was one of 10 departments within the school.

Regarding collegiality and informal professional development, participating teachers reported they consulted with one another from time to time though in recent years they had done so less frequently and departmental meetings were less common.

As for assessing their students, participating teachers said they primarily relied on tests and labs, and occasionally, project-based work. As one teacher commented, "Projects can kill you because being on a block schedule a project can take several weeks."

Although individual teachers reported they approached student learning from a variety of perspectives, depending on a particular class or unit of study, the overall

culture within the Science department was in favor of teacher-led instruction and traditional hands-on lab work. In the life sciences, teachers reported that their curriculum followed a fundamental, ordered set of topics: Chemistry, Bio-Chem, generalization of the cell, cell transport, all aspects of plants, the human body and genetics, human evolution and finally ecology. Regarding content materials, teachers reported that they used textbooks and CD-ROMs though class lectures were the major source of content information. Because of the nature of the life sciences, which they described as involving a lot of definitions and difficult terminology, they said there was a basic need to build students' foundation of knowledge. This is why they reported they felt lectures were the most effective way to deliver information. When, on occasion, they had tried to use an inquiry-based approach — encouraging students to begin with a question they wanted to pursue — they said students were not accustomed to this approach and quickly lost patience. Teachers said students made comments like, "Cut it out. Let's just do it" and "Cut to the chase, stop toying with us." Also, one teacher said that because of the volume of material they had to cover, there was "not a lot of freedom in what you do." Another teacher said, "It's a balancing game – trying to add everything. Covering the curriculum is the hardest part and technology takes so much time." One teacher said that the "curriculum is the same but the technology is changing." For this reason, they said they often viewed technology as an add-on: a place where students could go to seek additional information to respond to essay or research questions but not necessarily central to the delivery of information on a daily basis. Once a year, one teacher said she asked her students to conduct a large research project — in the past the topic had been digestion — that they could do together using the computers in the Media Center. More generally, teachers' integration of technology was more reliant on the production aspects rather than the information and communication aspects; for example, one teacher reported that the result of students having access to technology with respect to the life sciences was that their labs were "well put-together." She said a motivated student had the opportunity to create "sharper-looking assignments."

Teachers' use of video was consistent with their pedagogical approach to student learning. They said they had used videos in the past though they reported they were resigned to the idea that many of them were "boring." Although one teacher recalled how a science video she had used previously had featured an appealing character known as Hemoglobin, in general, she said "the information is good but the entertainment value is not" in most videos. Teachers reported they had used *NOVA* and other public television programming though not recently. In part, they said this was because they were no longer receiving a newsletter from New Jersey Network, their local station, which contained recommended programs they assigned to their students or used as a reminder to themselves to record for later in-class viewing. In terms of the length of videos, teachers reported they had used clips that are shorter (2-10 minutes) and longer (30-40). Teachers cited several reasons for this range, all of which had to do with the purpose behind their use: (1) Sometimes, one part of a video was too advanced to show it in its entirety. (2) At other times, as was the case with laser discs, the goal was merely "to give students something to look at" so the animation was less important than a static visual. (3) Sometimes students had a hard time "seeing a topic," such as oxidation reduction and anatomy and what tissues

look like, and an animation helped make it "stick in their minds." After viewing an animation, one teacher said, "Then students had an idea of what to do because they knew what to look for." (4) Audio and video was appealing to teachers because it was "another way to cover the material" and with Stand-Alone students, who one teacher described as being at a lower level, "visuals give them a language that makes sense to them." And, (5) sometimes only a segment of a video is aligned to standards and a related section of the class textbook.

Resources and Rich-Text Media

Participants reported that, although they had experience using web-based materials in their classroom practice, they did not have a systematic approach to finding new resources. In fact, one teacher described locating online materials in general and search engines in particular as a "crap shoot." Partially for this reason, teachers said they tend to return to the materials they already have "unless something really good comes along," which in their estimation did not happen very frequently. While the director of the Media Center, who described himself as an "avid searcher who likes to find material for his teachers," annually created and distributed a list of sites he recommended and that lived on the school's website, the teachers had varying degrees of time to review them. The chair of the science department said she also made copies of materials she received from companies to distribute among the appropriate teachers, letting them make decisions about what was valuable to them. Also, the general nature of these lists sometimes made them less of a priority, according to one teacher. For her, a "more legitimate way" of getting through to her was when a resource came from a direct recommendation of a fellow teacher. Lacking this, she said she used a search engine and then she was "at the mercy" of what she found. So often, she said, the material was at the college level or was simply not what she was hoping to find. For another teacher, who reported that he had used lesson plans he had found online in the past, the task of locating these resources also can be time-consuming. For example, in trying to find a simple "extra handout" on photosynthesis he could give to his students he found himself with a 25-page printout that was too cumbersome to use. Technology-related educational catalogs, where teachers "stumbled upon materials," conferences and word-of-mouth (among teachers as well as students) were also ways teachers had been introduced to new materials. The chair of the science department reported that she also received mailings — electronic as well as in the post — promoting new products, like lab materials. The textbook the teachers used also contained website references. Here too, though, teachers cited time as an on-going challenge. "Sometimes you go to these things [conferences] and there is so much material and you can't possibly look at it all. Less is best." As for the links in the textbook, teachers said so often they led to links of links rather than actual, ready-to-use resources.

The director of the Media Center also reported that subscription-based services were another source of content materials available to teachers. Depending on the availability of funds for a particular year he said he instructed teachers, and when appropriate students, to review potential materials, like those Groliers produced, to determine their value and fit with their curricular needs. He said he told them, "If

you like it then we can pay for it," indicating there were discretionary funds dedicated to the acquisition of support resources.

Response to Teachers' Domain

Strengths

- *Time-efficient*. One teacher said that the online resource had the potential to address the pervasive challenge of being constrained by time. She contrasted Teachers' Domain to what she commonly experienced when going online, "It's difficult because on the Internet there are so many sites. It is overwhelming sometimes. Just finding something can take you longer because you are surfing through and trying to eliminate what's not useful to you and trying to find what is… Too much technology means too much time taken up." Participants said they especially liked the folder feature, which allowed teachers to create individualized libraries to which they may return. This, too, they saw as a time saver.

- *Aligned to core standards*. Participants said aligning the materials to standards was very important given the school's curriculum and the responsibilities teachers had to teaching with these core standards in mind. The Media Center director said that this is the aspect of the site that made it stand out from other online resources. Groliers Online, for example, was a site that the teaching staff at the school liked because it was a "very nicely designed referenced site," However, it did not offer what makes Teachers' Domain unique: it was designed specifically for teachers and students and is curriculum-specific.

- *High-quality content*. Participants repeatedly commented about the high quality of the information — both comprehensives lesson plans that incorporated several textual and visual resources as well as individual materials — and said they were grade-level appropriate. In general, one teacher commented, "These are topics that teachers care about – and teach. For what they [WGBH] did, they did hit upon some good topics." Among the specific topics participants mentioned as standouts were the following: description of "How Cancer Cells Grow and Divide," the "Organelles in the Cytoplasm" video, the "Molecular Level of Genetics" PDF, and "A Mutation Story," a video covering sickle cell anemia.

- *Strong videos to offer explanations of tough topics*. Participants said they were drawn to Teachers' Domain resources, such as those concerning the human genome, which would help them teach what they considered "tough topics." They said video helped make these topics more accessible and interesting to their students. As one teacher said upon seeing an image related to organelles and cytoplasm, "The material is comparable [to other videos and resources] but it's different because now you get to see it in these big, beautiful color pictures. And you get to see the movement. You were talking [with your students] about the process and now you have something to back it up. It

gives them something to look at." Another teacher said, "I'd love to see the human body. Something like cell transport. All of the transport mechanisms. To see it is a helpful thing. Biology, let's face it, is a huge area. You have things like photosynthesis and cell respiration, which are difficult to get across. When students can see it happening – on a video – students get it."

- *Multi-media supports learning*. Participants said Teachers' Domain would allow them to support their students' learning on multiple levels. As one teacher said, "Great graphics. The more repetitive you can get in different ways, the better: an activity, a video, a document. The more varied ways you present something lets the kids get it. Repetition is the key." They said this was true of students at all levels of abilities, from Advanced Placement students with greater facility with textbooks to "Stand-Alone" and special education students, requiring hands-on experiences.

- *Manageable file size*. Participants reported how the chunking of resources into useful bits — of video, slides, lessons plans, supplementary articles, etc. — made them easy to use and follow. As on teacher commented about the length of the video clips, "Videos are good. They are short, which is nice, because you don't like to get too crazy." Another teacher said, although the videos in Teachers' Domain covered the same subject matter compared to other videos she had used, "the video clips were better than what I've seen. They are accessible by themselves. Nice and short — can incorporate them without losing too much time."

- *Well-organized*. Participants said the site "looks friendly" and brought teachers "step by step" through the lessons. One teacher said she liked that each lesson included suggested times and offered direct instructions like "Have the students perform this activity then watch this video." She said, "I don't think they can simplify it any more… You have all the information to help them understand DNA, DNA replication, protein synthesis in two pages. That's great. And it takes a few days – or maybe a week. Still that's a lot of information to pack in."

Challenges and Suggestions

- *Inconsistent video*. While participants reported they did not encounter many technical challenges while reviewing Teachers' Domain they said they had some difficulty viewing two videos during their initial review (one about sickle cell, another about organelles). They said they received the message, "Requested URL not found" when they attempted to view them. [During the case study interview, they were happy to discover they were able to view the same two videos.]

- *Unclear use of folders and links*. One teacher reported she was unable to save a resource into a folder because she thought she was in the "tour mode." She said she looked forward to sorting through this aspect of the site and making use of the flexibility she thought the site could offer.

- *Confusing file*. One teacher said she found one of the resources on mitosis confusing because there was no pro-phase. She said, "It wasn't incorrect. It started with metaphase. It was a little disorganized. When you call attention to one difference between plant and animal mitosis then you should go through all the differences. Say exactly how they differ – that would be more complete. They [WGHB resource] would actually go back and forth between plant and animal. This might be confusing to students." This was a relatively minor comment, however, as she went on to comment, "On the other hand, there was the interactive part about how cells divide and I thought that was really good. That showed similarities and differences between meiosis and mitosis and that was excellent because that is really hard for the kids to see. I have my kids doing an essay on that – it's tough for kids to follow."

Summary

Overall, Case Study 3 participants had a favorable response to the Teachers' Domain website. As the Media Center director summarized, "They have a very strong endorsement from us." While participants acknowledged that the site is a work in progress — and thought the breadth of the content in the life sciences as well as other disciplines could and would be expanded — they reported that the site had a lot of "good stuff," was "well organized and designed" and was "easily accessible."

Participants viewed Teachers' Domain as two parts extension of their current teaching practice, which was teacher-led instruction, and one part development of their practice. As one teacher explained, "I see it as a teaching tool and how to get an idea across… I would love to start a lesson with this every day. That would be such a great focal point. But I'd have to kill 10 of my colleagues to get the Proxima." Despite the feeling that they had the advantage of working in a technology-rich environment, the current reality at the classroom level — each room is not equipped with a permanent projector nor was there a working computer able to play videos without cumbersome password protections — would prevent them from taking advantage of the Teachers' Domain resources the way they would like to: as a daily lesson starter. "That would be in the best of all possible worlds," declared one teacher. Participants said they thought they might instruct students to use Teachers' Domain materials to produce essays though they did not envision students using it in the classroom nor during class time. The Media Center director reported that the site was "geared more to teachers" though some of the advanced honors students could make use of the resources on their own when working on special projects.

Case Study 4

High School
Inquiry-based and Traditional Science

Setting and Demographics

The fourth case study school was a four-year high school located in Westchester County, an affluent suburb roughly 23 miles from New York City. There were 1,286 students enrolled in the ninth through twelfth grades, with the following ethnic backgrounds: 79% White, 12% Hispanic, 6% Black and 3% American Indian, Alaskan, Asian or Pacific Islander. A very small percentage of the student population (2%) was English language learners and less than 1% was eligible for free or reduced-price lunch. The faculty consisted of 100 teachers and 15 additional professional staff and the average class size for tenth-grade science was 24 students. The attendance rate was 95% and among the 2001-02 graduating class, 80% went to a four-year college; 10% to a two-year college; 2% to other post-secondary work; 1% to the military; 6% to employment and 1% to something else (New York State School Report Card).

The science department had 14 full-time teachers and two additional staff, such as a special education teacher, who regularly collaborated with them. Science classes were held for five periods each week though they met only four days because the fourth class was a double period, which was often devoted to a lab.

Case study participants included a biology teacher, the chair of the science department who taught physics, the school's principal and the district technology coordinator. They had 4, 36, 34 and 26 years of experience as educators.

Technology Vision

The school's vision for technology integration had a long history, dating back to the mid 1960s when the school established a professional-quality television studio on its campus, and more recently, with the advent of personal computing in the classroom. Significant in this evolution was a 1991-93 committee report that was the result of parents, teachers and administrators working together to devise a comprehensive technology plan. Committee members explored questions of child development, pedagogy, professional development, infrastructure and obsolescence — as they all related to technology — and recommended a plan that others had revisited and updated multiple times since its initial release. The most recent update outlined three areas of focus; they were:

- "that the school environment offers opportunities for creativity, critical thinking, information access and manipulation as well as communication and multi-sensory stimulation;
- that the learning environment include access to a wide range of technologies and a wide world of information; and
- that our children be a part of the global classroom tapping into vast computer networks."

To meet these goals, the plan suggested the administration emphasize staff development and in-service training along with maintaining a robust technological infrastructure. Regarding learners, the plan declared a desire to go beyond the standards set by the State of New York and the national standards in Mathematics, Science and Technology.

Technology Infrastructure

The school had a reliable technology infrastructure with its own wide area network and fiber optic lines. This network structure had allowed the school to move from its original arrangement that placed the school library as the hub — an outgrowth of its early 1990s plan — to providing technology at the classroom level. In addition to two computer labs, many of the individual classrooms had clusters of computers, though according to the principal, the Galaxy projector was the most heavily requested item in the school. The biology teacher's classroom had one computer, which students were not supposed to use but was linked to a television monitor, allowing her to show websites, videos and DVDs. In addition, there was a traveling laptop cart though she did not use it with any regularity. She also reported that it was her understanding that the school would soon be wireless and that she did not know of any student who did not have regular access to a computer at home.

In addition to the district technology coordinator who was responsible for teacher professional development and curricular support, there were four technicians on site to help maintain access to computers at the classroom level and throughout the entire six-school district network. There were two additional computer teacher assistants to provide instructional support and a detailed website offering software tutorials, manuals and how-to files. The biology teacher said the most visible translation of the available technology support was announcements about new databases or curriculum materials the library had acquired for teachers' use

According to the chair of the science department, teachers in the science department used technology "all of the time" though it was not the kind of technology — computers and the Internet — that was meant by what he considered the code word *technology*. Instead, they used equipment and measurement tools; only those teachers whose focus was on research had their students use online resources regularly. He explained how the courses that were not mathematical, such as biology and forensics, or did not have a fixed curriculum, had more time for research. In his opinion, these research-oriented classes offered a greater opportunity to use the Internet and search engines. Additionally, all science classes had a lab component. Tracing his interest in science to the 1950s *Mr. Wizard* television show, the chair described himself as "old-fashioned," believing that when technology was used more often in other schools it had questionable educational value. Instead, he reported that he thought, "The best learning occurs when there is an interpersonal relationship. I wouldn't say that I'm a big supporter of computers in the classroom. It's a tool." He further questioned the value of using technology, such as probes and calculators, in data collection. While the data may be more precise, he said that it is important for students at the high school level to go through a more basic process of arithmetic and analysis. He said his colleagues held a variety of attitudes on the

same topic though no one "was knocking down the door" for more technology. Plus, he noted, the financial burden of outfitting an entire lab to do high-speed data collection and analysis with remote probes would be too great for the school to bear so his attitude of limited technology prevailed. Nevertheless, he said that there was a political desire to combat students' failure to learn with "human-independent solutions" that administrators can "throw money at."

School Culture and Pedagogy

Participants reported they were engaged in an ongoing conversation about classroom materials and were in the process of updating their science curriculum. Participating teachers said class time was devoted to a range of activities, including teacher-led lectures, independent student work on problem sets, multiple-choice tests and practice essays. Both Regents and Advanced Placement students supplemented their in-class learning, which was supported by teacher-made and publisher-produced handouts as well as online articles, with their textbooks, which they were expected to read at home.

In terms of how technology fit within the school's pedagogy, the technology coordinator said he was working with teachers to "spell out what kinds of activities should take place and what kinds of technology works with those activities." Acknowledging this need to make informed decisions about where technology did and did not fit he said, "Technology does not always go hand in hand. The challenge is to develop teaching strategies and to meet the need for professional development." Echoing this, the principal explained, "The technology doesn't wag the dog." The technology coordinator further explained how teachers had various levels of comfort with technology integration and how his goal was to get them to "take more responsibility with it." He explained that, although he tried to model teaching practices that integrated electronic resources into classroom practice, he said the teachers had to decide for themselves what would meet their needs. "I can show something," he said, "But if it doesn't make sense to them then they won't use it." Even the biology teacher who described herself as very comfortable with technology said she had never received formal training on technology integration in her classroom practice. She reported that she used her classroom computer and its connection to the TV monitor, to stream video, show a CD-ROM or play a DVD at least once a week for her students to view during a lesson. Likewise, the principal reported how several of the science teachers were relatively new to the school and to teaching and were familiar with technology integration having been exposed to it in their pre-service training. The biology teacher said her level of technology use was true for about one-third of the teachers in the science department; for others, use was less common. From the principal's perspective, this might mean using technology tools, namely web resources and a Galaxy projector, to assist what he referred to as "traditional" teachers in classroom presentations. He explained, "Teachers can show students something clearly in 30-60 seconds then move on to another part of a lesson. That's the way it should be used."

Technology use throughout the school also meant working in clusters and having students do more inquiry-based teachers participate in group work — something

that had become a recent trend. He said that in those cases where collaboration was required teachers were able to design projects that used digital resources to foster discussions that were not possible with the earlier generation of static student handouts. The biology teacher said that, in previous years, her use of technology for student learning — all teachers used computers for grading and attendance — had consisted of having students review websites at home and report what they had learned in class as well as to conduct research for large, once-a-year projects.

Participating teachers also reported making use of videotapes in classroom instruction, tending to show 20-50-minute segments. One teacher gave the following reasons for using a videotape: "A lot of times the material is better expressed when it is done in that format as opposed to me giving them notes. For example, showing the process of mitosis with voiceover… Or you want them to have an extension of the materials and how it relates to your actual life. And sometimes you have a double period and you don't have an appropriate lab or you have already done the lab that goes along with that unit and so you show a video." She said students had a range of responses to the videos she had shown, depending on their quality. She further noted that a video segment did not signal to students they were having an easy or free lesson; instead they were expected to take notes or respond to questions while they watching.

Resources and Rich-Text Media

The chair of the science department reported the school had a professional teaching staff that conducted a lot of independent reading and teachers did a great deal of resource sharing with one another. As the chair said, "Ideally speaking, no one's materials are their own, except for what they produce on their own." Teachers pursued knowledge about new resources, received alerts from the librarian, attended conferences and, at times, were inundated with offers from companies promoting products and services. Based on their interest in particular materials, teachers had the opportunity to make hardware, software and other kinds of resource requests. Depending on the availability of funds — each building within the district received a technology allocation — and the fit with the curriculum, the school acquired new resources each year. Individual science teachers also had their own budgets for materials based on the science department's annual budget, which was based on the school's overall budget. The technology coordinator and departmental chair oversaw the process of reviewing individual requests in their respective areas throughout the year in an effort to respond to teachers' needs rather than following a strict schedule that required teachers to make all requests in June for the following September. In addition to requests for new materials, the science department maintained two budgets: one for expendables (chemicals, specimens, etc.) and the other for equipment (microscopes, probes, etc.). Though teachers were not able to afford what the chair referred to as "big-ticket items" they could order items such as videotapes to augment their teaching. The biology teacher reported she had taped National Geographic, *NOVA* and Discovery Channel programs and purchased copies of BBC shows to use in her classroom. She also had as traded video tapes that her colleagues had bought or recorded.

The technology coordinator reported that he read many publications in search of potentially useful sites and participated in educational conferences throughout the country. He also said he attended monthly meetings of Nassau- BOCES (Board of Cooperative Educational Services), a partnership of schools throughout Westchester County, where he connected with other technology leaders and stayed current on new trends and materials. Similarly, the biology teacher had attended the Science Teachers Association of New York State (STANYS) conference. The biology teacher said she often started with Google or Alta Vista — either the general sites or the Images sections — because she often was looking for something specific related to a particular lab or lesson. She said for news articles she relied on CNN, MSN and the BBC's websites.

Aside from the acquisition process, participants expressed a general fatigue about being able to review and assess the abundance of materials available to them. As the department chair remarked about the onslaught of demo videos companies promoted, "So much of it is blah… Who has the time to really examine all of them? Who has the time to watch? Most of us teach and spend our time with students." Similarly, the biology teacher said the problem with many sites was the volume of information as well as their general disorganization, consequently, said she would like a site that sifted through available information, selected items of high quality and organized them according to state standards. "What kids need to know according to the standards is always on our minds," she explained. "One of the things I constantly go searching for is video clips. And it is one of the hardest things to find: something appropriate."

Response to Teachers' Domain

Strengths

- *Easy to use*. In general, participants reported how simple and straightforward Teachers' Domain was — both for them and their students. Upon visiting Teachers' Domain, the biology teacher reported she immediately created a profile, placing her AP Bio students into a group and selecting resources for them to access and use. (See *Figure 1* for a copy of the handout she distributed to her students introducing the online resource.) She said that she thought many of her colleagues would have an easy time navigating through the site and had helped one of her colleagues, to whom she had recommended the site, set up her own Teachers' Domain student group.

- *Clear organization*. Participants said the site was well organized and the section areas, such as "Cell," "Evolution," "Ecology" and "Genetics" were clear to understand. The biology teacher said, "Those make sense in terms of how we teach the material. They are the correct groupings as are the subheadings, like within "Evolution" there is "Classification" and "Deep Time."

- *Excellent video*. Participants reported that the video content was similar to streaming that WNET's National Teacher Training Institute offered, and with

which they were familiar. The technology coordinate said he thought the Teachers' Domain video was "friendlier."

Online Access to "Teacher's Domain"

AP Biology
Mrs. Taylor
2003-2004

1. Log on to http://www.teachersdomian.org/
2. Click on "register now." Fill in the appropriate information. (There are no fees and they will not spam you – just click to select no updates.)
3. Enter the school's info. Select Mamaraneck HS.
4. Select a sign-in name and password.
5. After completing registration, you are now taken back to the main page. Click on "My Groups" at the top right hand corner.
6. Enter the access number "162" at "Join a group." You are automatically accepted.
7. Click on "AP Biology" and then "AP Biology Unit 3B."
8. You now have access to online resources that I have selected for this unit.
9. Future resources will automatically show up as I add them to the AP Bilogy group. I will let you know in class when new materials are available for a unit.

Note – You may create you own folders with resources. For example, you may want to look for resources related to previous units as you begin to study for the midterm. You can also give access to you friends to the folders you create by providing them with the access number. However, you would first need to create a group of your own. You will not be able to just post things to group 162, which I control.

If you ever have questions about online materials, you can e-mail me at home
mhsbiology@hotmail.com

Figure 1

- *Depth of content*. Participants remarked how substantive the content was. The technology coordinator said, "There is a lot of meat" to the site. Likewise, the biology teacher said the site could help each student understand the current unit on genetics, which included understanding a complicated set of processes, breaking them down step by step and being in control when a student wanted to move on. Because of the depth of the content, the biology teacher said she would be more motivated to reserve time for her classes in the computer lab or request the mobile lab than she had been with other resources.

- *Search function is convenient and aids planning and use*. The biology teacher said how much she valued the ease of searching on the site. She commented, "If I know my unit is genetics — replication, transcription and translation — it is very easy to find those resources all gathered together. It's very easy to view them and get the main idea without having to do the whole activity. And then to sequence them and write some notes. I put them in the order I wanted students to view them." She further explained how this allowed her to offer a rationale for why and how she wanted students to use each

resource without having to produce individual handouts for multiple resources. "This is less paperwork for me," she said, "less explaining."

- *Mix of resources was strong*. The biology teacher reported how the range of materials, such as articles, videos and interactive activities, was one of the strengths of the site and she said she believed she could find materials for both her AP and Regents students because there is a "nice mix of mastery levels."

- *Interactive components support student learning*. Pointing to a DNA Shockwave activity on replication and protein synthesis as an example, the biology teacher said the interactive activities were what made Teachers' Domain unique. "My feeling based on all the different resources and websites," she said, "Is that there are very few that offer Flash/Macromedia types of activities for free." She said that requiring students to "click on something and manually make each step happen, such as choosing the correct nucleotide, would help students understand in a way" that she was not able to do on the board or by having them look at pictures in their textbooks. She said, "This kind of interactive thing with the Flash is better than just watching something like a *NOVA* clip." After her AP Bio students used the site, she offered the following summary, "The kids really liked the website. In fact, yesterday I took them as a class to the computer lab to look at resources that I put together for a chapter on DNA technology. Many of them expressed that the interactive activities really helped them to learn the concepts. Most found the site easy to navigate."

- *Useful as supplemental materials*. Because this was a new resource for students, the biology teacher said she did not plan to ask a quiz or test question that came directly from one of the Teachers' Domain resources. However, she said that as her students became accustomed to using the site — and as she became more familiar with it herself — she could envision making the reources part of the test material. She added also that this could happen only after knowing for certain that her students had access to a computer and could view the resources. In that case, she would offer reminders, such as "Make sure you view this [on Teachers' Domain] or print this out because it will be covered on the test."

- *Connection to standards*. Participants acknowledged the importance of standards in general and with respect to materials they used specifically. Upon reviewing lessons within Teachers Domain, the biology teacher commented, "As a teacher who does not write formal lesson plans that need to indicate standards, I don't find the standards necessary to view. However, it is nice to know that the items chosen help NYS teachers to meet standards. But, new/untenured teachers would find the link to the standards very useful, as they write up formal lesson plans that would be given to a principal or supervisor."

Challenges and Suggestions

- *Concern for video quality*. Prior to visiting Teachers' Domain, the science department chair said the problem with Internet video in general was the low-resolution. "It usually fills up two inches of screen. The quality usually stinks. You can't tell very much from it." The biology teacher said she was unable to locate the "full-screen" option for the video clips within Teachers' Domain but hoped that there was one so she could make use of her scan converter and display the video on the TV screen in her classroom. She said she was not certain this would work, however, as the resolution seemed low, making a full screen version hard to view. Consequently, she said she would like to have the option of high-resolution versions. Barring that she said she was limited to using the current iteration of Teachers' Domain as a student resource, where they viewed materials on their own time, or in a computer lab, where she had to compete with other teachers for a reservation.

- *Video snippets are inadequate*. Prior to reviewing Teachers' Domain, the science department chair said he was apprehensive about the value of brief video segments. He said there was a conundrum: "You can't tell very much from 30 seconds but you don't have time to watch 30 minutes. I would be suspicious of a teacher who has that much time to review and watch." While he acknowledged how the current generation of learners are immersed in visual stimuli he said he thought the pace of video and TV — the average scene length is a second and a half, he noted — whereas education is slow and methodical.

- *Problematic registration*. The science department chair said he found the registration process to be a "pain."

- *Potential generational gap*. The chair of the science department reported he thought younger teachers would have an easier and perhaps more successful time integrating technology into their teaching. He said, "Younger teachers can related better to this instructional paraphernalia."

- *Technical difficulty with video*. The biology teacher said she had trouble viewing one video within Teachers' Domain. Though she said she had completed the "tell us about the problem" form, she had not had time to check to see if the problem had been remedied — either on her computer's end or WGBH's. She said that she was able to access similar files without any difficulty.

- *"Update" function unclear*. The biology teacher reported that there was a small learning curve, especially related to the "update" function within Teachers' Domain. She said she did not realize that she had to click this button otherwise she would — and one time did — lose the annotated notes she had typed into the site. She said that this aspect of the site potentially could be very frustrating to teachers with lower levels of comfort and experience with technology.

- *Missing content*. The biology teacher reported several areas of content that were missing, most notably related to human systems. She said, "This is still a work in progress, right, even for the Bio? What I don't see here is anything about the human body." She also said she could not recall if there was a section about biochemistry, which both her Regents and AP students would have to know for their respective tests. For example, she said they would have to know: organic molecules vs. inorganic, carbohydrates, proteins and lipids. Plant biology was another area that she said was not covered. The chair of the science department, on the other hand, said he was unable to judge the life sciences content, as he had not taken a biology class since high school.

- *Links to news articles would be useful*. The biology teacher said that the site would be enhanced if, in addition to the materials already available, it also offered links to articles related to relevant current events, such as the discovery of a gene. She said these links could take the form of articles already produced by news organizations, like CNN, or that WGBH/PBS wrote in a "news style" on their own.

- *Additional trainings would be valuable*. The biology teacher recommended that WGBH offer professional development around the use of Teachers' Domain at the district level, giving teachers an introduction to the materials it contains and ways they could integrate it into their classroom practice. She also said that it would be worthwhile to hold trainings at state science conferences, like STANYS. In her opinion, STANYS was always eager to have presentations that help support the integration of technology into teaching and learning.

- *Test/quiz questions or some form of assessment would be useful*. The biology teacher said she would like to see Teachers' Domain add test questions and other assessment materials. She said if this were to happen then the site would have to create tiers of access rather than continuing with the current structure where students were able to view everything once they were logged onto the site. She reported that all of the science teachers in her department had used test question databases in the past and would welcome this addition. She said it is somewhat important for the questions to mirror other tests students must take, either Regents or the AP exam, though all questions would be helpful.

Summary

Case Study 4 participants fell into distinct camps: the biology teachers expressed a great deal of excitement for Teachers' Domain, declaring "I'm thrilled to find this website and it will absolutely change the way that I teach." The science department chair was equally moved, expressing considerable skepticism. He said flatly, "I don't see it as any great value. All of that video stuff is more middle school." And the district technology coordinator and principal said they were generally supportive and thought the resource would fit within the school's overall technology goals. Despite

her enthusiasm — as evidenced by both her recommending the resource to colleagues and taking her class to a computer lab to make use of the materials — the biology teacher said she was not certain how use of Teachers' Domain would play out on a daily basis given the current structure of her classroom. She thought the one computer/one TV monitor set up may require the majority of her students to experience the online resource outside of class for the foreseeable future.

Case Study 5

Middle School
Inquiry-based Social Studies

Setting and Demographics

The fifth case study school was a sixth through eighth-grade middle school located in Tucson, Arizona, with an enrollment of 1020 students and 55 teachers, 27 of whom have their Masters Degree. One teacher described this school as being in a "lower socio-economic area" and estimated that close to 85% of students were on free and reduced-price lunch. The school had a high percentage of Spanish-speaking students (according to one participating teacher close to 85% of the student body is Mexican-American) and bilingual classes were offered. The school offered parenting websites in both Spanish and English.

The school's district report card listed the school as "improving," which was the second highest level out of four: excelling, improving, maintaining and underperforming. The school employed team teaching and inclusion as its philosophies. Effective in 2001-02, in addition to the Stanford 9 achievement tests, all students were required to take Arizona's Instrument to Measure Standards (AIMS), designed to measure student achievement of the Arizona Academic Standards. Students must "meet the standard" or "exceed the standard" on all portions of AIMS or pass an AIMS Equivalent Demonstration (subject to approval by the state Board of Education) in order to be eligible for a high school diploma. In the 2001-02 school year, students at the school fell below the state average in all three subject areas on the AIMS. Students also fell below the state average in the Stanford 9 tests, however from 2001-02 to the 2002-03 school year 82% of students made expected progress in math and 79% of students made expected progress in reading.

Case study participants included two social studies teachers and one technology teacher. The teachers had been teaching for 24 years and 10 years and the technology teacher was in his sixth year.

Technology Vision

The school did not have a school-wide commitment to the integration of technology. Participating staff said they did not know of any official technology plan and were not required to use technology in their classrooms. The computer teacher felt that while the administration at the school was "open to technology," he did not think that it was "committed to any long or even short term plan for how they are going to use it… There are attempts in isolated areas such as counseling or encouraging the use of technology in assessments but not across the board."

Another teacher said that while the school invested "a lot of money" in the technology infrastructure it was only recently that they had begun to see that

without also investing in teacher training it was not "paying off." Another said that many of the teachers at the school did not see a need for it and they had been "encouraged and threatened but it is hard to get everyone to do it…I am forced to because of the way I have set up my curriculum," which was project-based.

Technology Infrastructure

While technology resources at the school were spread among two labs and most classrooms, use of technology was far from ubiquitous. Participating staff reported that teachers were discouraged by how few computers there were per classroom, the inaccessibility of the labs and the lack of technology support.

Each classroom had five computers, which were connected to the Internet, and there were two T1 lines, which teachers said provided fast connectivity. A technology teacher provided instruction to students during an elective period although the technology credit was required for graduation and a district technical support person solved technology problems. However, he also was responsible for all schools in the district, including three high schools, four middle schools and thirteen elementary schools. Participating teachers said there was a lack of technology experience among much of the staff, however, the staff used technology for administrative tasks: attendance was conducted on the network as was interoffice communication.

There was one lab in the computer room with 30 computers for teachers and students to sign up to use and there was also a lab in the library. The computer teacher said that the computer lab was busy when he taught class and the library lab was often booked because of the Accelerated Reader program, which was conducted there three to six hours of every day. He said that even if the teachers sign up to use the computer lab, nobody was there to help them. In addition, he said that some of the teachers did not use the lab because they had to walk across campus to get to it. He recommended that the labs be dismantled and the computers divided among curriculum teams where they could be accessed more easily.

The school did not have an official technology coordinator, and staff reported that there was inconsistent technology support. One teacher reported that she relied on one or two technology-savvy classroom teachers when she needed help because "waiting for the district person to schedule an appointment took too much time," while another said that she often depended on her students for troubleshooting. The computer teacher, who described himself as tech-savvy, said that he found himself filling the role of technical support even though it was not officially his job and had inadequate time to meet teachers' needs. While the administration "makes the attempt to get computer experts to come in and teach the computer skills to teach to their students…and the state championed the idea that every school is wired and put a gold star on our state, nobody is checking up to see how it is being used," he remarked.

Participating teachers estimated that about 30% of the students had computers at home, and as a result, teachers did not assign homework that required the use of computers outside of school. One teacher said she often kept her classroom open

beyond the school day in order to give her students access to the computers available there.

School Culture and Pedagogy

When participating teachers described their teaching, two of the three discussed project-based and interdisciplinary learning. The computer teacher had a more traditional pedagogical approach that subsequently influenced his use of technology. He discussed technology's ability to support skill building and job preparation while the other teachers described how technology could support their students' exploration of project-based work. For example, one of the inquiry-based teachers said she had an unusual classroom because she worked with "gifted and talented" students, and received greater flexibility from the administration in terms of curriculum planning. She commented, "Generally, I have no textbook. I get current information [from the Internet]…and I use texts from plays… and use video and listen to music." She also reported she took her class on a lot of field trips and added, "We go to the theater, we put on plays, we study musicals and cover jazz and blues curriculum…for example right now I am taking the sixth grade students to an archaeological dig and the eighth graders to Biosphere II." She reported that she focused on local surroundings to find resources in order to emphasize to students the importance of community. She said, "I am dealing with a group of student who haven't traveled much so I try to venture out and use what they know…at this age level and what they are dealing with socially I feel like I keep it simple by making it real." The other teacher, who taught general middle school social studies, discussed the advantages of technology supporting his educational goals and commented, "For the kids it is more interesting and current – topics that most teachers don't cover because it is not in textbooks yet like social issues. At this age level relevancy is really important, they need to know why they are learning it."

The computer teacher reported the importance of technology for job preparedness and how it could provide real-life application for students. He said that technology increases student motivation and engagement while also teaching basic skills. He emphasized what benefits technology could provide for lower-level learners; students could work something out independently in front of a computer if they needed more time.

In terms of requirements imposed at the school level, teachers said adherence to standards was encouraged by the administration but gave teachers latitude in how they were expected to adhere to them. One teacher reported the school offered training in Cox Education Network, which is an online resource that provided teachers with standards-based content and resources. She said that some of the teachers took advantage of this resource because of the tie to standards. She said that for her own teaching, she appreciated when her resources were tied to standards but if they were not she would make the connection herself. Another teacher said that while "right now there is a heavier emphasis on standards [than in the past], and it is helpful when resources list them for your state" he did not use them in his own teaching. The computer teacher, however, said that he had no choice but to use standards and that "if it [a particular resource] is not aligned to state standards I am

not allowed to have it in class….I have to have the corresponding standards to the lesson I am teaching on the board every day."

Resources and Rich-Text Media

According to the participating teachers, the reliability of technology resources in the school as well as the use of those resources by their colleagues varied greatly. They reported that each school in the district had a technology committee, comprised of students, parents, the technology coordinator and teachers, that made decisions about technology resources. There was a similar committee at the district level. However, participating teachers said they felt these groups were not always successful in practice, and that much resource acquisition was done in a more isolated manner on the department level, with department chairs making technology decisions and bringing those decisions to the principal.

Regarding the use of technology in the classroom, participating teachers said they most commonly searched the Internet to find information and materials. They also heard about new resources from colleagues and from calling local universities or community experts for recommended websites on particular topics. For example, when one teacher's class was doing a unit on architecture a local architect provided them with a list of relevant websites. Another teacher mentioned that one of his favorite online resources was the Library of Congress website where students could access primary source materials. He described that for a project on the topic of the American Civil Rights movement he "was able to access photos of the black students entering the school and you can really see the emotion…and the kids can put themselves in that time period… and by doing that these historical events stay with the students." Another teacher said that because she found most of her materials online, rich media were an important part of her curriculum, and used these particularly with her music and theater units. She said that while she and her students used "a tremendous amount [of these resources] for research, students also use video and audio clips within their PowerPoint presentations." She said that sometimes she implemented pieces of curriculum that she found online; she said, "The Biosphere II had an online curriculum and we used a lot of it." She said she also used MarsQuest and resources from an online Air and Space Museum. For his part, the computer teacher said that the first thing that "he frowns upon" in terms of online resources were pop-up ads. He said that while his responsibility was to teach computer skills, if he could use other resources he would look for resources that were not "linear." He went on to say, "Even if it is pretty and has pictures it is no different than me standing up there and lecturing… I look for things where students have to make choices…like a simulation, that's what would capture my attention…where students could use critical thinking and make decisions."

Regarding the challenges of using rich media in the classroom, teachers commented on the difficulty in sorting through the abundance of resources to find those that had high quality and would be useful. One teacher said he tried to find sites he knew were reputable, such as museum sites or sites that were tied to universities. Teachers also reported the small number of computers in their classrooms made it difficulty to rely on digital resources because they "have to juggle students between computer

work and other work." One teacher said he overcame the limited technology in his room by having some students do partner work on the computers while others were at their desks. While another teacher cited time limitations as a hurdle to using computer-based resources, stating, "When you only have the kids for an hour a day and then the class period is over and you have to start the next day by reviewing and then teaching new material…and it takes time to get on the computer." The computer teacher said that he "liked resources that provided immediate feedback for students — something that tells them what the right and wrong answers are and explains them."

Response to Teachers' Domain

Strengths

- *Easy to use*. Participants reported how Teachers' Domain was a very accessible resource. As one teacher stated, "This site can help teachers who don't know how to do it [integrate technology] learn how to use it."

- *Supports independent student work*. One teacher identified Teachers' Domain as a resource that would benefit in the hands of student. She said, "This has the power to change more traditional teaching because it allows for students to work independently…and have more control over their learning."

- *High quality*. Participants remarked on the strength of the quality of the materials contained in Teachers' Domain, and how teachers would be motivated to use them. "I thought it was well thought out," explained one teacher. "It was top quality, user friendly whether for a teacher or a student. Something that you would use repeatedly. The key is the high quality. I think that it would encourage teachers to utilize technology more in their classrooms if they were aware that this type of resource was available to them." Another teacher described how she was so impressed by the resources that she would use them as a basis for developing new lessons. She said, "It was such a good site that I would consider going in a back door and seeing what was there and then creating a lesson around that."

- *Interactive activities and multimedia resources are valuable*. Participants said the Teachers' Domain resources were unique because of their interactive quality. "The best part of the entire site is the interactive video," declared on teacher. "I haven't seen anything quite like this." Another asserted, "I have not seen anything like this on Science, but I haven't gone out of my way to find Science resources…this is like a bundled film series with interactive paragraphs and essays and charts and graphs…it has got some awesome resources and even if a teacher just used it for one day it would be easier to get a video from here than to go to the library and check something out."

- *Well-organized and time efficient*. Teachers reported how convenient the site was because it pulled together disparate resources into one online space. As a teacher said, "I ordinarily teach in a way that includes a variety of

resources…but it is not usually in one place [like Teachers Domain]…this site would make it easier for me to find everything in one place." Another teacher also remarked on the time-saving aspect of the video resources: "It has got some awesome resources and even if a teacher just used it for one day it would be easier for them to get a video off there than to go get it at the library."

- *Connection to standards*. Participants said the alignment to standards that the resources made them more appealing. "I thought it was excellent," said one teacher. "The fact that they had so many lesson plans and had the standards in there. It was very educationally slanted."

- *Help function*. One teacher said the help function made Teachers' Domain stand out from other resources. She said, "I like the help section…in most websites this is lacking."

Challenges and Suggestions

- *Navigation was difficult*. One teacher described the difficulty she had while moving through multiple sections of the site. She said, "It was hard to find something again once I wanted to go back to it. I wanted to compare resources from different grade levels since I teach sixth through eighth- grade so I have to be able to go back and forth."

- *Text too advanced*. One teacher expressed concern over the accessibility of the text among English Language Learners. She reported, "The text might be hard for ESL learners…. Eighty-five percent of our population is Mexican-American…and also fewer students from this population have computers at home so they are less familiar with the technology."

- *A review function would be helpful*. One teacher, who said he was oriented toward accountability said he thought the site could facilitate assessment. He said, "I would add a review on the end….I like how you can go through the resources step by step but a review at the end would help tie one topic to another…and it could give immediate feedback to the students. Then they could understand if they got the wrong answer. It is all about accountability now and we have to ask the students to be accountable for their time on task and having a website support that trend would be helpful." If assessment were added, another teacher explained, "I would want students to have privacy if they were doing assessments on the site."

- *Traffic or student user log would be useful.* "I would like to be able to keep track of how many times my students watched the clips or interactives, or how much time they spent on certain pages."

- *Greater control over the video*. One teacher requested the ability to control the video segments within Teachers' Domain. She said, "Having more user controls in the videos in addition to 'back or next'…if the clips were broken into parts

so students could go back and watch one part instead of having to watch the whole thing again – like a site map."

Summary

Case Study 5 participants reported how they immediately saw Teachers' Domain as a resource that could change more traditional teaching by encouraging student-centered work. They identified it as a unique online resource, bringing together different forms of technology, especially video and interactive activities. While they expressed an interest in using Teachers' Domain to further the kinds of inquiry-based projects their students commonly do, teachers were also concerned with accountability. As such, they said they wanted the opportunity to offer students feedback directly through the site as well as a means to track student progress as they used various materials.

Also, although participants had a positive response to Teachers Domain, they had a difficult time making the connection between the Life Science resources currently available and what similar materials in Social Studies might look like. They were enthusiastic, in general, but were not certain what the particulars within other disciplines may include.

Conclusion

Although the research underlying this report was not intended to take up the question of the uniqueness of Teachers' Domain, perhaps this is the most prominent of its findings. With respect to both the review of existing research and the five individual case studies Teachers' Domain is a stand out. That is not to suggest that the field of educational technology is not cluttered with scads of materials vying for educators' attention; it most certainly is. WebQuests, digital archives, videoconferencing and wireless technologies are just a few of the kinds of resources filling school buildings across the country. In part, it is precisely this clutter that gives rise to Teachers' Domain's strength. Teachers feel the pressures of accountability legislation, high-stakes testing and notions of 21st Century skills, but even more, they feel the desire to teach. And they want their students to learn. And it is within this simple desire — albeit wrapped in the messy complications of each school's culture — that case study participants expressed an enthusiasm for a service like Teachers' Domain. They were not unrealistic in thinking that it would make their jobs go any faster. They did believe, however, that is would offer the kinds of support they needed to get the job done.

While these case studies did not yield quantitative data that we may use to generalize over the entire population of K-12 schools or even a cross section of it — by its very nature a case study is an examination of one specific context — we can extrapolate some overlapping aspects of the collective experiences of the case study participants. As Teachers' Domain continues to develop, WGBH may want to consider the following:

When going online, educators have a baseline for quality and ease of use.
Because the Web is no longer in its infancy and a significant percentage of teachers have had first-hand experiences with the medium, educators have come to hold certain expectations of any online resource, namely, they want information to be useful, relevant to *their* students and, preferably, of a high quality. Likewise, they want navigation to be clear and the connection to standards transparent. Almost unanimously, case study participants found Teachers' Domain to surpass their expectations of what an educational web experience could and should consist of. Links and multimedia worked a vast majority of the time, materials were well organized and easy to understand, the link to standards and their school's curriculum was apparent and a rich array of materials in different formats in one place was very desirable to them.

Web functionality will continue to evolve.
Although Teachers' Domain met participants' expectations of what an educational website could offer, a small number of teachers and technology coordinators were able to identify functions and additions that may become future conventions. Built-in assessment modules, embedded information that is so recent only a website rather than a text book could keep up, and high resolution video supported by greater bandwidth capabilities were a few of the requests that participants put on a Teachers'

Domain "wish list." In developing these potential additions, WGBH has the advantage of belonging to the broader public television system so it may, for example, form a partnership with *FRONTLINE* and *News Hour* in order for Teachers' Domain to offer links to news articles on cutting edges topics. (These news articles would be in addition to the other types of materials Teachers' Domain already includes from FRONTLINE and similar sources.)

Pedagogy is a moving target — albeit a slow one.
Regardless of their pedagogical orientation, participating teachers found Teachers' Domain to be relevant and appealing. However, they tended to perceive the site through their existing lens: if they had an inquiry-based approach to learning they were drawn to the interactive activities and materials they could place in their students' hands; if they were traditional they focused on those information sources, such as videos and articles, that would enhance their own presentations and content delivery. Despite this strong tendency to interpret Teachers' Domain through their current schools' culture and past teaching experiences — something that is both commonplace and reasonable as change requires ongoing support and time to adopt new practices — a number of teachers as well as participants in professional development roles thought the resources could help traditional practitioners experiment with student-centered projects.

Schools dwell in an information and resource glut — and it is a time-consuming one.
With the abundance of materials available to them, many participants — teachers, technology coordinators and professional development specialists alike — had resource fatigue. Commonly, they were aware that an insurmountable number of materials awaited them online should they want to maneuver through cumbersome search engine results. They also could obtain new resources (video tapes, CD-ROMs, fee-based online services, etc.) through discretionary school or departmental budgets if they wanted to make a case for them. Though many participants thought Teachers' Domain stood out above many other resources with which they were more familiar — some thought its multimedia collection and interactive elements could only be had through a comparable paid subscription or something they painstakingly would have to cobble together from multiple sources themselves — they were not certain how it would have come to their attention had they not been participating in a research study. While several participants had familiarity with and trust in PBS, they saw its and its member stations' offerings almost exclusively as broadcast and video programming. WGBH in particular and PBS in general would be well served to build awareness through on-air and other outreach promotions.

No matter the high quality of resources, educators want support.
Participating administrators recognized, and teachers made requests for, professional development around the integration of Teachers' Domain. Educators have a hunger for collaborative experiences — be they at conferences, workshops, or ideally, with colleagues in their own classrooms and computer labs — that allow them to exchange ideas and discuss how a new tool or suite of resource will help strengthen their teaching. The National Teacher Training Institute and other professional

development efforts may be potential outlets for introducing practitioners to Teachers' Domain.

Ubiquitous computing remains a myth.
Despite the brouhaha over connectivity and the largely trumpeted student-to-computer ratio, teachers' reliable access to computers is a persistent challenge. Though there is nothing WGBH's Teachers' Domain can do to change this reality teachers are squeezed to meet curricular demands, leaving trips to computer labs unappealing. They prefer to have tools, such as computers, projectors and monitors, in their classrooms and in their control, untethered by niggling password protections and overprotective firewalls.

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