The Digital Lives of U.S. Teachers: A Research Synthesis and Trends to Watch

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The United States Department of Education’s 2010 National Educational Technology Plan called for educators to transform learning and teaching with digital resources and tools. However, classroom teachers are especially challenged by information seeking, use, and management as well as by increased pressure to provide accountability data and serve diverse learners. In response to these challenges, the digital library community, spurred to improve science, technology, education, and mathematics (STEM) education, is developing solutions that include metadata and paradata schema; highly curated, centralized collections; and integrated planning, management, and assessment tools. Still, local and external factors can hinder change and must be considered in design and implementation. In this paper, we integrate an extensive collection of research relating to educators’ digital “lives,” or processes; provide an overview of very recent developments in digital library technology that pose possible solutions; and illustrate essential facilitating conditions, including the vital role of the teacher librarian.

Introduction

Struggling American schools are widely considered to be in need of reform to address key challenges to student learning that include:

- Poor academic performance in science and mathematics (National Center for Education Statistics [NCES], 2011c), especially when compared to other nations (Gonzales, et al., 2008; Organization for Economic Cooperation and Development [OECD], 2010);
- Lack of exposure to 21st century skills in school (Board on Science Education, 2010; Project Tomorrow, 2010a; Rotherham & Willingham, 2009; Silva, 2008);
- High drop out rates related to student boredom (Bridgeland, Dilulio, & Morison, 2006; Chapman, Laird, & KewalRamani, 2010);
- Declining numbers of students interested in science, technology, engineering, and mathematics (STEM) (National Science Board [NSB], 2010; Project Tomorrow & Pasco Scientific, 2008);
- Few “workplace ready” students with employability skills like basic writing and mathematics, punctuality, and communication skills (Guy, Sitlington, Larsen, & Frank, 2009; Raybould & Sheedy, 2005).

Numerous initiatives to restructure schools through vouchers, charters, and various reform programs as well as proposals to increase teacher retention, skill, and accountability have all been examined as routes to improvement. However, effective student learning experiences can be reduced to uneven access to two contextual variables: high quality learning resources and high-
quality pedagogy (Maull, Saldivar, & Sumner, 2010b; Morris & Hiebert, 2011). Alone, neither variable is sufficient to improve student achievement (Arslan, 2010). While improving the quality of teaching would seem to be an obvious way to improve the quality of learning, the importance of improving access to digital resources cannot be understated. The number of teachers who do not integrate technology is dwindling (Project Tomorrow, 2010b). Studies have showed that the majority of K-12 teachers in the United States use digital media and technology in some aspect of their classroom instruction with most teachers reporting that they use the Internet for searching, finding, retrieving, using and digital media such as games, activities, lesson plans and simulations frequently or every day (PBS & Grunwald Associates, 2011). How technology is used to access learning resources, rather than if it used, for teaching is the differentiator.

Effective technology integration has become a centerpiece of educational improvement, as the White House Office of Educational Technology’s National Educational Technology Plan (NETP) (2010) underscored:

Although the expectation of effective teaching and accountability for professional educators is a critical component of transforming our education system, equally important is recognizing that we need to strengthen and elevate the teaching profession. ... Unfortunately, our education system often fails to give educators the tools to do their job well. We hold educators responsible for student achievement, but we do not support them with the latest technology the way we do professionals in other fields. ... Just as leveraging technology can help us improve learning and assessment, technology can help us build the capacity of educators by enabling a shift to a model of connected teaching. (p. 39)

**Categories of Teacher Technology Integration**

A major activity of contemporary teachers is to turn unorganized assemblies of resources, lesson plans, and student data into high quality, organized, validated technology-rich authentic learning opportunities and linked, meaningful assessments. The explosion of information and technology poses complications to all aspects of the learning process, and the approaches to integrating information and technology define the degree to which digital resources and tools can affect learning. To this end, three necessary conditions, or categories, of teacher technology integration have been observed by researchers (e.g., Way, 2009) that are reflected in the goals for teachers’ use in the NETP:

1. **Powerful use of innovative digital learning objects.** In this mode, teachers integrate technology by replacing physical resources with free, high quality digital resources. The teacher’s goal is to improve student skills using interactive digital resources. The act of swapping out and updating resources is often a first step, but the creation and sharing of resources in the context of teaching and learning is seen as a cornerstone skill for educators (Johnson, Levine, Smith, & Stone, 2010; Johnson, Smith, Willis, Levine, & Haywood, 2011; Levin, 2009).

2. **Curriculum planning and assessment tool to ensure consistency and differentiation.** In this mode, technology is integrated into the planning, delivery, management, and assessment processes in the classrooms. The teacher designs instructional experiences about and with technology. Technology tools ranging from student response systems, e-portfolios, and online assessments join digital resources in the array of technology that is integrated into the classroom (Education Networks of America [ENA] & Infotech Strategies, 2006; Levin, 2009) and into planning processes (Morris & Hiebert, 2011). New constructs of resource definition, description, and evaluation develop to fit new applications (Leary, et al, 2009).

3. **A new digital teaching and learning environment.** In this mode, technology pervades every activity that occurs in the teaching and learning process. Teachers are not only using digital resources in their planning, management, and assessment processes, but they are also changing the culture of teaching and learning by participating in technology-mediated professional exchanges, making use of and creating annotations and feedback for learning objects, and having students center their activities on digital resource location, use, creation, and sharing in learning (Education Networks of America [ENA] & Infotech Strategies, 2006; Levin, 2009).
In many ways, these discrete categories also form a continuum. Contemporary learning resources are increasingly digital and require not just keen information skills, but knowledge of ways to integrate digital resources in ways that enable all learners (Markless & Streatfield, 2009). Educators’ confidence in resource selection is a precursor to their confidence in the use of a wider arrange of tools that enable higher quality feedback and deeper student engagement (Code & Zaparyniuk, 2009). Finally, seamless and extensive meaningful integration of technology in all aspects of teaching and learning is essential if the visions of 21st century skills articulated by various organizations are to be realized. Regardless of the point on the continuum on which an educator resides, reforms that focus on improving the act of instruction without examining how teachers select and use the information and technology that undergirds it are incomplete.

In this paper, calling upon extensive education and information science research and policy of the preceding decade, we provide a review the current research relevant to each of the NETP goal areas described above and explore the theories and challenges inherent in each. Then, we introduce tools and approaches designed to promote consistent learning opportunities by allowing educators, especially STEM educators, to make use of high quality resources, design effective technology-infused activities, and engage in professional communities while serving their competing priorities of standards-aligned instruction and effective assessment. Finally, we present trends and possible cautious to the philosophical and technical pursuit of the NETP’s goals. Our aim is to provide overviews of important educational trends to guide further exploration, educational digital library development, and research.

Challenges to Integration and Planning
Despite the money and time spent on training primary and secondary teachers to integrate technology, few results have been observed in instruction and learning (Spaulding, 2010). As the role expectations of teachers have intensified in the areas of instruction, technology, and reform, these expectations often had negative consequences for teachers’ relationships with their students, pedagogical innovation, and sense of professional well-being (Valli & Buese, 2007). Myriad challenges affect the use and integration of learning objects in planning and teaching.

Powerful Use of Innovative Digital Learning Objects
The term “learning object” can be used to describe a wide array of types of learning resources from digital documents to video and audio clips to games and online simulations. The term is often used synonymously with the term “digital resource,” but the key notion of a learning object is granularity. Granularity of a learning object is small, like a digital video clip as opposed to a website containing a library of digital video clips. Their physical analogs might be a single worksheet, textbook passage, or physical specimen. Because of their small size and targeted focus, learning objects can be combined to provide activities of various lengths and purposes (Arslan, Gök, & Saltan, 2010; Griffith, 2003). Learning objects can be combined in a number of different ways or tailored for different audiences (Kay & Knaack, 2007, 2008; Pattuelli, 2006; Sing & Chew, 2009).

Often, replacing physical resources used in existing lessons with digital resources is a teacher’s first step in technology integration (Haughey & Muirhead, 2005), but this step is influenced by the teacher’s ability to locate, select, and manage resources (Sappey & Relf, 2010). Continued use is highly dependent on teachers’ abilities to reuse and adapt the learning objects they trust (Pattuelli, 2006).

So powerful is the role of the resource base for teaching, that an inability to find, use, and manage resources is a significant driver of teacher attrition (National Commission on Teaching and America’s Future [NCTAF], 2003), and confidence in these same areas can be used as a proxy measure of teacher effectiveness (Spaulding, 2010).

Resource location. As designers of learning activities, teachers are enabled and constrained by the digital resources available to them (Recker, et al., 2007). Teachers who lack sufficient skill to integrate digital learning materials continue to use non-digital resources and thus have fewer technology-enhanced teaching opportunities (Perrault, 2007a). Though there is limited current research addressing teacher online information searching behaviors (Maull, Saldivar, & Sumner, 2010a), in extant studies, teachers report that they are increasingly overwhelmed by locating, aligning and adapting of materials amidst the abundance of online resources that could potentially support their curriculum planning (Maull, et al., 2010a; Perrault, 2007b).
Indeed, many teachers are not prepared to enter the classroom with the information skills they need to locate, evaluate and effectively use resources that would enhance their instruction. Consequently, many teachers are not prepared to teach information and research strategies to their own (Duke & Ward, 2009). For example, one study of pre-service teachers showed that 36% did not have the necessary knowledge to use search engines effectively; 77% did not understand the principles of web technology that created the indexes used by search engines; and they used a limited selection of operators in order to narrow search results (Laverty, Reed, & Lee, 2008). The lack of ability to locate, select, or manage resources has a constraining effect on instruction. Pre-service teachers who were not only unfamiliar with content but were also not confident in finding or selecting resources referred to textbooks and web-based teaching resources created by publishers for critical decisions about materials and resources in planning curriculum and instruction (Lai & Lam, 2011).

Although in-service teachers perceive themselves as proficient in finding online materials for curriculum planning, many teachers surveyed did not report that they were comfortable finding information in specific tools such as periodical databases or educational digital libraries, especially in the area of discerning reusable learning objects from larger collections (Perrault, 2007b). Like their pre-service counterparts, teachers’ information seeking tends to be a recursive process of integrating a quickly located online resources into practice, discovering its shortcomings, and going back to search again (Perrault, 2007a). Teachers frequently reported using a web search engine in a quick look for age-appropriate resources on a specific topic rather than using the databases or digital libraries that they recognize as more reliable (Perrault, 2007b). Teachers stated that they felt that the time they saved by performing a quick web search outweighed the “satisficing” nature of their resource compromises. Perhaps, because teachers typically rely upon their files and ideas from colleagues for their curriculum planning (Perrault, 2007a; Williams & Coles, 2007), few teachers feel that mastery of search skills is an integral part of their practice (Duke & Ward, 2009).

**Resource selection.** The Web can be characterized as a double-edged sword for teachers: a plethora of educational content is available, but searches return many results, and separating good resources from bad resources can be a time-consuming challenge. Even when teachers have excellent search skills, they can struggle with resource selection because of the wide-ranging ideas of resource quality and the complex nature of resource alignment to curriculum standards (Mervis, 2009). For example, Barker (2010) found that teachers rated free sites, resources that indicated grade level and reading level, and descriptions of the time and resources needed, as well as sites that had graphics and video, as the most important resource qualities. Teachers rated sites marked with standards, affiliations with professional organizations, and local resources as less important (Barker, 2010; Landis, Murphy, Schretter, & Haury, 1995). While studies of science teachers showed that many teachers shared these preferences, subsequent questioning revealed that their preference statements were not based on feeling that aspects such as standards linkages and reputable creators were unimportant, but that the teachers felt that they did not have the time or expertise to evaluate resources for these qualities (Perrault, 2007b). Most online materials encountered in a web search are not aligned with the curricula of a school or with state standards, which makes them harder for teachers to use (Mervis, 2009).

Learning objects have such an enormous range of uses, appearances, efficacy, and audiences, a static checklist of quality is nearly impossible to devise. Instead, teachers are left to determine appropriateness based on context-specific qualities and personal preferences, not necessarily taking into consideration the best for the concept and audience.

**Resource management.** Organization of resources also poses an issue for educators. While teachers who lack information seeking skills are less likely to seek new materials, for many, their most significant and frustrating challenge is how to organize the materials they do have for use in future instructional events (Diekema & Olsen, 2011; Perrault, 2007b).

Even when teachers are exposed to information skills in their pre-service training and through professional development, this exposure tends to be to generic process-oriented models that do not address teachers’ unique needs for ready identification of resources that are context-specific, grade appropriate, proven effective, curriculum aligned, reputable, customizable, and supportive of authentic learning tasks (Markless & Streatfield, 2009; Pattuelli, 2007; Sing & Chew,
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2009). Classroom context is another important consideration for the effective use of digital resources in instruction (Pattuelli, 2006). However, the ability to re-locate these resources is just as important as finding the in the first place.

Teachers’ lack of confidence in information management affects more than just their instruction. Some researchers (e.g., Perrault, 2005; Puustinen & Rouet, 2009) pointed to barriers and enablers to teaching and learning created by unskilled resource management as did Ball and Cohen (1999) in their prior study’s link between teacher access to resources with planning practices “materials influence instructional capacity by constraining or enabling students’ and teachers’ opportunities to learn and teach” (p.4). Gitlin (2001) reported that teachers in a case study who could not quickly call upon interesting resources for their teaching followed the state core curriculum very precisely and relied on textbooks and prepackaged curricula. This adherence led to instruction that did not engage students and that was ineffective for transferring concepts. This behavior not only affects instruction, but it also affects learning on many levels because classroom teachers, school librarians, and other educators are expected act as models and mentors for students’ development of information strategies (Perrault, 2007a; Project Tomorrow & Pasco Scientific, 2008) and personal organization is an important aspect of academic success.

Curriculum Planning and Assessment
The wide variation in instructional planning, delivery, management, and assessment processes in classrooms results in a wide variation in student achievement. In addition to a great variation in the ways teachers seek and select resources for learning, the ways in which they plan and assess learning also undermine consistent student experiences from teacher to teacher, school to school, and academic year to academic year.

Increased need for differentiation. The number of students receiving special education services in the traditional classroom is the highest in U.S. history (Mervis, 2009), and many teachers struggle to support them (Garderen, et al, 2009). Using material off the Web is difficult for teachers who need to be able to tailor the material to needs of individual students (Mervis, 2009), yet digital resources have the potential to diversify the way teachers represent concepts and processes with images, simulations, tutorials, and other resources tailored to the learner’s needs.

For students to build upon and connect concepts requires a supportive learning environment dependent upon the teacher’s skills in selecting appropriate resources and structure for activities to bridge the gap between classroom content and informal knowledge (Hennessy, et al., 2007).

Data on student achievement. There is little evidence that technology, either resources or equipment, produces improvements in academic performance. The impact seems to depend more on how the technology is integrated including the level of student engagement, extent of group participation, and real-world connections (Saljo, 2010). However, public education in the United States is tied to accountability measures designed to ensure that only innovations that yield strong student achievement are implemented (Valli & Buese, 2007). To this end, assessments result not only in information that is used for instruction, but also for teacher evaluation and ranking. Tests provide information that is too late for instructional planning. Formative assessment is needed to ensure a continuous gathering of evidence of student learning. When teachers have access to student achievement data on an ongoing basis, they are willing to make instructional changes in response to these data (PBS & Grunwald Associates, 2011).

New Learning Environments
Bettering use of learning object use, curriculum planning, and assessment requires a tailored infrastructure for educators (Mervis, 2009). Likewise, improving teachers’ use of information is a process that must include, but not be limited to, promoting information skills; instead, teachers benefit from tools designed to help them plan their instructional encounters, integrate appropriate resources, and use appropriate and effective assessment to them with tailored information that allows them increase their focus on students.

Connecting instruction and digital resources to 21st century skills and standards. Teachers’ roles have changed as high stakes accountability has become much more a part of a teachers daily instruction (Valli & Buese, 2007). In addition, education and workplace leaders are calling for the integration of “21st Century Skills” and “World-Class standards” in our nation’s
schools (American Association of School Librarians [AASL], 2007; Hamilton, 2008; National Academy of Education [NAE], 2009b; Partnership for 21st Century Skills [P21], 2007). Although not clearly defined, these desired student outcomes embody multiple literacies (e.g., textual, visual, numerical, information), complex thinking, deep conceptual understanding, and analytical decision-making (Office of Educational Technology, 2010; Project Tomorrow, 2010b). The National Science Board (2010) and National Research Council (2011) affirmed that scientific understanding is dependent on the interplay of broad cognitive skills and domain-specific learning.

The disconnect between curriculum and learning environments can be starkly observed in contemporary science learning. Existing curricula give many disconnected topics equal priority, thereby losing important unifying themes and principles of science in favor of concept coverage. Students’ lack of content knowledge is partly due to the weakness of current science curriculum materials, which often aim to introduce many different science topics in outdated modes, rather than treating a few concepts in depth in exciting interactive formats (Board on Science Education, 2010; Vockley, 2007). As a result, many students do not become engaged in the content area and do not retain core concepts from one school year to the next (Duschl, Shouse, & Schweingruber, 2008).

**Time.** In just about every study of teachers' use of technology integration and instructional innovation, the issue of time is cited. Teachers average about 10 hours of planning a week (Ball, Knobloch, & Hoop, 2007; Perrault, 2007a), and the majority of the time they spend online looking for curriculum materials occurs during the school day (Mardis, 2009a). Teachers have said that they do not have enough time to incorporate digital resources into instruction because of the time it takes to locate learning objects and preview websites, and the hours it would take to define and engage in professional development to upgrade their skills (Cuban, Kirkpatrick & Peck, 2001; Davis & Krajcik, 2005; Perrault, 2007b).

It is very likely that time is also a matter of confidence and perceived value. Teachers are unlikely to invest time in activities in which they do not feel confident (Recker, et al., 2007) and in which they do not see a benefit (van den Berg, 2002). Therefore, to change teachers’ behavior in digital resource use and curriculum planning, the tool would need to be easy to use and demonstrate immediate differences in student time on task and achievement (Maull, et al., 2010a).

**Possible Solutions to Integration and Planning Challenges**

In contrast to the many issues relating to teachers' location and use of digital learning objects, The 2011 Horizon Report suggested that educators' management of the overwhelming abundance of teaching and learning resources easily accessible through the Internet pushes educators to look at ways to best serve learners and to revisit roles in sense-making, coaching and professional learning (Johnson, et al, 2011). In order for this trend to be realized,

[Technology must be used comprehensively and purposefully to create robust education support systems for standards and assessments, curriculum and instruction, professional development and professional learning communities, and administration. ... Technology makes it possible for states and school districts to update their standards more frequently to reflect changing demands. Web sites and collaborative tools, for example, make it easy for states and school districts to compare standards and curriculum and to work together to infuse them with 21st century skills. And they make it easy for teachers to access and use standards, rubrics, exemplary student work and classroom lessons, among other resources, to improve teaching and learning. (Vockley, 2007, p. 13)]

Solutions are being investigated that encompass new metadata schema, paradata approaches, and integrated planning, management, and assessment systems.

**Lightweight Metadata Schema**

Metadata schema for learning objects is an extension of classification and organization schemes used for physical media such as books. In addition to reflecting descriptive information about the object, metadata have been used to reflect the characteristics of effective learning objects. At a glance, teachers want to know if a digital resource is:

1. Motivating to the learner;
2. Controlled by the learner;
3. Designed with appropriate media, colors, text size and sophistication, and placement of information;
4. Containing clearly stated and enough questions and activities;

However, capturing these characteristics in metadata that remain flexible enough to adapt to changing educator needs is a challenge and has encouraged fresh looks at resource description approaches.

**Learning Resources Metadata Initiative.** The Learning Resources Metadata Initiative (LRMI) [http://wiki.creativecommons.org/LRMI], launched in June 2011, is a collaborative effort of the Association of Educational Publishers (AEP), a nonprofit group for educational content developers, and Creative Commons, a nonprofit that promotes the legal reuse of copyrighted intellectual and artistic works. It is funded by the William and Flora Hewlett Foundation and the Bill & Melinda Gates Foundation.

Typically, after states adopt new standards, commercial publishers and experts develop assessments, instructional materials, supports, and resources. However, school administrators want teachers to supplement, or even supplant, the resources they use with free, high quality learning objects and metadata schema have evolved to enable access to these resources. Creative Commons is leading the development of technical specifications for vocabularies appropriate for lightweight metadata schema and that will be based, at a minimum, on the Common Core State Standards.

Still in its early stages, LRMI have convened a technical working group to compile best practices in vocabulary development. Common vocabulary will enhance the findability of objects across applications and repositories.

**Learning Application Readiness framework.** The National Science Digital Library (NSDL) of the United States has developed a Learning Application Readiness (LAR) framework to be used in learning management systems, educational resource registries, and customized curriculum services. The LAR concept refers to how closely resources, collections, and their related metadata are aligned to educational goals, curriculum, or professional development needs of users, and how readily those resources and collections can be embedded in tools and services that educators and students use (Sumner, 2010). A learning application generally uses frameworks that characterize resources by subject, education level, resource type, audience, and educational standards, among other elements. The goal of LAR is to maximize description in a minimum number of fields, thereby creating a “lightweight” description structure that will enable easy transportation of resource metadata without substantial requirements for crosswalking and controlled vocabulary (Ginger & Goger, 2011).

**Paradata Schema**

While streamlined metadata can enhance the portability of learning objects, paradata has the potential to take the place of an unwieldy number of fields with user and system provided feedback that can increase meaningful use.

The term “paradata” developed to describe a large class data elements that are produced during the process of survey data collection such as respondents’ marginalia and submission time stamps. Paradata serves a different function than metadata. From the standpoint of educational digital libraries and learning objects, paradata are the data about how the object is used, versus metadata that focuses on what the learning object is. In addition to helping users readily identify useful resources, this information can also be mined for indicators of quality that then can be applied to retrieval algorithms (Bethard, et al, 2009; Leibbrandt, et al, 2010).

Paradata adds an important layer to the description of learning objects because it aids implementation and builds educator community through the exchange of implementation experiences. Two related efforts are promoting the development and use of paradata to educational digital library developers. In a study led by Maull (2010a), teachers demonstrated social sharing behaviors and a willingness to use interactive digital materials with peer support. As relief from the isolated nature of teaching, online communities offer teachers venues to exchange resources, obtain information or advice, and socialize with other teachers (PBS & Grunwald, 2011). Because curricula, lesson plans, textbooks, online resources and other formats are information networks shaped by social interrelationships (Perrault, 2007b), teachers have a
unique need for a collaborative network that allows users to contribute knowledge that provides relationships and context to resources and users (Maull, Saldivar, & Sumner, 2010b).

**The Learning Registry.** Debuting on November 7, 2011, the federal Learning Registry (<http://www.learningregistry.org/> is a collaboration among federal agencies including the U.S. Department of Defense, the U.S. Department of Education, the Institute for Museum and Library Services (IMLS), the National Science Foundation (NSF), and the White House Office of Science and Technology to make digital learning resources easier to find, access and integrate into educational environments. It was developed in response to a lack of a central access point to educational materials development with federal support. Because the locations of resources will be decentralized, the Learning Registry makes use of lightweight metadata that allow creators to retain their identities and accompanied by robust paradata to encourage use (Klo & Bienkowski, 2011). The Learning Registry is leveraging existing and emerging technologies so that multiple search engines can expose learning resources with the intent that this networked environment will enable digital resources in multiple applications, open educational resource collections, mobile devices, and online learning platforms, and digital libraries (Jesukiewicz, & Rehak, 2011).

**Information for Learning Object eXchange.** The Information for Learning Object eXchange (ILOX) has been developed for the European Learning Resource Exchange (LRE) a federated repository for learning objects that allows for a range of international educational uses, metadata formats, and authentication processes. ILOX wraps metadata and paradata-like ratings, user feedback, and number of downloads, into a package that can be easily exchanged between systems and clearly identify access rights and ownership (Massart, et al, 2010).

**Integrated Tools for Curriculum Planning, Resource Management, Data Generation, and Assessment**

In the U.S., the national Common Core standards movement is generating a common curriculum framework to be used by all states. This large national effort is prompting digital library developers to consider new applications that support teachers’ use of the new standards. These new applications bring together metadata, paradata, and curated collections in ways that enable consistent instructional products with little reliance on educators’ information skills. Instructional resources and products of consistent quality are a core component of effective instruction and strong student learning; consistent instructional products can more easily be built in a system based on a shared purpose and including multiple sources of innovation in the process (Davis & Krajcik, 2005; Morris, & Hiebert, 2011).

**Curriculum Customization Service.** The Curriculum Customization Service (CCS) (<https://wiki.ucar.edu/display/dlsccs/HOME>) is an integrated platform for middle and high school science teachers to access interactive media resources, customize curriculum, and share tools and resources with other educators in their school districts. CCS is designed to promote purposeful planning and to support information management and sharing. CCS provides teachers a personal workspace and tools to customize selected materials to address key concepts. It also creates community by linking teachers who other teachers who have used particular resource. Teachers are able to share meaningful context-of-use feedback with one another seamlessly (Sumner & DeVaul, 2009).

Along with the University of Colorado-Boulder, the University Corporation for Atmospheric Research (UCAR), the National Science Digital Library (NSDL), Digital Library for Earth System Education (DLESE), and the American Geological Institute, an advisory board of teachers from the Denver Public School (DPS) district participated in the CCS design process and customized the tool to their teachers’ workflow (National Science Foundation [NSF], 2010). To date, CCS has demonstrated remarkable success. In the 2009-2010 academic year, CCS was released in a field trial to all middle and high school science teachers in DPS. DPS is a racially and socioeconomically diverse large urban school district, with approximately 75,000 students, of which a large majority represent minority groups. Preliminary results suggested that CCS is a promising and scalable model for embedding educational digital libraries into teaching practices and planning (Saldivar, 2011).
Brokers of Expertise. In an effort to promote teacher community, showcase best practices, and enable teacher access to high quality learning resources aligned to Common Core and state standards, the state of California established the Brokers of Expertise (BoE) project <http://www.myboe.org/>. BoE also allows self-publication of individual teaching resources that could potentially guide others in classroom lessons and encourages educators willing to share their knowledge to contribute to paradata associated with resources.

Like CCS, BoE includes tools that allow teachers and administrators to monitor progress through rigorous assessments and access to a variety of effective short cycle tests proven in other locations.

Essential Conditions
In order for schools to take advantage of these innovative developments for educational digital libraries and respond to the challenges teachers face in information use and curriculum planning in a digital environment, essential conditions present in schools must be acknowledged.

Cost- and Agenda-Neutral Resources
Teachers look for ways to engage their students by finding and using, learning units, vocabulary and content activities. Having a large number of high-quality, free materials is vital to teachers. However, schools are often committed to products produced by commercial organizations that are fee-based. For teachers in low income schools, online resources may be the only ones available (Barker, 2010).

State laws, many of which have been rewritten to include digital content as an acceptable use of state textbook funding, will serve as catalysts that spur the transition to digital textbooks. Already, major advancements in-and support for–digital textbooks have occurred in Indiana, Virginia, West Virginia, California, and Texas (State Educational Technology Directors Association [SETDA], 2010). Florida has passed Senate Bill 2120 mandating entirely digital textbooks by 2015. However, digital textbooks are not necessarily spurring a move to open digital content. Rather, textbook publishers are still controlling content and even populating supplementary materials lists with their fee-based content (Mickey & Meaney, 2010).

A dimension to fee-based resources is that they reflect the commercial or philosophical positions of the creators (Roseman, Kulm, & Shuttleworth, 2001). The commoditization of content poses a particular challenge to the ongoing development of curated curriculum planning systems. Any links that the developers of tools or content must be acknowledged in order for educators to make knowledgeable decisions about possible biases or perspectives present in the resources they use in their classrooms (Rosenbaum, 2011). True savings and innovation without quality compromise can only come from a move toward greater use of digital learning resources (Duschl, Shouse, & Schweingruber, 2008).

On Site Support
The use of digital resources and tools can add to the preparation required for teaching because teachers need support in gaining the skills they need to use technology easily (Saptey & Relf, 2010). A high number of teachers in Perrault’s (2007a) study reported they were not comfortable with the online resources that had been developed with a specific intent to support teaching and learning. Almost half of the teachers did not use these time-saving resources despite a strong influence of lack of time cited for the non-use of materials. Typical K-12 curriculum materials support teaching strategies for student learning but not teacher learning (Davis & Krajičík, 2005) but where teacher technology learning support is available, instructional innovation thrives (Windschitl & Sahl, 2002).

Principals. School administrators are essential, but often overlooked, players in technology integration. District administrators and principals provide the systemic momentum for technology-mediated change by facilitating a climate of innovation (National Center for Education Statistics [NCES], 2011b); prioritizing expenditures for technology acquisition and maintenance (Blumenfeld, Fishman, Krajičík, Marx, & Soloway, 2000); providing access to professional development; by ensuring broadband availability and use policy; and by scheduling time for professional learning. However, “District administrators are also concerned that they do not have the staff to identify or create digital resources that meet their standards” (Project Tomorrow, 2010,
p. 15). If administrators do not see how a technology-based change positively, directly, and quickly affects student learning, they are not likely to support it (Owen & Demb, 2004; Perrault, 2007b).

Administrators view digital resources as essential elements in the future of schools. Moreover, administrators recognize that both online learning components (Project Tomorrow & Pasco Scientific, 2008), open content (Duschl, Shouse, & Schweingruber, 2008) will soon become standard parts of the K-12 learning experience. School administrators have expressed interest in a system that integrates high quality resources with lesson planning, course tracking, and accountability measures (Mardis & Hoffman, 2007; Maull, Saldivar, & Sumner, 2010; Maull, Saldivar, & Sumner, 2011).

**Teacher librarians.** However, some school administrators are eliminating one important element of onsite support: teacher librarians. A growing number of these school-based information professionals are eliminated with no replacement. Numerous studies have demonstrated the key role of the school librarian in support of technology-mediated change (Everhart, Mardis, & Johnston, 2011). Unfortunately, few principals recognize that school librarians support teachers’ use of digital resources (Hartzell, 2002). Research has shown that a school’s technology planning, leadership, professional development, curriculum alignment, technology use, and perceptions of technology’s effect on learning could all be attributed to school administrators’ opinions (Anderson & Dexter, 2005; Kowch, 2009; Owen & Demb, 2004).

**Adequate Bandwidth**

Use of learning objects such as video clips can be problematic for teachers because skipping, pausing or buffering which indicates that the device and/or infrastructure do not have the ability to handle the teachers’ increasing Internet activity (Mardis, 2009b). About 78% of teachers have difficulties at least part of the time, and up to a quarter consistently have problems (PBS & Grunwald Associates, 2011). The majority of these difficulties are due to inadequate bandwidth.

In many schools, bandwidth capacity dictates how teachers integrate the Internet into their classrooms. While 99% of public schools in the United States report having Internet access, classroom connections are less frequent (National Center for Education Statistics [NCES], 2011c). Even if classroom access is available, many building-level policies impede the integration of the Internet into teaching and learning.

Many (over 80%) of school connections were not meeting school officials’ needs because they were overloaded and poorly managed, leading to slow performance or restricted use (Federal Communications Commission [FCC], 2010b). For example, in a study done in Michigan, education officials reported having to develop and enforce bandwidth use policies that limited video streaming and other high-capacity uses; the Michigan finding was confirmed by the overwhelming majority (n=934 or 89%) of a nationwide survey of school officials (N=1060) that reported that their networks were too slow to support video streaming. This factor influenced teachers’ use of the Internet in their classrooms as much as their skills with technology integration (Mardis, 2009b).

**Respect for Professional Expertise**

In his seminal essay, “The Question of Technology,” Martin Heidegger (1977) justified the notion of a curation tool that enables the collection, aggregation, analysis, planning, and transportation of metadata, paradata, and student achievement data. He explained that once technology was used to create more resources than were manageable, the resources would need expert input to be organized, or curated, into focused collections. The tools explored above provide Heidegger’s mandate for curation.

However, Michel Foucault raised cautions that could apply to the use of such a tool. As a physical instantiation of state power, the state-mandated or state-supported curriculum-planning tools are a form of architecture that reflects the predominating priorities of the state. With design of the Panopticon, Jeremy Bentham created a prison structure feature that enabled surveillance and thus discovery of activity that the state deemed unacceptable. Foucault (1975) extended Bentham’s idea of the panopticon to a critique of architecture of the period; one could extend it further to the architecture of curriculum planning tool and the transparency enabled by paradata transportation and data mining promote the detection of prohibited, ineffective, or discouraged acts by teachers. In a way, the shift to transparent curriculum planning tools is the only economical
choice for financially beleaguered education agencies because the preventative power of observation is significantly less expensive than the cost of enforcement (Foucault, 1977).

Because learning and thus, to a great extent, teaching is a change process, information is used to contribute to the creation of new knowledge (Bransford, Brown, & Cocking, 2000). In contemporary education, governed by ideas of consistency and accountability, this larger idea of knowledge construction as a goal for K-12 education is obscured by more immediate ideas of “college readiness” and “workplace readiness.” The idea of readiness implies that a failure to be ready is possible and that readiness is something that requires consistent application, structure, and enforcement. In other words, those who are workplace ready have more power than those who are not and educators in schools who produce many workplace ready students are entitled to rewards beyond those available to educators at schools that do not produce as many workplace ready students. For these reasons, it is not unforeseeable that tools that enhance resource use and planning could inadvertently contribute to increased teacher monitoring.

**Conclusion**

This paper has integrated an extensive body of research and policy to provide an overview of challenges and solutions that are changing the ways educators interact with digital learning resources. To build and study educational digital libraries, it is imperative that researchers and developers be aware of trends driving the new digital lives of teachers. For a variety of well-established and long-standing reasons, teachers continue to struggle with using digital resources to enhance learning, provide workplace readiness, meet accountability measures, provide classroom differentiation, adhere to curriculum standards, and foster 21st Century skills, in an ever-diminishing time frame. These challenges are increasing the need for high quality, appropriate resources to be pushed to teachers along with the feedback and usage patterns of other educators.

In acknowledgment of these challenges, the federal agencies have issued three directives:

1. Create an “integrated approach for capturing, aggregating, mining, and sharing content ... for multiple purposes ... across many learning platforms” (Office of Educational Technology, 2010, p. 78);
2. “Take steps to create a pool of digital educational resources” (Federal Communications Commission [FCC], 2010a, p. 246); and
3. “[I]nformation created or commissioned by the Government for educational use by teachers or students and made available online should clearly demarcate the public’s right to use, modify, and distribute the information” (Orszag, 2009, p. 8).

In response, emerging STEM digital library projects are generating metadata and paradata schema to deploy in the context of curated collections of digital resources and tools designed to meet these national commands. Given the other currents in schools presented in this paper, it is just a matter of time before all digital collections encompass curation tools. However, the impact of these changes to learning resources access must take into account essential conditions for local implementation and sustained use. Changes in the digital lives of teachers also offer myriad opportunities for research into challenges and solutions.

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