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CROSS & JOFTUS

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Abstract

This review of literature on behalf of the Smithsonian Center for Education Museum Studies (SCEMS) serves to inform the work of the *Digital Learning Resources Project* (DLRP) research team as they conduct their investigation with teacher groups and develop prototypes of digital tools for lesson-building. The open question discussed in this review is how museums in general – and Smithsonian in particular – will adapt to and remain relevant in the digital age with search, social, mobile components and instructional tools for learning. In this study, we review the literature on web enablement paradigms, new pedagogies, teacher roles, and the relationships between museums and their education audience in the digital era. Other questions relevant to the research and evaluation being conducted for the *Digital Learning Resources Project* (DLRP) are discussed through the literature as well: 1) How can SCEMS help teachers find and use the resources they need more easily on the smithsonianeducation.org site? and 2) Institutionally, how can SCEMS ensure that its collection and other Smithsonian resources get maximum exposure on the web within other content repositories and search engines? The review offers recommendations for prototype design and partnership development based on four themes raised in the literature: 1) optimizing the search engine, interfacing, and tagging to provide higher-yield search results for teacher and student audiences; 2) expanding partnerships and data sharing; 3) meeting teacher needs; and 4) exploring instructional tools, web trends, and devices which bear consideration for the next generation of the SCEMS site.

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Special Thanks to Steve Midgley who provided valuable consultation on this document. Mr. Midgley served as Deputy Director for Education Technology for the U.S. Department of Education and leader of the Learning Registry Initiative and author of the Education Broadband Plan while serving as Director of Education for the FCC between 2009 and 2011. He now works

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Introduction

Digital Learning for a New Era

The Internet and web together have sparked a revolution in our society and have struck the education community with particular force. The current funding crisis in education, combined with rapid advances in technology – in communications and content sharing – are challenging our relationships with information and learning and positioning us on the threshold of a new era (Kratz & Merritt, 2011). What has happened for formal education and schooling is also affecting museums. The authors of the Smithsonian Institution's Strategic Plan also described us as "on the verge of a new era" where knowledge is expanding faster than we can calculate, and long-held authoritative sources are competing for the attention of our teachers and students against what is most immediate and accessible.

> *We …live in a time when technology is changing before our eyes. Delivery channels that seemed like science fiction a decade ago now live on every desktop. Think about the potential for the Smithsonian, holder of remarkable and scientifically important objects and home to world-class expertise, to expand knowledge and add meaning to our world.*
>
> - Inspiring Generations Through Knowledge and Discovery: Smithsonian Institution Strategic Plan; Fiscal Years 2010-2015, p. 2

This potential is a powerful one, but one that is easily lost if we are not attuned to the ever-changing world around us, and in the case of K-12 education, if we are not attuned to the realities of our nation's teachers and students. The open question is how museums will adapt to and remain relevant in the digital age with search, social, mobile components and instructional tools for learning. In this study, we review the literature on web enablement paradigms, new pedagogies, teacher roles, and the relationships between museums and their education audience and partners in the digital era.

The Smithsonian Institution is the world's largest museum and research complex, with vast collections and expertise in history, science, the arts and culture. Its expanding digital presence represents its commitment to broadening access to people everywhere. Focusing on digital outreach to educators and students, the Smithsonian Center for Education and Museum Studies (SCEMS) launched www.smithsonianeducation.org, whose main feature is an indexed collection of learning resources that are aligned to all state, national, and now, Common Core standards of learning. The site's 2,000 record-collection of resources such as of lesson plans, video and audio clips, and interactive instructional games is one of several Smithsonian finding tools such as its Collections Search Center (7.89 million catalogue records, 779,100 images), Other Smithsonian websites also offer digital collections and tools for specific subjects and collections; the Center's goal, unique at the Smithsonian, is to provide access to all Smithsonian resources for classroom learning in the most useful and relevant ways. The impetus for the Digital Learning Resources Project was to help the organization better understand educational uses of Smithsonian digital resources and to provide a roadmap for future digital development. The specific research objectives focus on educators' ability to identify, analyze, and extract digital content, with the ultimate goal of enabling all users to achieve their own personal learning objectives through the Smithsonian's resources.

Evaluations of smithsonianeducation.org over the last nine years have delivered a variety of perspectives on the effectiveness of the SCEMS site in growing a user base in the education

community and increasing the exposure of Smithsonian's digital learning assets. User surveys have revealed that teachers are coming to the site and accessing content, but not returning to the site regularly. Teacher feedback in earlier studies has indicated that teachers are choosing to do time-consuming adaptations to the materials, which may discourage repeat visits (Ito, Langa et al., 2010). A review of the site's general analytics shows a fairly limited number of page views per visit beyond an initial entry. This can be interpreted in any number of ways. It could mean that users are finding what they need, quickly assessing its value, and extracting it for classroom use, or it could mean that users are not finding what they need and are going elsewhere. The ability to capture paradata, or metadata on how resources are used by teachers visiting the SCEMS site, along with targeted usability research with teachers, is necessary for gaining a fuller picture of what is needed.

Smithsonian digital resources curated by SCEMS are getting some exposure beyond the smithsonianeducation.org site through aggregator sites that have ingested the collection (such as Thinkfinity and Brokers of Expertise); however, with the rapid increase of open educational resource portals in recent years, and the call from the federal government to increase student access to these types of resources, a more aggressive approach to outreach and partnership bears consideration (SRI International, 2012).

Structure of Report

This report is the first volume of several that will support and document the work of the *Digital Learning Resources Project,* which includes an environmental scan, user testing with teachers in California, prototype development, and testing with a national sample of teachers convened in Washington, D.C. As a first step, an exploration of the literature related to online learning, museums and digital learning, and website architecture has been undertaken, drawing from the fields of museum studies, pedagogical and learning theory, and educational technology.

Since the questions being explored in the *Digital Learning Resources Project* are relatively new ones within the museum world (2-3 years) and the academic review cycle of peer-reviewed journals is often 9 months to a year in length, finding current peer-reviewed research is challenging. To address this gap, this literature review contains a list of supplemental reading resources in the section called "For Further Reading." This reading list includes blogs, news articles, online papers, and other non-traditional sources. The intent is to address the need for both traditional, peer-reviewed research and sources that are more generative and current.

Ultimately, the principal aim of this review is to serve as the foundation of the work of the research team as they conduct their investigation with teacher groups and develop prototypes of digital lesson-building tools.

A full exploration of the opportunities needs to address several questions. How do instructors engage with technology? What do we know about teacher interactions with museum digital content? How can large digital collections help or hinder the accessibility of museum resources? And finally: How are current trends and tools on the digital landscape impacting museums, museum educators, and schools?

Classrooms and Museums

Understanding what teachers and learners require in this new era is not as difficult as one might imagine. There is, in fact, a good deal of consensus around standards for teaching and learning, and the core set of skills needed for academic success in the 21st century. At present, 45 states and 3 territories have adopted our nation's Common Core State Standards, and school systems in these states are aligning or have aligned their curricula to ensure that America's students acquire the necessary skills to remain competitive in the global marketplace. The Partnership for 21st Century Skills offers a "Framework for 21st Century Learning"[1] that describes the key skills for tomorrow:

- critical thinking
- synthesis of information
- ability to apply lessons to the real world
- innovation and creativity
- teamwork and collaboration

National groups supporting science education are playing a key role in supporting these reforms. The Next Generation Science Standards[2] (released in 2012) provide a framework for how teachers should build learning experiences that:

- foster connections
- create coherence (i.e., coherence of core explanatory ideas or questions that students use to make sense of the world around them)
- are multidisciplinary
- are relevant to students' lives

Museum educators have been engaging students in these ways in museums for decades by providing hands-on activities, problem-solving role-playing activities, and collaborative exploration of artifacts, artworks, and science exhibits (Kratz & Merritt, 2011). Museums are uniquely positioned to help usher in this new era if they are prepared to create a greater online presence by exposing collections to broader audiences..

While there have been many studies over the years of how young people experience learning in museums, there is limited research on the teaching and learning that occurs remotely in classrooms with digital museum resources. This learning is categorized as "informal learning" in the literature, or as learning that occurs outside of school through community programs or museums themselves. Informal learning experiences that incorporate web technology, such as social media, are growing at a rapid pace and are considered by organizations like the National Science Foundation (NSF) to be a natural bridge to school learning (Bull, Thompson, et al., 2008).

We can draw somewhat from the existing body of research on digital learning in general and from a few studies of the use of museum resources by teachers. These studies provide a valuable framework for designing tools that improve teaching and learning experiences with digital museum assets, yet this is an area in need of further study.

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[1] Frameworks available at: http://www.p21.org/overview/skills-framework

[2] http://www.nextgenscience.org/about-standards-development-process

A recent U.S. Department of Education evaluation of online learning practices (Means, et al., 2010) explored the dimensions of effective online learning experiences, categorizing the ways that learners acquire knowledge using digital assets:

- **Expository instruction.** Digital devices transmit knowledge.

- **Active learning.** The learner builds knowledge through inquiry-based manipulation of digital artifacts such as online drills, simulations, games, or microworlds.

- **Interactive learning.** The learner builds knowledge through inquiry-based collaborative interaction with other learners. Teachers become co-learners and act as facilitators (Means et al., p. 3).

Each of these categories represents a different level of learner control over the information being consumed. In the more traditional expository instruction approach, the digital device is transmitting the knowledge (i.e., through passive consumption). In the active learning category, the learner is interacting with the content through manipulation, exploration, and use of tools. In the interactive learning category, the learner works with other students to collaboratively build knowledge. While these categories apply to traditional face-to-face instructional design, the study found that technology and the use of digital tools and content greatly enhances learners' ability to access knowledge.

An and Reigeluth (2011-12) studied the degree to which teachers have integrated technology into their learner-centered instruction. Research on the effectiveness of the learner-centered model is continuing to grow, but An and Reigeluth cite several recent research studies pointing to the evidence that students are more motivated to learn and that they achieve deeper levels of understanding and engagement in learner-centered environments. Their study of 126 teachers found that teachers of learner-centered classrooms had a positive view of technology as a critical part of students' learning and were willing to take the time to learn to use new technologies to improve their teaching. Many of the teachers were found, however, to be using technologies for "low-level" tasks such as email and drill and practice rather than for more exploratory or problem-based learning. Teachers cite the major barriers to better technology integration as being: 1) lack of technology, 2) lack of time, 3) assessments, and 4) lack of knowledge and training.

Are the assets that museums provide to educators presented along with the proper tools to enable students to fully engage with the assets on more interactive levels? Two recent museum studies have explored the degree to which their online resources have catalyzed deeper learning practices in the classroom. The results have been mixed. A study of digital museum content use (Saiki, 2010) examined the level of interactivity on 153 museum websites in order to better understand whether or not museums had begun to utilize their images and content in ways that engage learners on an active, rather than passive, level. The researchers contend that museums tend to focus on "object-based learning." While this kind of learning is valuable, the ways in which museums represent and interpret objects on their websites often inhibits rather than engages the user. The evaluation rated website content on Laurillard's five-level framework (Laurillard, 2002) of "narrative," "interactive," "communicative," "adaptive," and "productive."

The framework is based on Bloom's taxonomy of cognitive stages of learning (Bloom, Engelhart et al., 1956). Sites that fall into the narrative level are those that deliver content that is consumable only "as is" by the user. The user passively receives the information provided, which requires the lowest cognitive engagement.

The interactive level includes sites that encourage exploration through links to other pages and online tours of the museum, but content cannot be changed or adapted in any way. The third, or communicative, level allows users to share and post ideas, comments, and ratings of materials.

The adaptive level allows users to discuss their interpretation of objects and receive direct feedback from an instructor. The productive level incorporates tools that enable the user to manipulate the object and discuss and demonstrate their understanding of the content to the teacher—by writing a story, for example, or creating a similar object. This final stage requires the highest level of intellectual engagement from the viewer and ensures greater long-term understanding and retention of the concepts presented. This is a useful lens for viewing Smithsonian content and web tools for the new era. Can it be said that the assets chosen and provided to educators, along with the proper tools to enable students to fully engage with them, qualify as being on the "productive" level?

Of the 153 websites evaluated using this framework, 45.1% were assessed at the narrative level, 33.3% were assessed at the interactive level, 35.9% were communicative, 24.8% had adaptive features, and 22.2% had productive features. Researchers conclude that while museum sites are making great strides in becoming more interactive, communicative, and productive, nearly half remain at the narrative level.

Borun, Schaller, Chambers and Allison-Bunnell (2010) used Kolb's experiential learning theory (1984) to test the role of learning style, age, and gender in the preferences of online and other multimedia activities being developed at the Franklin Institute in Philadelphia. The participants were (154) middle-school students in a laboratory study and an online survey of adults (2,593). The students and adults were given Kolb's learning inventory to map their learning styles to four types – practical, creative, social, and intellectual. They were then given a series of online activities to determine the match between their learning styles and their preferences for particular experiences. They found the most popular (37%) of the four learning styles among both children and adults to be the "practical" (likes to solve problems and find solutions). The "creative" (enjoys brainstorming and open-ended exploration) was the least frequent (8%).

These findings, if valid, would have strong implications for the science community, in which open-ended, "no right answers" exploration is necessary for discovery. Those with a practical style would respond more favorably to structured, goal-oriented activities (such as puzzles or quests), indicating, perhaps, a need to offer a balance between guided, structured exploration and open-ended activities. Other studies on learning styles have debunked this notion, however, and found no strong evidence that tailoring learning experiences to learning styles, as measured by learning-style inventories, has an effect (positive or negative) on academic outcomes (Pashler, McDaniel, et al., 2008).

Museum research for the last five years, both in the U.S. and abroad, reveals that teachers seek lesson plans and ideas that are related to concepts or big ideas, are closely linked to both state and national standards, are interdisciplinary, do not require a museum visit, and have educational value. They are looking for museum sites that offer simple designs and language and easy-to-search databases as well as materials that are easy to download and free from copyright issues (Buffington, 2007; Kelly & Breault, 2007). Museum studies suggest that providing teachers with outlines, teaching ideas, suggestions, and Internet links is more valuable than trying to design a "one-size fits all" lesson plan. These studies also show that most teachers do not use lesson plans in their entirety. Instead, teachers tend to pick and choose the parts of the lesson plan that they like and find most useful (Horwitz & Intemann, 2007; Leftwich & Bazeley, 2009). Research regarding how teachers analyze the content they find to determine its value and relevance is extremely limited. Available studies have focused on teacher preferences and behaviors rather than the analytic basis for those behaviors.

Studies show that once nce content is e taken from a site, ("extracted" in the terminology of this project)teachers use the content in a variety of ways—they need content that can serve them at any point in the learning cycle, from preparing a lesson at home, to pre-teaching, to delivering it in class for individual student interaction or group work. Finally, they use it for reflection and assessment. Teachers favor high-quality images to form the foundation of lessons that they build. The object itself, just like in a museum, takes center stage. How that object is interpreted begins with how it is annotated on the site, but ends with how the teacher and the students *use* it and analyze it in a given context.(Buffington, 2007; Leftwich & Bazeley, 2009).

These findings suggest that showcasing high-quality images and providing flexible content, tools, and suggestions for teachers would be a better investment of time and resources than in the development of more fully designed, less flexible lesson plans. Does this mean that there is no place for the existing collection of high-quality lesson plans on the site? This question, as well as the question of what types of tools teachers would be most likely to use if they had them, are worth further exploration. The question is part of the research planned by the DLRP.

The Importance of a Good Search

If teachers are looking for sites that offer simple designs and easy-to-search databases as the above findings point out, the importance of a good search must be examined as part of the discussion. Exciting and engaging digital resources are not worth much to teachers if they can't find them.

Among the chief principles of good usability is to provide a multifaceted approach by connecting content to information architecture in sensible ways. The research and evaluation being conducted for the *Digital Learning Resources Project* asks two important questions:

1) How can we help teachers find the resources they need more easily on the Smithsonian Education site?
2) Institutionally, how can we ensure that the SCEMS collection and other Smithsonian resources get maximum exposure on the web within other content repositories and

search engines?

Studies examining the usability issues of museum websites have pointed out a number of common problems with website designs that impede users' abilities to effectively search and find what they were looking for, which may be applicable to DLRP evaluation findings (Marty & Twidale, 2004; Masri & Grossman, 2009; Solas, 2010). Literature on shared metadata and open educational resource repository communities is still emerging, but has been supported by recent philanthropic and government efforts, such as the Learning Registry, a joint venture of the U.S. Department of Educational Technology, the Department of Defense, and the Shared Learning Infrastructure (SLI) project, funded by the Gates Foundation.

Connecting Content to Site Architecture

Re-examining museum web content and improving navigational features to optimize searching does not need to be a costly enterprise, but should be done with both internal and external audience needs in mind (Masri & Grossman, 2009). Website users today are searching by taxonomy more than ever before and often entering through a Google search rather than a more intentionally developed "front door" website search. Creating taxonomies to organize content dynamically is becoming more common. Simple tools for content tagging and display, such as Drupal's (CCK) module, have entered the marketplace to make the process more automated. Masri and Grossman describe two types of users to keep in mind when reorganizing website content: hunters and wanderers – those who enter a site to find and retrieve what they want quickly, and those who like to explore. "Provide your hunters with distinct navigational links, but give your wanderers items of interest to pursue." (2009, p. 2). Audience studies with both internal and external audiences are an essential ingredient and can be accomplished with small groups and low-tech exercises such as card-sorting to display viewing preferences or surveys.

Older studies evaluating museum sites (Marty & Twidale, 2004) found that "too much content can frustrate users, making them less willing to spend time with the website." Also, having too many choices, they found, could lead users to "make choices without understanding the consequences" or to "focus on one area at the expense of others" (ibid. p. 5). The same was true for the artistic design and graphical interfaces of their sample sites. They found examples of artistic designs that were more distracting and disorienting than helpful, and graphical interfaces that were difficult to navigate. Finally, Marty and Twidale found that exploratory interfaces proved confounding for users who were looking for something specific, but that these same interfaces were more geared toward the user who wanted to take the time to explore the collection at a leisurely pace. Sites intended to encourage exploration can, if poorly designed, result in bad searches or "dead ends," thereby discouraging repeat visits.

More recently, a joint venture of the Walker Art Center and the Minneapolis Museum of Art examined two interface designs and tested user search success rates within their "ArtsConnectEd" site (Solas, 2010). ACE1, the original interface for the site, was created in the mid 1990s. It provided access to digital collections from both museums and allowed users to search works of art from both institutions, annotate the works, and add them to their own collections. The ACE1 search interface was very basic, with a simple keyword field and options

to limit by museum. ACE2, the comparison interface, provided subtle differences by emphasizing the browse interface, with keyword as another filter. It included their object metadata as "facets with counts," incorporated spelling prompts and word-stemming capabilities, giving users a way to differentiate between words and meaning (for example, "painting" vs. "painting-the medium"). Their findings indicated clear advantages to the ACE2 interface over ACE1 because it immediately exposed more of the collections to users after a query and resulted in significantly fewer dead-end searches. These interface improvements illustrate the two museums' attempts to make the complexity of the metadata that describes an object more easily interpreted to an outside audience.

When organized for an educator audience, the challenge becomes even greater. Organization of content must be based on established hierarchies and filters for grade level, standard, subject area, etc., while keywords for objects within a museum collection are more ambiguous, causing what some have termed a "semantic gap," leads to unsuccessful searches.

> *Most museums have what Google would kill for: semantic knowledge of their collection. We know who made the object, when, and where, and what it is made of. Limiting users to a simple keyword search denies these organizational concepts that can reveal our collections in their fullness* (Solas, 2010, p. 13).

This means that educators searching through museum websites or digital collections databases may be thwarted in their efforts if sites are not linking a museum's semantic knowledge of objects to a common tagging system and taxonomy that is easily understood by the audience. The extent to which this is happening with the Smithsonian Education site should be further explored.

Promoting Effective Metadata and Visualization

In a "live" museum experience, objects are situated with other related objects. Curators have designed experiences or choices of experiences for the audience, taking a point of view or or trying to impart a message. Museum collection websites, on the other hand, have tended to be either too "heavily authored," or not interpreted at all—digital databases lacking context. Online collections are often categorized in relation to collection-type metadata that describes the object, its location, inventory number, etc.—all more relevant and meaningful to someone with museum training than to a typical visitor, teacher, or student. Social tagging is a way to bridge this gap in online collections and make databases more searchable by their intended audience (Trant & Wyman, 2006). The resulting tags are called "folksonomies." Social tagging was introduced as part of many user-participatory features commensurate with Web 2.0 technologies, facilitated by services such as del.icio.us, introduced in 2003, making the feature easily integrated into most websites (Al-Khalifa & Davis, 2006).

Early studies on the value of folksonomies found evidence that they were offering a number of benefits to both users and museums. A Museum of Modern Art study found that there was substantial variation between curator terminology to describe an object and the terminology of non-professionals. One example found 57 unique terms used to describe one object by volunteers in the study. A British study in the same year reviewed 10 websites, comparing

professional manual tagging, social tagging, and automated term extractors. Their findings showed a stronger correlation between the relevance of professional, manual indexer and folksonomy tags over the automated tagging (Al-Khalifa & Davis, 2006).

Museums can also use social tagging as a way to learn more about their users as well as to help clean up "noisy" metadata. Using a "push" feature to share common tags can help users explore more of the collection as well (Trant & Wyman, 2006).

Large digital collections must also consider issues of visualization of content to facilitate the user's ability to analyze the value of their search results. Urban, Twidale and Adamczyk (2010) discuss examples of collection dashboards produced by various museums, libraries, and archives. Choices ofwhether to display all content, whether accompanied by images or not, are made by each institution and weighed for their advantages to the user as well as their advantages to metadata management. Collections that display all resources with or without images offer more on both counts. Dashboards for displaying search facets, counts, and images—along with other relevant data from the collection—help audiences to more easily analyze the relevance of the content to their needs.

Based on these findings, SCEMS would benefit from considering the integration of social tagging tools or folksonomies into the site to facilitate better search results as well as user interaction. Also recommended is an examination of the current visual display of results once a search is completed.

Crowd Sourcing Alignment

Crowd sourcing is not a recent phenomenon; many industries have utilized it as a variant model of testing and feedback generation, in which the testers are largely unidentified and are given voluntary access to the tested item(s). They are also given autonomy in the type and depth of responses they tender. Online crowd sourcing, however, has introduced some unique aspects to this model, which do require some additional inspection and definition as part of this topic. In the April 2012 issue of the *Journal of Information Sciences,* Enrique Estellés and Fernando González gave what has become a widely agreed upon definition of the term "crowd sourcing" through their analysis of 40 other definitions in contemporary use over the last two years:

> *Crowd sourcing is a type of participative online activity in which an individual, an institution, a non-profit organization, or company proposes to a group of individuals of varying knowledge, heterogeneity, and number, via a flexible open call, the voluntary undertaking of a task. The undertaking of the task, of variable complexity and modularity, and in which the crowd should participate bringing their work, money, knowledge and/or experience, always entails mutual benefit. The user will receive the satisfaction of a given type of need, be it economic, social recognition, self-esteem, or the development of individual skills, while the crowd sourcer will obtain and utilize to their advantage that which the user has brought to the venture, whose form will depend on the type of activity undertaken* (p. 9-10).

The validity of crowdsourcing as an instrument to develop reliable, descriptive data or supplementary assertions has been shown to increase proportionately to the volume of subjects allowed to participate in the item analysis and data submission process (Anastasiou & Gupta, 2011). As such, the online venue offers a credible and dynamic distribution and participation environment for collective alignment processing and organizing, as managed via a crowdsourcing based strategy.

As a means of harnessing the collective analysis of thousands of informed consumers, the basic approach of providing direct annotation and assertion input options can be viewed as an entry-point to solicit raw data or to hone existing data-sets associated with resource items and collections in general (Boyang, Appling & Lee-Urban, 2011). With the advent of a single, national framework in the form of the common core state standards, the recent publication of a unified tagging convention for those standards by the Learning Resources Metadata Initiative (www.lrmi.org), and the release of machine-readable Common Core State Standards data structures by Jess & Co. as part of their Achieve Standards Network (http://asn.jesandco.org), crowd sourced data, assertions, and modifications can exponentially increase usability of one's resources within one's own constituency while simultaneously promoting those activities out to many other communities engaged in similar activity.

As a critical consideration for any resource authoring agency, the Smithsonian has been and will continue to be responsible for the efficacy and utility of the metadata associated with its collections, as well as the specific strategic alignment of data to the Common Core State Standards where educators and education in general are seen as a primary audience for those resources. Additionally, consideration should be given to enabling educators access to correlating like resources, identifying, sharing, and/or developing requisite instructional activities and materials, and developing sequences of delivery models that can be documented, researched, and shared as value-added supplements to the original assets referenced within a localized collection.

Distributed Curation and Data Sharing

Sharing open educational resources and building communities of learning are central components of 21st century learning and are being supported by both policy and infrastructure changes at the federal level with the creation of the Learning Registry and the Common Core State Standards (SRI International, 2012). Ensuring broader exposure for SCEMS resources as well as the larger Smithsonian collections database will require increased efforts to form strategic partnerships and share data within these infrastructures and others (Masri & Grossman, 2009; Miller & Wood, 2010; SRI International, 2012). In addition to providing broader exposure of branding and content on the web, these new infrastructures feed back to their parent sites valuable paradata, which enables them to more effectively monitor and evaluate the impact of their digital assets on the education communities they serve.

The concept of sharing machine-readable metadata across large web-enabled repositories originated with initiatives such as Dublin Core (1995) and the more recent W3C Resource Description Framework (1999) specification. The overarching goal has been to provide meaningful descriptions of web resources that are both human readable (semantic) and machine readable (computable). Early efforts to organize learning resources within like data structures

began as early as 2002 with the Institute of Electrical and Electronics Engineers (IEEE)'s, Learning Object Metadata (LOM) Initiative (ltsc.ieee.org/wg12/20020612-Final-LOM-Draft.html), followed more recently by the National Digital Information Infrastructure and Preservation Program (NDIIPP) of the Library of Congress, called "Recollection" in 2010 (Barker, 2005; Miller & Wood, 2010). In order to enable the sharing of metadata within and across domains, such as books and music, initiatives such as schema.org were developed to standardize domain targeted metadata vocabularies. Specific to educational resource identification and tagging, the Learning Resource Metadata Initiative (LRMI) co-led by the Association of Educational Publishers and Creative Commons has devised and released a unifying metadata framework for tagging learning resources to better expose agreed upon descriptive fields such as subject area, grade level, instructional object type, and learning standards (Common Core).

In 2010, the U.S. Department of Education released its Education Technology Plan, *Transforming American Education: Learning Powered by Technology* (see "For Further Reading"), which outlined a vision and strategy for investment and support of education technologies across the K-16 schooling system. Among their series of recommendations was the expansion of student access to open educational resources through shared technology infrastructures. "Create a learning registry, an open-standard registry of all content developed by various agencies throughout the federal government so that states, districts, and schools can access and leverage it and combine it with their own repositories of content."(2010, p. 21) Just one year later, the Learning Registry was launched as a joint venture between the Department of Education and the Department of Defense. The Learning Resource Metadata Initiative (LRMI), a joint venture of the Association of Education Publishers and Creative Commons and funded by the Bill and Melinda Gates Foundation and the William and Flora Hewlett Foundation, was launched in tandem to support the Learning Registry by developing the necessary system for metadata tagging similar to schema.org. OER repositories and state-sponsored websites that wish to expose their standards-aligned content to others on the web now have a mechanism to do so. SCEMS was an early partner in the LRMI project, along with the National Archives, the National Science Digital Library and the Library of Congress. In addition to the Learning Registry, the Gates and Carnegie Foundations began work on another infrastructure initiative called the Shared Learning Infrastructure (SLI) in 2011 that is currently being piloted in five states (NY, CO, IL, MA and NC). This infrastructure is designed to work within states to connect disparate student learning metadata into personalized "Learning Maps" for each child, aligned to the Common Core State Standards[3]. The Council for Chief State School Officers (CCSSO) is administering the pilot.

The benefits to Smithsonian and any museum of sharing metadata within these distributed metadata collaboratives are two-fold. Not only will more Smithsonian content surface within other repositories, but analytics on how those resources were used and annotated (which were viewed the most, favorited, commented on, shared, etc.) can be extracted and fed back to SCEMS for evaluation. The first such user analytics were supplied to SCEMS through the Learning Registry as part of the DLRP and are being incorporated into the research findings.

[3] See presentation at: http://siia.net/index.php?option=com_content&view=article&id=844:siia-webcast-ccssogatescarnegie-shared-learning-infrastructure-summary-a-implications&catid=27:education-overview&Itemid=898

Partnership Development

In addition to the benefits of shared metadata, there are distinct benefits to partnering with community sites and content repository managers through APIs, data feeds and simple licensing terms of use for content. Sites such as Curriki, Connexions, Knewton, HippoCampus and Khan Academy offer wide exposure in the education community and social networks for sharing that further promote the exposure of resources. Partnerships will happen in fairly ubiquitous ways, as resource developers and publishers apply common tagging conventions in their markup language through efforts like LRMI, Charlene Gaynor points out in her article *Metadata - The Big Data of the Educational Resource Community* (2012) the inevitable pooling of information and resources that will occur whether through intentional partnerships or not.

> *Ultimately, LRMI will provide a framework within which a massive array of educational content, ranging from books to videos to lesson plans, can be cataloged, filtered, and delivered. Both commercially published and Open Educational Resource materials will be represented, ensuring that those seeking learning resources will have access to the widest possible range of materials*.[4]

And in fact, it is through intentional consideration that many such agencies have elected to participate in early adoption and implementation of these efforts such as Adaptive Curriculum, BetterLesson, CK-12, Houghton Mifflin Harcourt, Learning.com, LearningStation, McGraw-Hill, National Science Teachers Association, PCI Education, Pearson, and Rosen Publishing. By electing to carefully craft and release similar metadata with direct URL feed back to the originating resources, Smithsonian can draw diverse users from a variety of "partner" locations and present them with not only the original resources desired, but also exemplary instructional customization and organization tools for extended engagement and use.

21st Century Tools and Trends

Staying on top of the technology trends that are influencing schools is critical for museum educators producing digital learning resources and tools. More importantly, perhaps, is the ability to build systems and supports that are flexible enough to accommodate evolving technology advancements. The New Media Consortium is a non-profit organization that dedicates itself to forecasting these trends for educators by issuing their annual "Horizon Report." In 2010, they unveiled a special museum edition, covering the top trends in museum technologies (New Media Consortium, 2010).

Results of their polling and field research of the museum landscape found that high-quality media images (video, audio, augmented reality, and animations) were becoming more and more valuable to audiences. At the same time, digitization and cataloguing were continuing to demand the largest share of their budgets. Museums were beginning to understand, through their own visitor studies, that increasingly their visitors want to connect with collections in places other than the museum itself, using a variety of mobile devices. Finally, open educational

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[4] See: The Association of Educational Publishers (AEP). Friday, August 24, 2012 http://www.ednetinsight.com/news-alerts/voice-from-the-industry/metadata---the-big-data-of-the-educational-resource-community.html

resources were challenging traditional museum conceptions of audience and interpretation.

Challenges facing museums cited in the 2010 report include the failure of many museums to employ comprehensive strategies to keep pace with the digital world, and failure to identify and obtain new funding streams for new media projects that are handled outside of their traditional operating budgets. It was also noted that traditional workflow models of production and curation of content within museums were not in step with the faster-paced world of multimedia networks and production channels where innovation and experimentation often come before careful study and scholarly review, the more traditional museum sequence.

In 2011, the Horizon Report looked at issues at the forefront in wider education circles beyond the museum world. Their findings show that resources and relationships are being made increasingly available to teachers and students through the Internet, ebooks, mobile devices and social media. People expect to be able to work, study and learn whenever and wherever they want, challenging traditional notions of schooling and the workplace. Technologies are also increasingly cloud-based, resulting in a decentralization of IT support beyond the sponsoring institution (The New Media Consortium, 2011).

The Horizon Report tracks the "time to adoption" of new media trends in education each year on three scales: One year or less, 2-3 years, and 4-5 years. In 2010, the report cited mobiles and social media as trends to watch in museums that were within one year or less of adoption. "Museums are poised to use mobiles to create and deliver educational and interpretive experiences, supplying contextual information to engage the visitor and allow them to make connections between objects and ideas, people, places and institutions." (2010, p. 6) At the time of the report, the Diamond Museum in Antwerp, Belgium had just developed a Mobile app that let students discover the history of the city through use of a GPS enabled geolocation game. The Museum of London, more recently developed *Street Museum,* a similar geolocation app. Students choose an identity and are given a map and a crossword puzzle to fill in to solve a mystery about a historic person or place. This type of student-centered app was ahead of its time. Since then, more and more museums have invested in mobile applications for their audiences. Their stories and lessons learned clearly have relevance to SCEMS for future development of digital tools.

Changing Relationships and Social Media

Museum education sites are providers of high-quality materials that, in the right hands, will catalyze high-quality learning experiences for students. Nonetheless, with the changing views on the delivery and consumption of knowledge in our education system and our world, museums must wrestle with similar paradigm shifts in their relationships to their audiences. Where is the proper place for the authoritative voice? The question for museum educators is whether or not they can serve as collaborators in a partnership where the raw material for learning experiences provided by museums online is openly interpreted and shared by students and teachers in new ways through social media. "Social media have proven to be very effective in engaging audiences, not simply connecting them, and provide museums with real opportunities to dialog with audiences in new and substantive conversations and learning experiences." (New Media Consortium, 2010, p. 6)

The perception of the role of the museum audience has evolved during the second half of the 20th century and the beginning of the 21st century in interesting and significant ways (Stylianou-Lambert, 2010). Technology and the Internet are at the center of this disruption. Historically, museums have been viewed as the authoritative voice with messages to convey to passive learners and audiences. Gradually, this paradigm has shifted to a more participatory relationship with museums that Stylianou- Lambert of Cyprus University describes as "Spectacle/Performance Paradigm" of the last decade. This paradigm is characterized by multimedia approaches to audience engagement and interaction with exhibits and the ability for audiences to more freely interpret meaning through their own perspectives and chosen mediums. Most recently, however, a concept of museums as "an open work" is emerging, where the audience acts in partnership with museums to contribute and interpret content that is publicly displayed on museum websites through social media. This movement is not without its critics who are concerned that the academic rigor of professional museum interpretation and curation will be lost in favor of more questionable interpretations for which the museum is still held ultimately responsible. This authority is further challenged by the notion that users may wish to annotate or adapt a museum resource and share it with others.

Content Creation and Sharing

The trend towards utilizing publicly created content through social media such as Facebook, Twitter, YouTube, Flickr and others has caught on in the business world with examples such as news media requesting videos from citizens related to news items and toy companies such as Lego inviting Lego Club members to create new kits. In the K-12 education world, teacher-created lesson plans are being shared in multiple ways within community sites and content repositories such as Thinkfinity, Share My Lesson, Curriki, Brokers of Expertise, and Teachers.net (Bull et al., 2008; Chao, Parker & Fontana, 2011). The popularity of these sites tells us that teachers want to share lessons and belong to such communities, but the literature on how teachers specifically take advantage of social media for their teaching is extremely limited to date.

In the museum education world, social media was recognized fairly early as an opportunity to build communities of practice outside of the museum walls and to more fully engage audiences. Early museum attitudes about social media spaces were more about "build it and they will come" without thorough discussion of audience needs and strategic, sustained relationship building (Russo, 2011). Creating more sustained participation in social media spaces, museums need to develop better understandings of the types of cultural exchanges they wish to elicit. This necessitates a better understanding of their audience.

Smithsonian's Cooper-Hewitt National Design Museum is an early example of a museum that effectively built an online community of practice utilizing an already-established and well-understood audience of teachers. The museum's signature Summer Design Institute (SDI) program was restructured in 2006, after finding that the communities that were fostered during the summer program were too difficult to maintain long-term, the museum created the Education

Resource Center (ERC).[5] ERC integrates standards-based lesson plans, created by teachers related to design and provides a space for community dialogue. "This has reinforced a community of practice of educators in a trusted environment (the museum) with the potential for the outcomes to inform others and provide new knowledge in museum learning" (Russo, Watkins, Kelly & Chan, 2008, p. 27).

The Royal Commission on the Ancient and Historical Monuments of Scotland (RCAHM) experimented with user-generated content with the opening up of a national online database of monuments and heritage information created in 1997 called *Canmore* (Clari & Graham, 2012). *Canmore* includes 300,000 archeological sites, ancient monuments and buildings, maritime and industrial sites. In 2009, the site was updated with Web 2.0 functions and the public was invited to contribute their photographs of historical monuments (uploaded through Flickr). Their aim was to change the relationship with their audience from a provider-consumer model to that of a shared partnership, acknowledging the wealth of (non-professional) knowledge that exists in the country regarding its heritage.

The result of opening up the site to user contribution was profound. Clari and Graham studied the impact of this transformation and recorded 2,800 images and 450 comments uploaded during the time of their study (2012). The site was designed to be "self-policing." Registered users on *MyCanmore* can upload images, comments, review and edit their contributions. Users can also flag inappropriate contributions. User-contributed images are stored separately from original RCAHM material, however, and can be removed at any time by their webmaster. While *MyCanmore* is considered a success, the museum notes that the design of the site (multi-layered and site-centered) prevents users from having conversations with each other about the collection, which they view as a limitation to be addressed in future iterations of the site.

The Liberty Science Center created *Exhibit Commons* to test the idea of public and professional curators working in partnership to create learning experiences around exhibits (LaBar, 2010). The hypothesis was that the public would be useful in determining what the public might want to experience. This took some courage on the part of the LSC to abdicate their authority to some degree, but the results were extremely positive. Four exhibits were created with public content. Evaluations found these exhibits to be extremely popular. Visitors appeared to be very willing to engage with user-created content and excited about creating their own.

The use of sharing and annotation tools among teachers is not well documented in the literature. The extent to which SCEMS wishes to pursue the idea of teacher-created content sharing on their site is a matter for further consideration by the research team. Issues of copyright and fair use will undoubtedly come into play, but the precedents in the literature cited here, and in the larger education world indicate that teachers are creating and sharing lesson plans online in a variety of ways and this is a trend worth paying attention to.

Mobile Internet

Thus far we have considered museum learning resources largely from the perspective of the educator and curator rather than the learner and student. Rapid growth in usage of mobile

[5] http://www.cooperhewitt.org/tagged/educator-resource-center

Internet technologies represents the need to focus on learner-centered design of museum content. Mobile technologies in effect put the user in the driver's seat because learning becomes truly personalized and active rather than generalized and passive. With the proliferation of mobile devices, such as smartphones and tablets, users will demand a seamless learning experience from anywhere, such as the classroom, home and museum. Statistics show that mobile media technologies such as tablet/smart phone apps and the mobile web represent the future of Internet access rather than the browser on desktop computers (Meeker, Devitt, & Wu, 2010). While mobile app building can be costly and achieving interoperability of mobile web content is challenging, mobile media technologies are increasingly being utilized to draw attention to specific exhibits and websites. Lessons learned from early examples will provide valuable insights to SCEMS as they consider mobile learning in the future.

Today's students operate in a world that is increasingly connected. They and their parents expect to be able to utilize technology to assist with family communications as well as work and school projects. A 2010 national survey of over 42,000 students and over 35,000 parents on their current technology practices and expectations show emerging trends of e-textbooks, mobile learning and online/blended learning, as having the largest impact on schooling. "These trends include the essential components of the student vision of socially-based, un-tethered and digitally rich learning, but they also directly address the three new "E's of Education" – enable, engage and empower." (Project Tomorrow, 2010, p. 3)

The survey polled middle-school students and parents on the features they would prefer in an e-textbook and found that parent and student views differ in their priorities. For example, 67% of parents request features such as animations and simulations, 59% want links to real time data, 67% want quizzes and self-assessment tests, and 57% want online tutors. The students, however, placed their priorities elsewhere. Forty percent requested communications and collaboration applications, 36% wanted access to 3D content, and 50% wanted anything related to a mobile application or capability. This result is of interest because it can serve as an effective proxy for the types of features that would be favored by students using SCEMS digital tools. What to do about the discrepancy between students and their parents is an interesting question. Further, do teachers favor what parents report? These data were not collected, however other parts of this review document do illuminate various needs expressed by educators in relation to digital media including e-texts.

Mobile learning access for middle and high school students was on the rise at the time of this survey, having jumped 42% from 2009 to 2010 (Project Tomorrow, 2010). Researchers found negligible differences in access for indications of poverty or community type. High school students reported that they use their devices at school to check grades, take notes, use the calendar, access online textbooks, send emails, or to learn about school activities. Some schools are allowing students to use the BYOD (Bring Your Own Device) model, but many still have concerns about how to effectively use mobile devices in schools. Despite concerns about devices being a "distraction," administrators and teachers alike are showing increased support for the use of mobile phones and tablets in the classroom as compared to previous Speak Up findings in 2009 due to the ability of the devices to increase student engagement, improve communications and create more opportunities for personalized learning experiences (ibid., p. 7).

A web-based survey of 852 adults and 909 youth (aged 8-17) sponsored by the Museum

of Science and Industry in Chicago found that smartphone ownership continues to increase exponentially in both young and adult populations. Eighty-nine percent of adults surveyed own a cellphone and 23% own an iPod Touch or Tablet (Beasley & Conway, 2012). Teens are actually more likely to own cellphones than adults, the survey found, and equally likely to own a smart phone. Forty-nine percent of youth own a cellphone at age 10 and 93% own one by age 16. It is exciting to think of the potential created with increasing numbers of students owning smartphones with diverse application capabilities. As such, they are poised to grow as the most numerous consumers with the most advanced skills to make use of new and exciting museum and resource discovery apps as they are being developed by agencies abroad.

Although little advance research was done by the museum, in 2009, The National Gallery of London launched the first-ever museum app in the world, called *LoveArt* to showcase its collection of Old Masters paintings. In this app 250 paintings and 200 minutes of video and audio were designed specifically for the iPhone, to play to the strengths of the device, using touch and zoom features to view images and the rolodex or gallery view to scroll through collections. The app was targeted to audiences who were interested in ready-access to the Old Masters Paintings and were iPhone users whom developers hypothesized were on the move, tech-savvy and creative. The *LoveArt* app was not in the strategic plans of the museum but, was brought to the museum by Antenna Audio, a multimedia company and trusted partner of the museum for many years. Antenna Audio approached the museum with the idea for the project and offered to do the development for free as a business investment and a way for them to enter into a new market. It was agreed that some of the development costs would be recovered by the company when profits were made from the sale of the app. With this opportunity presenting itself, the museum garnered the resources it needed and used innovative cost and timesaving measures to provide developers with the needed content for the app. The app was made available for free on iTunes for the first 12 weeks and received 70,000 downloads. When the museum started charging a small fee, downloads dropped to 16,000 in the first week and have been tapering off since (Lagoudi & Sexton, 2010, p.16). While the project proved to be a huge success (based on user reviews on iTunes and revenues generated) during the first year of its release, the museum and its developers were beginning to discuss issues of "shelf life" for the app at the time of Lagoudi and Sexton's report.

Canadian museums have also begun to develop mobile apps to engage visitors outside of the museum walls (Kennedy, 2012). Exciting advancements such as location-based content delivery apps have been made recently with the launch of *Rideau Timescapes,* released in 2012. This app enables users to view historical photographs of the Rideau Canal while physically standing at different places around this UNESCO World Heritage Site. Users can then see the changes to the landscape that have occurred over time. Increasing the level of participation of the smartphone app user, the Royal BC Museum created *Aliens Among Us,* an app that allows users to photograph and locate on a GPS enabled map invasive species to the region. This app had over 1,000 downloads within the first month of its launch in 2012 (ibid., p. 26).

The biggest challenges noted by other Canadian museums involve the lack of planning for simple content management systems to keep the app current and the lack of a specific target audience. Too many museums have rushed into building apps that do not have the type of flexibility needed to be easily updated and therefore became obsolete very quickly. Staffing

needs to be in place as well to continue to support these updates and improvements. Museums need to think about the constant need of technology upgrades as well. Kennedy quotes a wide range of estimates for building apps depending on their sophistication level from $10,000 to hundreds of thousands of dollars. Some museums, unable to keep up with the costs associated with maintaining mobile apps continuously, have opted to simply maintain “mobile-friendly” sites in preparation for moving to the next level at a later date.

Native smartphone apps have distinct advantages over mobile web in that they have access to hardware such as cameras, storage, accelerometers etc., which a mobile web browser does not. Furthermore, because native apps' access to hardware is not mediated by a browser layer, they tend to have significantly higher performance. The challenges presented in both the National Gallery of London and Canadian museum cases demonstrate the essential pitfalls of native smartphone app development versus "mobile-friendly" websites. Native apps must be proactively downloaded, installed, and updated by the user, who cannot simply point the mobile browser to the general museum website or a targeted URL. Native apps must also be maintained and updated as changes are made to functionality or content. As a result, native apps are not just expensive to develop; they are also expensive to maintain. The advantage of the mobile web is that content can be updated without downloading new versions of an app. Mobile web content can be maintained by curators and educators through a content management system, rather than through software releases managed by costly development teams. What's more, a well-architected website can detect what device and browser accesses the museum website therefore only one website needs to be maintained rather than several apps for the various platforms: iOS, Android, PC, Mac, etc. Still, mobile web developers must contend with browser compliance just as in the desktop domain. Currently the tradeoff with mobile web is speed and interactivity and as technologies mature there will continue to be tradeoffs between web and native applications, and a strategic decision will be needed based upon volatility of the information, need for specific hardware access, intended audience and use, etc. There is likely an intermediate step to consider such is a hybrid model (see blog by Doug Seven in *For Further Reading*).

The use of mobile devices by museums has been largely tactical to date. A strategic approach incorporating web, community, and mobile learning into a coherent whole must ultimately be the goal. The lesson offered by these case studies is to be very clear about the target, goals, and added value of a mobile app or mobile web for your intended audience before venturing into these types of development projects. Mobile apps can be powerful tools for drawing attention to your website in terms of branding and interactivity, but you must be clear about the “added value” and it is still too early to measure the full impact (in dollars and visitor numbers) of various types of apps being used by museums so far. A broad and well-considered mobile strategy has significantly more promise than a singular move toward mobile app development for increasing the potential, for not only site visits, but for access to structured learning resources.

Conclusion and Recommendations

This review of literature offers valuable insights and frameworks for consideration as the DLRP moves forward with user testing, prototype design, policy, and planning. It also raises

important questions for further study. The conclusions and recommendations fall within four categories: 1) optimizing the search engine, interface and metadata structure to provide more fruitful search results for a teacher and student audience; 2) expanding partnerships and data sharing; 3) teacher needs; and 4) instructional tools and web trends and devices which bear consideration for the next generation of the SCEMS site.

Optimizing Search and Metadata

Studies on "findability" and interface design in large digital museum collections indicate the need to examine the extent to which the interface, tagging and filters as designed within the smithsonianeducation.org site architecture are providing optimal searches for their intended audience. The site should demonstrate the following functionalities:

- Offer simplified searches and increase returns that include a comprehensive listing of assets from all digital Smithsonian repositories through the larger Collections Search Center where possible.
- Provide filters built from a teacher's perspective.
- Folksonomies can increase user engagement as well as findability and should be afforded visibility in addition to centrally determined taxonomies.
- Improve initial metadata for browsing/analyzing resources as coordinated with flexible view options when reviewing returned lists, more visual representations of the resources, include relevant file format information, resource types.
- Provide learners and educators increased means to select, assemble, save, and organize items for extended use and investigation.

Expanding Partnerships and Data Sharing

Government and philanthropic efforts to provide mechanisms for data sharing across large repositories of digital learning resources and community sites for content sharing indicate a growing need for respected and authoritative content providers such as Smithsonian to join more fully across multiple partnerships and data structures. This type of activity could prove beneficial to SCEMS and the larger Smithsonian Institution. Further work and study should be prioritized in order to:

- Define business models or benefits to Smithsonian for sharing with particular partners.
- Develop list of potential partners.
- Implement LRMI 1.0 tagging and markup conventions.
- Create outreach strategy and metrics to monitor success.
- Provide single-point, curated metadata to partners in multiple, machine-readable formats.
- Continue Smithsonian publication data in Learning Registry framework.

Teacher Needs

Studies on digital learning in the classroom and use of digital museum resources indicate that teachers need flexibility to create curricular sequences that meet the learning needs of their particular students. One-size-fits-all lesson plans are rarely utilized as presented, but often taken apart, reorganized or augmented by the teacher while building a lesson. User testing and prototype design should explore these findings in greater detail regarding teachers' need for:

- Flexible assets for use in multiple ways with students to engage their interest.
- Tools that maximize the use of high-quality images.
- Tools and suggestions to help adapt resources to diverse learners that aren't overly scripted.
- Content aligned to Common Core State Standards.
- Collecting and saving resources in a dedicated space on the site.
- Preferences for viewing content and search results.

Tools and Trends

Trends in the use of social media and mobile phone and tablet use in schools is expanding and gaining greater acceptance. It is critical, however, that a strategic approach to web, community and mobile learning should be taken before large investments are made. SCEMS should consider the following preliminary steps:

- Incorporate mobile-friendly features in current site content and functionality.
- Mimic iPhone Rolodex or gallery views to assist with later potential mobile device integration.
- Research the extent to which teachers would use social media to contribute content to the site.
- Research the extent to which teachers would share content or participate in online communities.
- Geolocation tools and augmented reality are emerging trends, which bear consideration for the K-12 mobile learning audience.
- Examine carefully the specific value-added of any mobile learning application along with costs associated with its on-going management, weighing them against the advantages of mobile web investments.

The Smithsonian Center for Education Museum Studies is to be commended for designing a project that will create a partnership to answer the critical questions of 21st century museum learning. Herein lies opportunity as well as responsibility for both leadership and innovation in the museum world and within the K-12 education community. If it achieves its goals, the Digital Learning Resources Project will serve as a model for replication as the community of digital museum learning continues to evolve in our ever-changing digital world.

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For Further Reading

Blogs, Websites & News Sources

3 Reasons Apple's iPad Textbooks Will Rock the Classroom

http://www.dailyfinance.com

(Munarriz, R.A. AOL-Daily Finance/The Motley Fool. 19 January 2012.) In January of 2012, Apple announced partnerships with major textbook publishers and its efforts to develop a new platform for digital textbook additions. Apple's presentation addressed the flaws of paper textbooks for students and for publishers. The company also presented it plans to offer ease of use and more enjoyment with its new digital textbooks.

Home Computing, School Engagement And Academic Achievement of Low-Income Adolescents

http://cfy.org/wp-content/uploads/2011/09/CFY-ETS_Research_Study_FINAL.pdf

(Tsikalas, K., Lee, J., & Newkirk, C., *Computers For Youth Foundation,* 2007.) An internal study conducted by the Computers For Youth Foundation on the "relationship between specific home computing practices and low-income adolescents' school engagement and achievement." Data was collected by sampling 174 sixth and seventh grade students from the 2,000 students that participate in the CFY program. Student scores on the New York state standardized test over the two years of CFY intervention were also considered.

How Do Teachers and Students Use Museum Websites

http://www.museum-ed.org/

http://www.mediaandtechnology.org/panels/2007.html

(Wetterlund, K., Presented at the *American Association of Museums Annual Meeting* in Chicago, Illinois, May 2007.) Wetterlund's presentation at the AAM Annual Meeting details her observations and findings from working with teachers in the ARTstor program. Wetterlund, an art museum educator with sixteen years of experience partnering with teachers, studied classroom habits of teachers using digital images and works of art provided by digital museum collections. Wetterlund's original powerpoint presentation from the AAM Annual Meeting is available online, as well as a follow-up blog that Wetterlund posted on Museum-Ed.org.

How To Help Teachers Find Your On-Line Resources

http://www.museum-ed.org/component/option,com_jd-wp/Itemid,29/p,36/

(Wetterlund, K., *Museum-Ed Blog,*) In this article, Wetterlund, founder of Museum-Ed and Editor of the Museum-Ed Listserve and Website, describes her method for linking online museum resources to other resources that teachers frequent, thereby increasing the traffic of online museums.

iPad – The Space Between The Cool And The Useful

http://www.chici.org/cool2012/papers.html

(Culén, A. L., Gasparini, A., & Hercz, R., Presented at *Cool aX Continents Cultures and Communities Workshop*, 2012.) Culén and Gasparini, professors at the University of Oslo, partnered with Hercz, a mobile banking professional, to compare the 'coolness' and utilitity of the iPad across the fields of education and banking. Their reflections, presented at the Cool aX conference, are a synthesis of their various studies on iPads as an educational tool.

Math That Moves: Schools Embrace the iPad

http://www.nytimes.com/2011/01/05/education/

(Hu, W., *New York Times Online*, 4 January 2011.) An article profiling Roslyn High School on Long Island, which implemented a pilot program to provide iPads to all students in two humanities classes. The article includes interviews with Larry Reiff, a teacher involved in the program, and Larry Cuban, a professor emeritus of education at Stanford University, who believes education funds are better spent elsewhere.

Teachers Using Cell Phones For Class Lessons, Homework

http://www.huffingtonpost.com/2009/11/28/teachers-using-cell-phone_n_372710.html

(Armario, C., *The Huffington Post Online,* 28 November 2009.) The article profiles various teachers utilizing cell phones and student connectivity in the classroom. Ariana Leonard's uses cellphones in her high school Spanish at Wiregrass Ranch High School in Wesley Chapel, Florida. Katie Titler also uses cellphones in a Spanish class in Pulaski, Wisconsin, as does Jimbo Lamb in a math classroom at Annville-Cleona School District in south-central Pennsylvania. Various perspectives on cell phone use in the classroom, as well as interviews from school and district level administrators are also presented.

Understanding Cool in Computing for African-American Youth

(McCrickard, D.S., Doswell, F, Barksdale, J, & Piggot, D., Presented at *CHI'12 Conference* in Austin Texas, 5-10 May 2012.) A presentation and paper from academics in the field of computer science at Norfolk State University and Virginia Tech University. The paper offers the reflections of digital designers who have "created interfaces for African-American youth' and offers a synthesis of design parameters for creating 'cool.'"

Museums in the Digital Domain

http://kovenjsmith.com/archives/275

(Smith, K. J., *Parts 1-4,* 19 October - 16 November, 2009). Koven Smith is presently employed as the Director of Technology at the Denver Art Museum. He is an active blogger and commentator on museums and technology. This 4-part blog series describes the changing nature of digital museum assets, what museums need to do to hold the attention of their web audience, and where some museums are out of step with today's digital world.

Mobile Web

http://icenium.com/community/blog/icenium-team-blog/2012/06/14/what-is-a-hybrid-mobile-app-

"What is a Hybrid Mobile App?" by Doug Seven (2012). This blog describes the differences between native apps, mobile web and hybrid models and weighs the advantages of each.

Learning Registry; Sharing What We Know

http://www.learningregistry.org

Learning Registry is a partnership of the Department of Education and the Department of Defense, as well as additional federal, non-profit, international and private agencies. These agencies collaborate for the purpose of creating a platform and unified protocol for digital innovation and content authoring. The Learning Registry is not meant as a portal or engine that "educators will go to", but is instead a vehicle for open sharing and leveraging of applications and learning management tools.

Learning Registry Metadata Initiative (LRMI)

http://www.lrmi.net/about

A joint venture of the Association of Education Publishers and Creative Commons and funded by the Bill and Melinda Gates Foundation and the William and Flora Hewlett Foundation, this initiative seeks to support the Learning Registry by developing the necessary system for metadata tagging similar to Schema.org.

Tin Can API

http://tincanapi.com/what-is-tin-can/overview/

A new technology that captures a variety of paradata from learning activities. More flexible than older systems, it can lift data from a broader range of web activities.

Earlier Relevant Museum Research

ArtsEdNet: Assessing An Arts Education Website

http://www.archimuse.com/mw97/speak/borland.htm

(Borland, C., in D. Bearman & J. Trant (Eds.) *Museums and the Web 1997 Proceedings*. [CD ROM]. Archives & Museum Informatics, 1997.) ArtsEdNet is an online service for K-12 arts educators, produced and provided by the Getty Education Institute for the Arts. This study assesses ArtsEdNet's success in meeting its stated goals: to provide teachers with access to classroom resources, to provide a forum for teachers to connect, communicate and collaborate, and to provide web-based professional development to teachers.

Developing Online Teacher's Resources at the Museum of Tolerance: A Case Study in Innovation and Evolution

http://www.archimuse.com/mw2003/papers/bordac/bordac.html

(Bordac, S., Brucken, C., Blanshay, L., Geft, L., & Samuels, E., in D. Bearman & J. Trant (eds) *Museums and the Web 2003 Proceedings*. [CD ROM]. Archives & Museum Informatics, 2003.) This study traces an 18-month development process to create a digital Teacher's Guide for the Museum of Tolerance. The study is meant to provide a case study of the collaborative and dynamic process of designing for the web.

Evaluating the Usability of a Museum Website
http://www.archimuse.com/mw2001/papers/schweibenz/schweibenz.html

*(*Harm, I. & Schweibenz, W., in D. Bearman & J. Trant (eds.) *Museums and the Web 2001 Proceedings.* CD ROM. Archives & Museum Informatics, 2001.) This study evaluates usability engineering as a method of designing for the web and investigates how the Saarland Museum's website implements usability engineering in its web design.

Formative evaluation of the On-line Teacher Resources Project: Final report
http://www.selindaresearch.com/SheddOnlineTeacherResourcesFormative.pdf

(Gyllenhaal, E. D., Beaumont, L., & Tyree, A., Unpublished manuscript from the John G. Shedd Aquarium, Chicago, Illinois, 2003) This unpublished finding of the Shed Aquarium summarizes the results of formative web-site evaluations conducted using heuristic evaluation and on-site user testing.

Front-end evaluation of the On-line Teacher Resources project: Final report.
http://selindaresearch.com/SheddOnlineTeacherResourcesFront-End.pdf

(Gyllenhaal, E. D., & Schaefer, J., Unpublished manuscript from the John G. Shedd Aquarium, Chicago, Illinois, 2002). This unpublished finding of the Shed Aquarium summarizes the front-end evaluation conducted by the Aquarium as an initial step in developing online teacher resources. The front-end evaluation surveyed teachers to identify preferences for finding and using online resources, particularly lesson plans.

Investigating Heuristic Evaluation: A Case Study
http://www.archimuse.com/mw2003/papers/haley/haley.html

(Goldman, K. H., in D. Bearman & J. Trant (eds.) *Museums and the Web 2003 Proceedings. CD ROM. Archives & Museum Informatics,* 2003.) This article provides an overview of heuristic website evaluation; a technique for evaluating websites that balances the need for in depth usability testing with the fiscal realities that many non-profits, particularly museums, face. The article provides a case study for the accuracy and effectiveness of heuristic evaluation.

Rethinking University Teaching: A Conversational Framework for the Effective Use of Learning Technologies

(Laurillard, D. Published by Routledge Falmer, 2002.) A foundational framework for evaluating web content on five levels of "narrative", "interactive", "communicative", "adaptive" and "productive", based on Bloom's taxonomy and hierarchy of cognitive learning.

Usability Evaluation For Museum Websites

(Cunliffe, D. Kritou, E., & Tudhope, D. *Museum Management and Curatorship*, 19(3), 229-252., 2001.) A case study comparing and contrasting the benefits and limitations of different methodologies for summative evaluation of museum websites. Evaluation methods of direct observation, log analysis, online questionnaires, and usability inspection methods (such as heuristic evaluation) are considered.

Reports

National Education Technology Plan 2010; Transforming American Education: Learning Powered By Technology

http://www.ed.gov/technology/netp-2010

(U.S. Department of Education, Office of Educational Technology) The National Education Technology Plan outlines a model of learning that employs advanced technology to improve academic achievement and student learning, to increase educator effectiveness and best practices, and to use data driven decision making for continuous education improvement.

The Gates Foundation: Next Generation Learning

http://www.gatesfoundation.org/postsecondaryeducation/Documents/nextgenlearning.pdf

Report of the Gates Foundation on the Next Generation Learning initiative, its vision and goals.