

Discovery and Use of Online Learning Resources: Case Study Findings

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Abstract

Much recent research and funding have focused on building Internet-based repositories that contain collections of high-quality learning resources, often called 'learning objects.' Yet little is known about how non-specialist users, in particular teachers, find, access, and use digital learning resources. To address this gap, this article describes a case study of mathematics and science teachers' practices and desires surrounding the discovery, selection, and use of digital library resources for instructional purposes. Findings suggest that the teacher participants used a broad range of search strategies in order to find resources that they deemed were age-appropriate, current, and accurate. They intended to include these resources with little modifications into planned instructional activities. The article concludes with a discussion of the implications of the findings for improving the design of educational digital library systems, including tools supporting resource reuse.

Keywords

Case studies, Education, Human-computer interaction, Qualitative studies.

Introduction

Much recent research and funding have focused on building Internet-based repositories that contain collections of high-quality learning resources, often called 'learning objects' (Wiley, 2001). Resources in such repositories are typically described using metadata, literally data about data (LTSC, 2000; Weibel, 1995). Much like a library card catalogue, metadata for learning resources usually contain basic information about the resource. For example, the Learning Technology Standards Committee (LTSC) Learning Objects Metadata Working Group (LTSC, 2000) defines an extensive scheme with over 80 elements to describe resources. These include, subject area, resource type, rights management, and author information. These metadata records are intended to support users (including teachers and students) in finding relevant resources.

The National Science Digital Library (NSDL) is an example of such an educational digital repository. The U.S. National Science Foundation sponsored NSDL provides access to a comprehensive collection of science, technology, engineering, and mathematics (STEM) education content and services to learners, educators, and academic policy-makers (Lagoze, 2002; Wattenberg, 1998; Zia, 2001). Similar national initiatives aimed at building large scale repositories of learning resources exist in other countries, including the Curriculum Online in the UK, the Canadian eduSource project, and the Australian Learning Federation.

To date, a primary focus of these initiatives has been on developing technical standards, metadata standards, and specifications for system interoperability. These efforts, it is claimed, will support the reuse of learning resources within a wide range of applications, and the seamless transition of content between learning management systems (ADL, 2001). In this way, the technical foundation will lead to faster development time, lower development costs, and produce better learning, education, and training (ISO, 2002; Sumner & Dawe, 2001).

However, missing from such initiatives is a deep characterization and understanding of learning environments, and how digital learning resources may fit into such contexts. Developing this perspective requires adopting teacher and student perspectives, rather than simply focusing on technological concerns. Moreover, ignoring these perspectives risks hampering successful adoption of innovation (Moore, 1991), and the history of educational technology is replete with such omissions (Cuban, 1986). Unfortunately, the current learning object movement seems to have ignored the teacher and learner perspective. Few studies exist that document how non-specialist users, in particular teachers, find, access, and use digital learning resources (Friesen, 2003). In short, we lack understanding about the use and eventual effectiveness of educational digital learning repositories and resources in instructional settings.

To begin to address this gap, this article presents findings from a case study of mathematics and science teachers' practices and desires surrounding the discovery, selection, and use of digital learning resource for instructional purposes. In selecting study participants, careful effort was taken to find teachers who, while experienced in the classroom, were not high-end technology users, as they are more representative of typical teachers. As described by Moore (1991) in discussing the processes of technology adoption, users can be viewed as comprising successive waves of adopters: Early Innovators, Early Adopters, Pragmatists (early majority), Pragmatists (late majority), and Traditionalists. The majority of technology users can be characterized as pragmatists. Many new technologies have encountered significant challenges in becoming adopted by the pragmatists. To do so requires establishing a niche market, providing an easy-to-use and enjoyable alternative, and demonstrating improved productivity in important areas (Moore, 1991). As such, our case study focused on the requirements of this class of users.

The purpose of the study was to identify teachers' 1) motivations for using digital resources, 2) barriers to using digital resources, 3) search strategies and selection criteria when looking for digital resources, 4) adaptation of digital resources for their instruction, 5) use of digital resources in and outside of classroom instruction, and 6) desired functionalities in repositories and tools. In this way, the study focuses on understanding the teacher's perspective regarding the prospects and uses of educational digital repositories of learning resources. Consistent with the case study methodology, the research approach was open-ended and exploratory (Johnson, 1997; Yin, 2003). Our intent was not to answer experimental hypotheses, but rather to begin to focus on developing research questions.

The context for this study was a formative evaluation of a digital library tool, called the Instructional Architect (Recker, Dorward, & Reinke, 2003). The Instructional Architect (IA) is a tool designed for use with educational digital libraries, by providing a container and authoring environment for resources found in such repositories. As will be described, study participants were asked to engage in a number of activities involving the use of digital resources for instructional purposes. Specifically, they were asked to use Internet search engines, educational digital libraries, and the IA to locate and use digital library learning resources in their instruction.

The next section of the article describes the context surrounding the study. Then, the study's participants and methods are presented, followed by a description of the findings. The article concludes with a discussion of the implications of the findings for improving the design of digital repositories of learning resources, including tools supporting resource reuse.

The Context for the Study

The Instructional Architect (IA) is an Internet-based service designed for use with educational digital libraries by providing a 'container' environment for resources found in a library (and is especially tailored for learning resources located with the National Science Digital Learning). In particular, it enables users (particularly teachers) to discover, select, sequence, annotate, and reuse learning resources stored in digital libraries into new instruction (e.g., lesson plans, study aids, homework). At the same time, it has the goal of fostering communities of teachers and learners who use the NSDL, by supporting resource sharing and recommendations. In this way, the IA is intended to increase the utility of learning resources for the classroom teacher. The IA portal is available at <http://ia.usu.edu/>.

Currently, the entry point to the IA offers several options. Returning users can log in to access (and edit) existing projects (instruction), or use the IA to create a new project (new instruction). New users can create an account, view an introductory tutorial, or begin accessing the system without logging in. The user can then use the Gather Resources Tool to find and collect learning resources, or the Author Tool to sequence and annotate these resources in order to create instruction, activities, lectures, lesson plans, study aids, or any other personalized collection.

Gather Resources Tool

The Gather Resources Tool supports searching across digital libraries for one or more learning resources. From a search screen, users enter their search terms, which are used to query participating digital libraries. Currently, queries are sent to a collection of metadata records from a variety of digital libraries including the National STEM Digital Library (nsdl.org), the SMETE Open Federation (www.smete.org), and the National Library of Virtual Manipulatives (matti.usu.edu). Search results are parsed and displayed by the IA to the user. Users can preview the candidate learning resources and then select (via a checkbox) resources they want to use in their own instruction (see Figure 1). They can also remove previously selected resources.

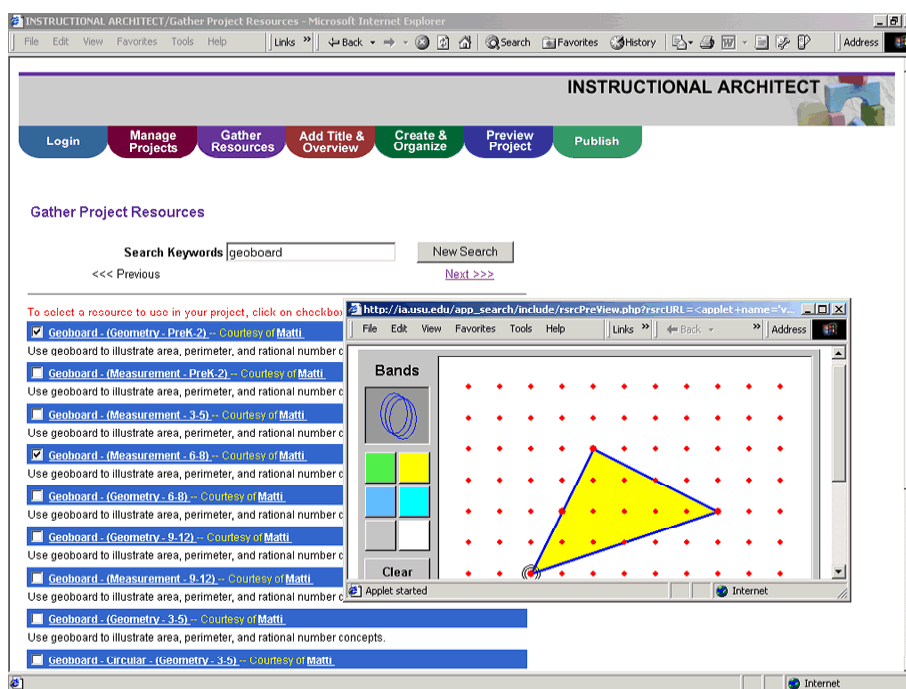


Figure 1: The user previews and selects candidate resources

Author Tool

This tool provides several authoring functions that enable users to organize, sequence, and annotate selected learning resources into an instructional project. Specifically, the tool guides users through a series of steps in which they accomplish the following:

- *Add Title & Overview* – Create a project homepage including a title and brief introduction for the collection of resources.
- *Create & Organize* - Create, modify, delete and order individual webpages containing previously selected resources. Optional resource captions or descriptions can be added to scaffold learners' interactions with individual resources (see Figure 2).
- *Preview Project* - See what the final project looks like.
- *Publish* – Receive a URL for the collection.

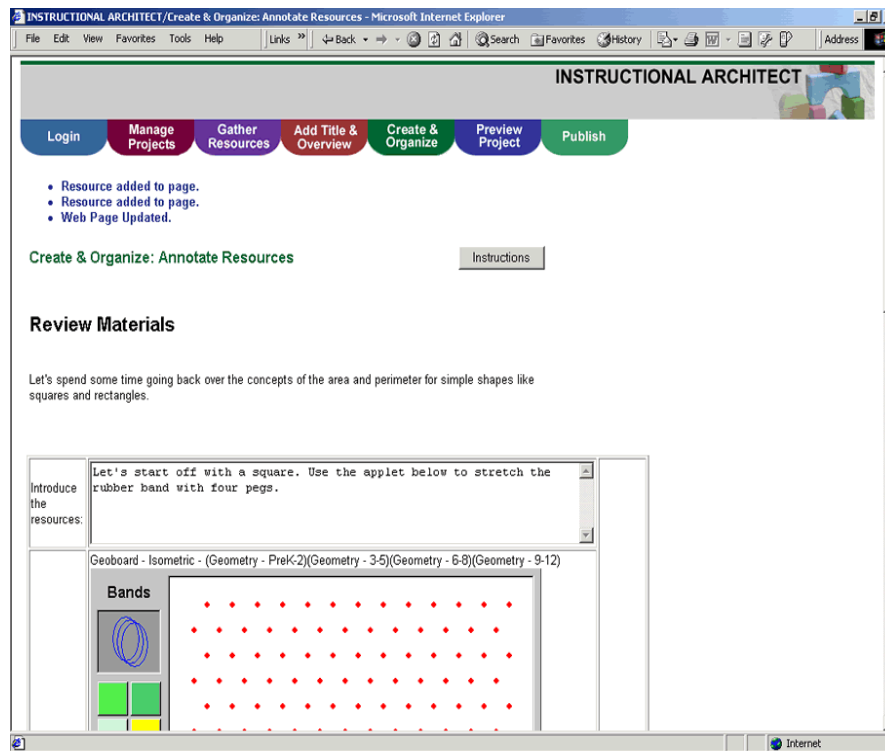


Figure 2: The user adds annotations to selected resources

The outcome of interaction with the IA is a set of linked Web pages containing sequenced and annotated learning resources from participating digital libraries. These are saved on the server for future use, including as teacher presentations, learning activities, self-paced instruction, or in any other instructional situation. To facilitate use as broadly and as simply as possible, the IA is completely form-driven and compatible with any browser on any platform.

Design and development of the IA used both user-centered design (Norman & Draper, 1986) and developmental evaluation (Patton, 1994) approaches, in which each design cycle was followed by evaluation. In particular, the project design and development was informed by a needs assessment, expert review of the prototype interface, testing by members of the target audience, analysis of code changes by constituents, and a case study of master teacher use of software. An earlier article described how evaluation results were used to inform interface design (Dorward, Reinke, & Recker, 2002). The current article presents findings from analyzing the case study of teacher use.

Participants and Methods

Eight (five men and three women) experienced middle and high school science and mathematics teachers from the state of Utah were selected to participate in a study lasting ten weeks during 2002. Participant selection was based on candidates self-described level of electronic resource use in instruction, content background in the disciplines served by participating STEM digital libraries, and diversity of employment characteristics. In terms of information technology competence, we sought participants who were comfortable with, yet not high-end, information technology users.

The study consisted of the following phases:

- Phase 1. Informants attended a one-hour focus group, in which they completed a demographic survey and discussed their current use of Internet resources. The survey asked participants about their teaching area and experience, as well as to comment on their current use of Web-based learning resources in teaching. They then received a 2-hour training session introducing digital library concepts and tools, including the IA. As part of the training, they ran through two hypothetical instructional scenarios, one in mathematics education and the other in science education, in which they used the IA to create products.
- Phase 2, four weeks. Informants were asked to use Internet resources in their teaching. They were asked to use their favorite search engine to locate resources. They completed coding sheets describing their activities.

In particular, for each activity, participants were asked to describe their instructional objectives, their search objectives, successes and barriers in their activity, and how their work was used in the classroom.

- Phase 3, four weeks. Informants were asked to use the IA to locate and use digital library resources. As in the previous phase, they completed coding sheets describing their activities.
- Phase 4. Researchers observed and interviewed Informants as they searched for and accessed learning resources for their students.
- Phase 5. Informants participated in a one-hour debriefing conference call.

Data Analysis Methodology

Data collected during the study included an initial survey of teacher demographics and attitudes toward the use of digital resources, coding and description of weekly instructional resource retrieval and use, pre- and post-study focus group interviews, and observations.

In order to describe how instructors search, adapt, and incorporate learning resources into classroom instruction, we compiled and analyzed a wealth of qualitative data. These data came from transcriptions of focus group interviews, from the coding sheets, and from observer comments. In the findings reported below, teacher quotes came from the focus group interviews in which participants were reflecting on their overall experience with using digital learning resources.

The three authors independently analyzed this qualitative information using QSR N6, a software coding and organization program (QSR, 2002), in order to identify recurrent themes. In most instances, there was consensus on resulting themes and associated textual information. In the few instances where interpretations varied, the team discussed the issues and reached agreement. As we will describe, many of the themes were validated by our prior research experience, while others emerged through discussion and debate.

Findings

The purpose of the study was to examine how teachers access, select, and use learning resources in the classroom. Findings addressed the following questions:

- What motivates teachers to use online resources?
- What barriers do teachers perceive to using digital resources?
- What search strategies and selection criteria do teachers use when looking for online resources?
- How do teachers adapt and use digital resources for their instruction?
- How do teachers use digital resources in and outside of classroom instruction?
- What functionalities do teachers want in tools that use digital learning resources?

Motivators for teacher use of digital resources

Overall, the teachers in the study felt that easy access to large numbers of high-quality learning resources increases their productivity by saving them time, improves their practice, and better meets the academic needs of their students.

With respect to how access to a breadth of high quality learning resources impacts productivity, teachers involved in the study always referred to time. The belief that searching the Internet saved time was reflected in the following comments:

"the access speed and breadth of content is much easier than [performing] manual searches of non-electronic resources."

"this is my favorite thing about the Internet – you can get quick facts, tables and pictures to use at a moment's notice."

"Things are just so unlimited now. It is never like I need to go back to the library for more resources or I didn't order enough books. It is all right there on the web, so that saves a lot of time."

Study participants also believed that use of digital resources improves the quality of their teaching and their students' learning. One teacher commented, "If I'm teaching out of a textbook what is that? I have to be on the Internet, I have to show them what is happening right now, shots from the Hubble, etc. That is just so valuable to the kids." Another teacher was motivated to use digital resources because "students have more choice about what, when and how they learn - it's the only way to generate interest and promote life-long learning." The teachers also believed the process of accessing learning resources increased the level of technological literacy among themselves and their students. One teacher noted that, "These kids need to be learning the computer skills that will really get them ahead in life. ... I know that the kids are getting a better education now."

Barriers to teacher use of digital resources

Study participants also identified barriers to using digital resources. These barriers primarily related to the quality of the resources, and the abilities of teachers and students to access and use them.

Digital resources that were out-of-date, slow, unavailable, charged a fee, or contained information that was too "simple" or too "advanced" discouraged study participants: "it can be very time consuming finding relevant, timely, and grade-appropriate material – it requires a lot of 'sifting' through search engine hits as well as the sites and resources they offer." One teacher noted frustration at "spending time on fruitless searches, which resulted in either lots of irrelevant resources or resources of less quality than that found in books."

Search strategies and selection criteria

In general, teachers involved in this study used multiple strategies when searching for resources. Often they liked to start out broadly and review a number of resources, and then engage in more refined, specific searches. However, at other times they wanted to access resources on teacher-oriented Web sites that were already filtered or categorized, so that they could immediately start a refined search by grade level or topic. They preferred sites that were dependable, in particular well-known sites that provided collections of learning resources and links. One teacher stated,

"I'll find that the resources change so much from one year to the next. So what I try to do is stick with solid sites, like NASA, and that way I know that the site is only going to improve from year to year or month to month."

When using Web search engines, the teachers generally preferred using Google, Yahoo, and WebCrawler, as well as education-specific search engines. One teacher tended to focus on "the first couple of pages of hits because the winners will be near the top."

In addition to conducting their own searches, they also asked students to assist in locating resources, as well as subscribing to mailing lists that notified them about pertinent sites. One teacher described her approach:

"all you have to do is get on their e-mail list and they do the research as to the hot educational sites, really good stuff. They e-mail me once a week, and I just look through and bookmark links to the best ones."

Teachers involved in this study also placed high value in being able to access learning resources that focused on teacher needs, or were built by teachers: "I love going out to teacher sites, I use those probably more than anything else." They valued knowing what resources other teachers were using in order to gain new ideas and approaches to their own teaching. For example, one teacher frequents web sites that provide teacher-created resources with collected learning resources and links, finding that teacher sites usually provide age-appropriate activities and information that are easy to modify and relate to their state core standards.

When searching for suitable learning resources, the teachers looked for a wide variety of both informational and instructional resources ranging from background information, contact information, graphics, data sets, maps, worksheets, assessments, tools, interactive applications, real-world examples, and links to other sites. Participants found sites that indexed these resources and identified related links were particularly beneficial.

“I particularly like sites that include indexes or tables of contents so that I know quickly what is on the site and where to locate it. I also like sites with printable diagrams, especially simple black and white ones.”

Interestingly, teachers were more inclined to select smaller-grained, isolated resources, than fully developed lesson plans.

“No, I’m not looking for entire lessons. I’m pretty much just searching for the frills and extras.”

“I don’t use the Internet for specific lessons. I look for thing[s] like the latest pictures from the Hubble or little things like that to supplement a lesson.”

In sum, study participants identified the following general criteria for selecting learning resources: age-appropriate, current, accurate, and related to state core concepts in the curriculum. They wanted resources that were simple, with clear instructions that provided an appropriate overview of a topic that students would find engaging and interactive. The teachers looked for the basic building blocks that they could wrap their own instruction around, or extras they could insert into their existing instruction. As described by one teacher: “when you are searching, you are after the interesting extras that you can’t get out of a textbook.”

Adaptation and use of digital resources for instruction

The teachers in this study preferred resources that needed little or no modification. They wanted to spend their limited time finding resources and then creating appropriate instructional contexts or wrappers for them: “It is going to take me enough time to search and find and create the link, that I don’t want to mess with modifying a page.” Another teacher described this dilemma: “I end up with several pages of good sites that I have yet to go in to modify to make them appropriate. And there is some good stuff that is right there, I just haven’t found the time to get it all ready.”

The teachers valued resources that were in a convenient format for downloading and adapting for instruction, especially those resources that could be used with little or no modification. One teacher stated: “If I’m modifying a site, I’m usually just grabbing a picture or a little text and usually putting that into PowerPoint. So I need things to be in a fairly common format to work with word processing programs.”

When they did adapt or modify a resource, their activities ranged from simple organization to modification. Organization activities included bookmarking, listing, grouping, or sequencing resources, as well as “creating a mini-tour of websites.” One teacher felt that the ability to “group a few [resources] together with control over the sequence and introductory text is a wonderful [functionality].” Another explained that, “I do have on my page a list of links that are broken down specifically for [the topic of] space or whatever. I also have a main area for our current projects.”

On occasion, study participants made modifications to resources to better meet student needs: “once Internet sites are ‘sifted’ and resources are found, I revamp resources and lessons to fit my instructional time frame and the learning abilities of my students.” In another example, one middle school teacher felt that it was easier to find simple elementary-level resources and augment them, than to modify high-school level resources: “the [...] thing that is really nice at the elementary school level is the number of sites that are already built that I can send a student to without having to modify it. I can just put a link on my class page as a reference.”

The teachers also discussed perceived barriers in adapting or modifying resources for their own use. They worried about the time that it would take and the difficulty of modifying a resource intended for another use to fit their own needs. Another concern was around copyright issues and how it might affect their use of digital resources, as explained by this comment: “I think that when I modify, I’m always worried about stealing someone else’s copyright. So the majority of my links are to the original sites.”

Teacher use of digital resources in and outside of classroom instruction

Teachers involved in this study used digital resources for both teacher-based activities (e.g., classroom lectures) and student-based activities (e.g., self-paced instruction, home-accessed activities, and student projects).

Teacher-based activities primarily entailed using digital resources for classroom lectures, particularly PowerPoint presentations. “I either: 1) modify and create print-based material, 2) link to a site(s) from our classroom webpage to have students working at that site, or 3) provide information for manipulation and exploration of math topics.”

Teachers also used digital resources as background information for content topics or for possible field trips. “One thing that [I] use the Internet for is data. Data that I can use in my classroom that comes from real life that would relate to them.” Other uses included: whole- and small-group instruction, in-class discussions, content instruction, and real-world data presentation. Occasionally, study participants would use digital resources to introduce topics, tie instruction to the state core curriculum, provide interactive activities, and post student work.

Study participants acknowledged that many Internet resources are “intended it to be used by students rather than the teacher.” Consequently, these teachers encouraged student-directed searches for digital resources in assignments and activities. Students would often access these from home, completing self-paced modules and accompanying assessments. The teachers also had students use web-based learning resources to make-up absences, create projects, individualize student instruction and research, and provide free-time activities. As described by one teacher:

“Yeah, I really like a page that I can just put in. It is nice too because that really serves as an enrichment opportunity to have a link. Then if a student really wants to go crazy on a subject they can start at my site and link to the resource and go nuts with it.”

Tool functionalities

Over the course of their involvement in the study, teachers made several suggestions for improving the functionality of tools for searching for and adapting digital learning resources.

For search tools, the participants wanted to be able to access teacher-focused and generated resources. They also requested resource collections that had already been filtered for education and that included “recommendations tied to specific resources rather than to individuals.” The teachers also wanted their students to be able to access filtered search engines: “I think it would be very cool to have a search engine for kids, without having to worry about filtering. Something that doesn’t post a million and a half commercial things; with accurate, up-to-date, free information.”

It was very important to the teachers that resources be categorized by grade level, content area, and type. One teacher wanted to “see resources grouped by subject, and would love a master list of URLs recommended by other teachers.” They also requested that resources be linked to the state core standards.

Furthermore, study participants wanted features that increased accessibility to resources. These included additional information about the types of digital repositories and resources that were available. One teacher indicated that she “would have liked to have been better informed as to what was out there.” Another felt it “would also be nice to go in and say that I’m looking for an activity or a picture, or a specific thing.”

Teachers wanted to download resources in a common format, or one that was compatible with word processors. They also wanted repositories to include indexes or tables of content that facilitated a quick review for location of resources. One teacher “would like a table of contents or glossary for [a digital library] in some type of organization order. And some way to browse that.” Lastly they wanted to be able to preview resources before selecting them for use.

When using and presenting resources, the teachers wanted to be able to use items from a variety of sources, both inside and outside of a particular digital repository. They also wanted to access and combine information from multiple electronic textbooks. One teacher noted, “I mean, we just spent I don’t know how much buying new science books and won’t use more than two chapters out of each one. I mean how great would it be if we could select and regroup chapters from different books.”

For classroom use, teachers wanted to be able to require logins to access certain resources, not only for instructional purposes, but also as a “protected area for testing, grades, other class management stuff, or just whatever.” These teachers also felt that password logins would help them address possible copyright issues.

Limitations of the Study

It is important to note key limitations of the study. First, as is typical in case study method, the study involved a small number of teachers. The purpose of the case study methodology is to delve deeply into areas in which hypotheses are unclear, and to focus on contextual commonalities among participants, rather than differences (Johnson, 1997; Yin, 2003). As such, a small sample size is preferred. In addition, a key data source was focus group interviews. In these settings, while the conversation is rich, it is hard to infer individuals' opinions.

As noted, the teachers involved in the study were all experienced. It seems possible that less-experienced teachers, regardless of their comfort with information technology, might have different strategies for searching for learning objects. For example, because of their relative inexperience, they may be more inclined to search for larger "granularity" objects, such as lesson plans or units.

In addition, the participants could not be characterized as early adopters of information technology. Instead, their experiences are probably more characteristic of 'pragmatists', rather than high-end technology innovators or resisters. These participants are likely to be more skeptical of information technology for its own sake, attitudes that are probably more representative of typical teachers.

Teachers were also involved in our study during a period that school was in session. It is likely that their experiences would have been different had they been involved during a different time period, for example a summer workshop, when time constraints in terms of lesson planning are less pressing (Sumner & Dawe, 2001). These represent variables that merit future research.

Finally, our study was conducted at a time when the participating digital libraries were in the process of seeding and growing their collections. As such, content quality and coverage was uneven. The latter caused a small level of frustration among our classroom teachers as they attempted to search for interesting and relevant learning resources. Nonetheless, the teachers were uniformly enthused about the potential of educational digital libraries, and envisioned a wide range of possible uses for digital resources in learning contexts.

Conclusions and Implications for Design

Much has been made about the great potential that learning objects and repositories may have within instruction. Yet little is known about how target users, in particular, teachers, plan to use such resources. To address this gap, this paper presented findings from a case study of mathematics and science teachers' practices and desires surrounding the discovery, selection, and use of digital learning resource for instructional purposes. These findings offer a number of suggestions for digital library tool designers, and the Instructional Architect in particular.

In terms of discovery and selection of digital resources, the teachers involved in this study were primarily interested in finding resources that they thought were age-appropriate, current, and accurate. This definition of 'useful' learning resources has also been found in other studies of teachers' perception of resource quality (Sumner, Khoo, Recker, & Marlino, 2003).

Educational digital libraries can and are supporting these desires through the use of item-level metadata, for example, the 'audience' and 'subject' elements in Dublin Core Education Working Group metadata standard (DCMI, 2002). Organizations and standards bodies are also developing controlled vocabularies for use with these elements. For example, the Gateway to Educational Materials (<http://www.geminfo.org>) project has developed controlled vocabularies to describe a resource's audience, target grade level, language, and subject. Such vocabularies should help users focus their search, but only if they match terms and concepts used by teachers. In addition, digital libraries, such as the Digital Library for Earth System Education (www.dlese.org) are addressing teachers' desire for resource accuracy and currency by developing education-specific collection accessioning and review policies (Marlino, Sumner, Fulker, Manduca, & Mogk, 2001).

The teachers in our study employed multiple search strategies, including flexible and broad searches, as well as specific searches, often by age-level and topic. The teachers also expressed a strong interest in the ability to browse the collections. As previously noted, it is possible that these discovery strategies are influenced by where a teacher is in his/her lesson planning process and his/her available time (Sumner & Dawe, 2001). As such, tools must support a variety of discovery strategies to accommodate difference lesson planning style and constraints.

Prior research points to the problem of relying solely on keyword search for resource discovery. Specifically, teachers may have an ill-formed conception of what they are looking for, have difficulty translating an instructional intent into a search query, or may lack understanding of Boolean search syntax and semantics (Soloway & Wallace, 1997; Wallace, Kupperman, Krajcik, & Soloway, 2000). The Instructional Architect currently supports only keyword searches, so means must be added to expand search and browse options.

The teachers also expressed an interest in teacher-recommended learning resources and teacher-created repository of resources. In this way, teachers seemed interested in resources that were pedagogically relevant to their current context, as opposed to generic digital resources. This functionality could be implemented by an automated recommender system (Resnick & Varian, 1997), a popular technology in electronic commerce in which the interests of entire communities are leveraged to provide targeted, personalized recommendations of products or resources to individuals. In related work, we have developed a prototype educational recommender system, which can provide such personalized recommendations of web resources (Recker, Walker, & Lawless, 2003).

Teachers were looking to link resources to the state core education standards. This finding underscores the growing importance of linking collection items to specific K-12 educational standards in the United States. It suggests that metadata standards define elements and controlled vocabularies that enable these linkages to be described in ways that are meaningful to teachers.

In terms of resource usage, findings suggests that teachers in the study were more likely to use learning resources that needed little or no modification, could easily be incorporated into planned instructional activities, and could be used to enhance or enliven an existing instructional activity. As such, these teachers preferred resources whose granularity is smaller than a typical class lesson.

This finding raises important issues regarding the ‘optimal’ granularity of digital learning resources. Granularity can be defined many ways, for example file size or semantic density (as defined by LTSC Learning Objects Metadata Working Group (LTSC, 2000)). Typically, educational digital libraries will catalog resources of varying granularity, from ‘large’ (for example, full courses) to ‘small’ (for example, a simple graphic). The findings of this study suggest that the way in which a digital repository catalogs and displays resource granularity will have a large impact on users’ perception of system utility. They also suggest that resources designers should concentrate their efforts of developing resources with smaller granularity, as opposed to large granularity resources such as modules or even entire courses. Given this focus, tools that support resource composition by teachers also become necessary. This is, of course, the niche that the Instructional Architect is intended to fill.

In the end, it is imperative that digital libraries and tools be easy-to-use, save users time, have demonstrable value, and fit into existing contexts, while not adding complications to teachers’ already busy lives and their heavy workload (Swaim & Swaim, 1999). Otherwise, they risk not being adopted by the majority of users. For example, the teachers mentioned desired functionalities such as secure areas for testing, grading, and classroom management. This suggests that emerging tools must be easily integrated with widely used classroom and learning management systems and standards.

In summary, we believe that there is a strong need for continual, in situ user studies in order to better understand the impact and adoption of emerging digital learning technologies and tools in educational contexts. In particular, as argued by researchers in distributed cognition, the mediational properties of tools can only be understood in terms of their embedding context (Brown & Duguid, 2000; Pea, 1993). Thus, tools offer opportunities or affordances for action, which may or may not be acted upon in any given situation. As such, any complete understanding must include systemic analyses of tools, actors, and contexts, and not simply focus on technological concerns.

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