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An NSDL Retrospective: The Case of the Instructional Architect

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July 2008

Revised: November 2008

Introduction

This retrospective essay covers the period from 2001-2008, during which the research group at Utah State University (USU) focused on designing, developing, and evaluating a National Science Digital Library (NSDL.org) web-based service, called the Instructional Architect (IA.usu.edu). Later in this period, the focus was on disseminating the IA service in school contexts by developing and implementing formal and informal teacher professional development opportunities. These efforts have been funded by a series of National Science Foundations grants.

This essay is presented as three sections. In the first section, we describe our efforts to build a simple software system, the Instructional Architect, deploy it with users, and integrate it with the NSDL core technical infrastructure. In the second section, we describe our efforts to better understand the target context of educators, and to develop sustainable and scalable teacher professional development models. The final section reflects on how the IA fit within the NSDL program. Each section also includes a subsection describing evaluation strategies.

This essay also reflects shifts in our thinking over this period. Early efforts reflected a kind of *technological determinism* (i.e., ‘if we build it, they will come’). This eventually shifted to a more *socio-technical* approach. An unspoken assumption of early work was that teachers and their students would access and use such technologies in unproblematic and seamless ways. Unfortunately, the history of educational technology suggests that this is seldom the case (Cuban, 2001). Instead, after spending time with ‘real’ people (teachers and their students) in ‘real’ contexts (classrooms), it became clear that we needed to better understand the complex ways in which systems cross institutional boundaries (Agre, 2003).

The Instructional Architect

The Instructional Architect (IA) is an end-user authoring service designed to support the instructional use of online resources in the National Science Digital Library and on the Web. The IA enables users (particularly teachers) to discover, select, sequence, annotate, and reuse online learning resources stored in digital libraries to create instruction (e.g., lesson plans, study aids,

homework – collectively called IA projects). In this way, the IA is intended to increase the utility of online learning resources for classroom educators (Recker, 2006).

Two Examples

We begin the description of the Instructional Architect with two examples created by teachers using our tool (see Figures 1 and 2). The foreground of each figure shows one of the teacher's selected online resources. The background shows the output of using IA: a web page containing the content created by the teacher, consisting of activities and annotations for online resources (referred to by links). Note how the level of detail in the projects varies; the project in Figure 1, intended for middle-school students, provides detailed activities for the students, whereas the project in Figure 2 (intended for kindergarten students) seems to be more of a lesson plan sketch.



Figure 1: Screenshot of an IA project page aimed for middle-school students

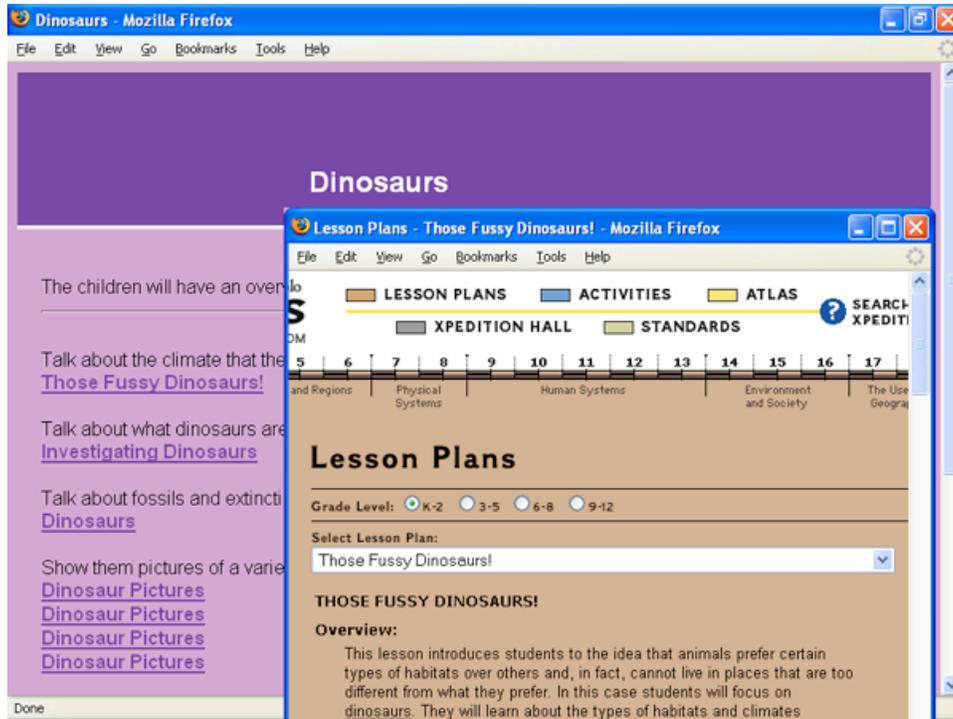


Figure 2: Screenshot of an IA project page aimed for kindergarten students

As is apparent from the figures above, teacher-created projects are fairly simple. Teachers are not web designers, nor should we expect them to be. Instead, they are professionals attempting to efficiently and effectively address classroom and learning issues.

Indeed, much of the functionality of IA could be recreated with blog software coupled with a social bookmarking system. However, as previously noted, by following a user-centered design process, we believe the system better meets the basic requirements of teachers who wish to use digital library technology to quickly and easily meet classroom demands.

System Description

From the home page of the Instructional Architect, users can 1) browse projects, 2) register as a new user, or 3) login as a registered user or guest (with reduced functionality).

1. Browse. Users can access IA projects by performing keyword searches or by browsing these IA projects by subject area, grade level, author's last name, or title (see Figure 3).

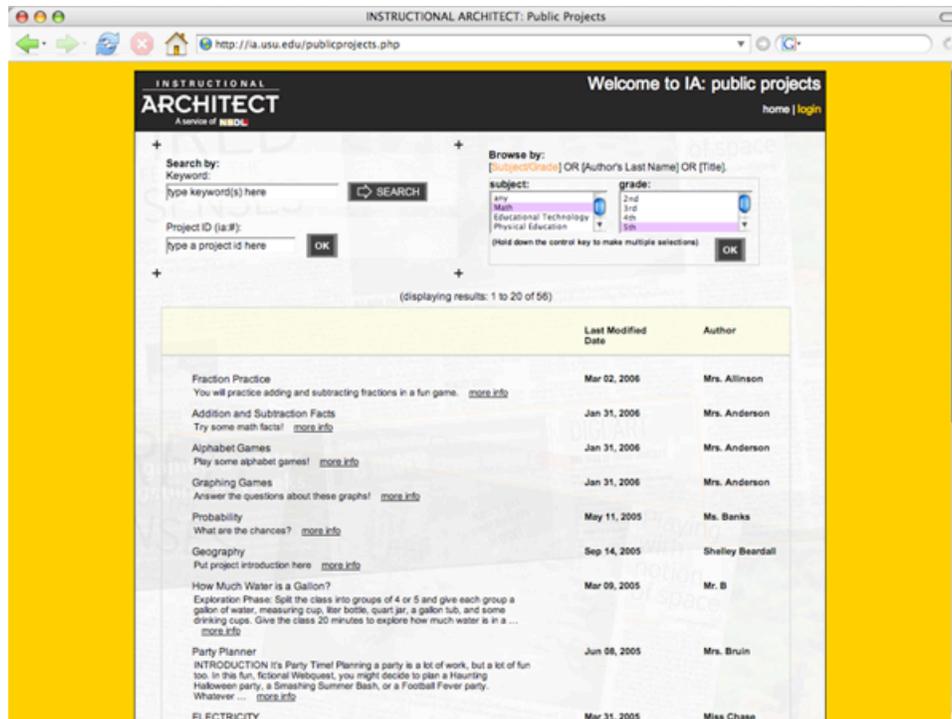


Figure 3: Browse IA projects

2. Register. Users can create a free account, which provides them secure access to their saved resources and IA projects.

3. Login. After the user logs in, the IA offers three major usage modes. First, with the ‘**My Resources**’ tool, users can search for resources in the NSDL Data Repository. Queries are sent to the NSDL REST-based search interface (Lagoze et al., 2006). Metadata records for matching resources are displayed to users in an abbreviated form (including title, author, brand, description, and date). After browsing these results and viewing resources, users can select desired resources for further use. Users can also select any Web resource including interactive and Web 2.0 content (such as RSS feeds and podcasts), and add it to their list of saved resources. Users can also organize their selected resources into folders (see Figure 4).

Second, with the ‘**My Projects**’ tool, users can create web pages in which they they select a look and feel for their project, input selected online resources, and provide accompanying text in order to create learning activities (called ‘IA projects’).

Finally, users can share their IA projects by ‘**Publishing**’ them and setting permissions on them, such as a) *user-only* view, b) users and their students (*student* view), or c) *public* view (anyone browsing the IA site). Users can also add basic metadata about their IA projects, including subject area, grade level, and core curriculum standard. These are then used to support browse and search of existing IA projects, as described above.

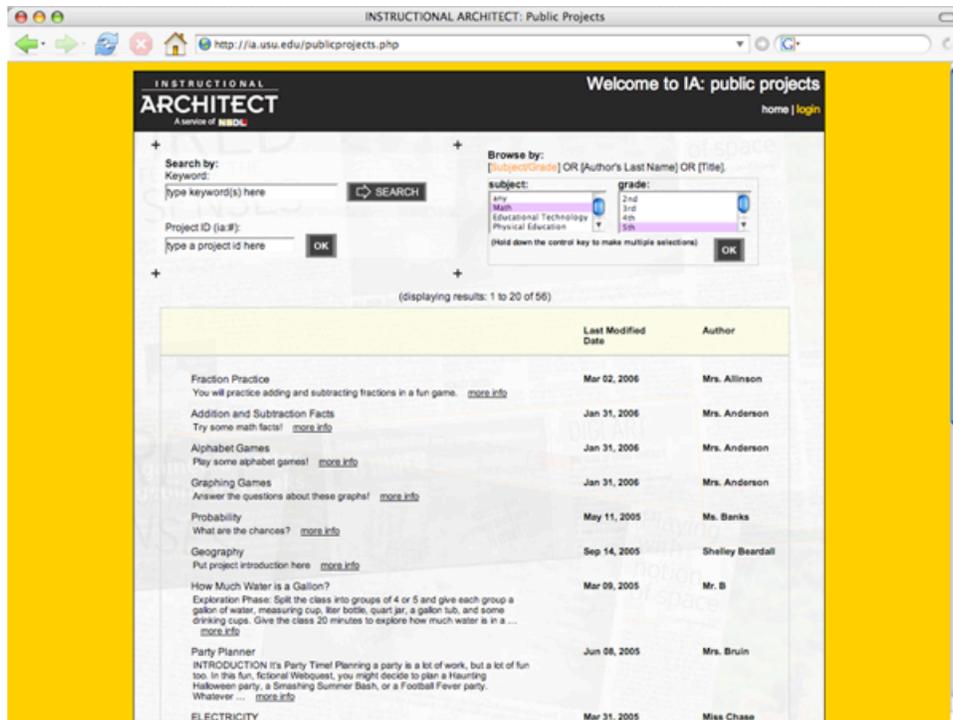


Figure 4: My Resources

Evaluation Strategies

Early design and evaluation efforts (2001-2002) focused on measuring usability and utility, referred to as ‘**developmental evaluation.**’ This included a **needs assessment** and **interface design and development** of the IA. Each design cycle was followed by an evaluation that helped inform the design of the subsequent phases. **Participants** included graduate students as early testers, pre-service teachers, and expert teachers.

Methods included literature reviews, focus group interviews, and expert review of prototype interfaces, early testing by members of the target audience, and analysis of code changes by constituents. Early recommendations included a search tool, and combination tool, and a reflection tool. In addition a more in-depth case study approach was conducted with 8 in-service teachers in Utah. They provided input on how Internet resources were currently used in their teaching practice, and contributed to the needs assessment.

At that time, the design, development, and evaluation of our project were hampered by the fact that the NSDL was co-evolving with our project. This meant that technical standards were in flux, resulting in system instability. In addition, the library collections were simultaneously being seeded and grown, resulting in uneven and sometimes sparse holdings. The latter caused no small amount of frustration among our classroom teachers as they attempted to search for interesting and relevant learning resources. To address this problem, we worked with other educational digital libraries, including SMETE.org, DLESE.org, and the National Library of Virtual Manipulatives (nlvm.usu.edu) to devise means to query their metadata. We were able to greatly benefit from the maturity of these projects.

In 2005-2006, as the NSDL gained maturity, our project worked on tighter technical integration with the NSDL Core Technical Integration. This included queries of the NSDL search service, pilot implementation of **community sign-on** (CSO) via Shibboleth, and co-branding. At the same, however, the NSDL as a whole, seems to suffer a bit from ‘wheel reinvention.’ For example, many projects are developing tools with similar functionality to the IA. Partly due to the ‘not invented here’ syndrome, projects wanted functionality that differs slightly from what the IA provides. Hence, they found it easier to simply built their own. In general, the NSDL as a whole needs to consider strategies that avoid ‘tool silos’.

The IA as a Teacher Tool

As NSDL tools gained maturity, it became clear from field testing that we needed to better consider the target context. For example, many schools lacked sufficient technological infrastructure (e.g, inadequate computers, filtering software that blocked access, overbooked labs). In addition, many teachers lacked sufficient technology knowledge, as well as knowledge of how to use technology in service of content and teaching goals, referred to as *technological pedagogical content knowledge* (Mishra & Koehler, 2006).

As a result, we embarked on a project of developing a teacher professional development model. The perspective informing our approach is one in which teachers can be viewed as designers of learning activities for their students, a position generally aligned with a constructivist learning philosophy, and called ‘teaching as design’ (Brown & Edelson, 2003).

As part of the ‘teaching as design’ framework, Brown & Edelson defined a continuum of teachers' curriculum use, ranging from **offloads** to **adaptations** to **improvisations**. In offloads, the curriculum is implemented essentially unchanged and the bulk of instructional decisions are contained in the resources. In improvisation, the teacher flexibly borrows and customizes pieces, while playing the major role in the decision-making process. The adaptation category represents the mid point of the continuum.

Brown and Edelson surmised that curricular materials afford and constrain design, interacting with teachers’ unique knowledge, skills and experience. But they noted that the continuum is neutral with regards to quality or effectiveness of the teacher or their designed activity. For example, in designing a class activity, an offload strategy may be planned by a teacher with low pedagogical or subject matter knowledge who cannot perceive a need to adapt a resource. The same offload strategy might be employed by a teacher with high pedagogical or subject matter knowledge who plans to wander around the room giving individual help to students.

Informed by this framework, we argue that the kinds of learning activities teachers can design are both supported and constrained by the wide availability and diversity of NSDL resources, and that the design of these activities also interact with teachers’ unique backgrounds and needs. Brown and Edelson's continuum of teacher curriculum use provides a starting point, then, from which to examine how and why teachers use online learning resources. In particular, aspects of the Brown and Edelson continuum were operationalized to classify teacher design of learning activities, as follows:

1. **Improvisation:** teachers link to resources as a starting point or reference, but have clearly designed their own elements such as learning goals, added instructional content or activities, description of context of resource use, and assessment items;
2. **Adaptation:** a midpoint, with only some of the elements listed above;
3. **Offload:** teachers provide links to resources with little additional teacher-created instructional guidance (e.g., explanations or instructions). Use tends toward lists of links (perhaps with added navigational information).

Professional Development Model

Following best practices from the teacher professional development literature (Borko, 2004), we designed a professional development model consisting of two hands-on workshop sessions with between-workshop activities that include teaching, sharing, and communicating.

The characteristics of the professional development model are summarized in Table 1. The model follows a modified problem-based learning (PBL) approach (Barrows, 1996), which was selected in part because it has proven to be effective in professional development settings with adult learners (Walker & Leary, 2007).

During the first session, teachers are each asked to identify an instructional problem and then to design learning activities using the Instructional Architect and using online resources from the National Science Digital Library to meet identified classroom needs. Although PBL intends students to be self-directed, typically problems solved by students are carefully designed and sequenced to both promote student learning and mimic real world problems. In our case, in an environment where teachers needed to see immediate relevance, we opted to err on the side of authenticity and have teachers select their own problems. This has the disadvantage of not being able to design problems that bring out the features of the professional development that we identify as most critical to learn, but the benefit of allowing teachers to see immediate benefit from their efforts.

Between the two workshops, participants design further activities, some of which are implemented in their classroom. They also engage in small group interactions. Note that in the full version of PBL (Barrows, 1996), these types of interactions have two essential parts, the first serves as a discovery phase, in which group members discuss the problem, brainstorm about their existing knowledge gaps in relation to finding a problem resolution, then split up the task of addressing those knowledge gaps. This phase was not part of our workshop model predominantly because teachers were not asked to solve the same problem, rather one that was unique to their own classroom. The second phase consists of reflection, a critical analysis of solutions and of the knowledge used as part of that solution. This phase was a part of the workshop, both in between the workshop activities, and supported by a simple email listerv, as well as within the second workshop. In addition to online interaction, participants were encouraged, and did engage in face-to-face interactions where possible.

Table 1. Professional development model

Phase	PD Goals and Activities	Data Collected
Workshop 1	Learn about digital libraries and tools Learn search techniques	Pre-survey Observations

	Engage in modified PBL. Participants: <ul style="list-style-type: none"> Identify authentic instructional problem Design IA project(s) to address need 	
Between workshop activities	Continue modified PBL Activities: <ul style="list-style-type: none"> Implement IA project(s) in classroom Review peers' designed activities Write reflection paper noting barriers and successes 	Email discussions and follow-up Reflection papers
Workshop 2	Increase design capacity with online resource Finish modified PBL activities: <ul style="list-style-type: none"> Reflect on and discuss designed activities and classroom implementation stories Reflect on and discuss pedagogical and design strategies 	Group interviews Observations Post-survey Webmetrics IA project analysis

At the second session, participants present, discuss, and reflect upon their classroom implementation activities and experiences. Table 1 also shows data that are collected at each stage for research and evaluation purposes.

Evaluation Strategies

In 2004/5, we began a more systematic implementation and evaluation of teacher professional development workshops, including face-to-face and online versions. Through working with other NSDL projects, we were inspired to implement and collect detailed webmetrics (described later) analyses of usage, as well as developing online surveys that used items developed by other NSDL projects. These more automated forms of data collection greatly helped in our understanding of users and their needs.

During this period, we also worked more closely with NSDL projects, including the Exploratorium, Wayne State, and the Math Forum, to share teacher professional development materials and strategies.

Evaluation methods include online surveys, participant observations, classroom observations, group interviews, key informant interviews, IA project analysis, and webmetrics.

Findings were analyzed in terms of implications for current and future IA programs, product upgrades, and evaluations, specifically:

- 1) The impact of IA curriculum on participants in terms of their knowledge, attitudes, and competency using digital resources and IA.
- 2) Feedback from participants about how the IA curriculum could be improved.
- 3) Feedback from participants about how IA itself could be improved.
- 4) Feedback from participants about how the evaluation and instruments used could be improved (called **participatory evaluation**).

The IA as an NSDL Service

In terms of fostering collaboration, a critical venue over the years has been the NSDL Annual meetings. The project particularly benefited from participating and attending sessions, as well from spontaneous ‘hallway’ conversations.

During this period, project PI’s were integrally involved in the NSDL’s nascent Evaluation and Education Impact Standing Committee (EEISC) committee. In particular, the exchanges at NSDL Annual meetings helped clarify out thinking. Most recently, the long-term sustainability and utility of these NSDL committees has been questioned, as their volunteer nature competes with more urgent project demands.

Evaluation Strategies

Participation in this committee spurred two important evaluation activities. The first was the development of a logic model for our evaluation program, which made explicit the existing current conditions and assumptions that justify the grant, the program objectives, program activities to achieve those objectives, and desired outcomes from the program. Also included in the logic model are research and evaluation milestones and objectives that measure our progress and results (see Figure X for an early example).

The second development was the implementation of user tracking and analysis (called ‘webmetrics’) in greater sophistication since the beginning of operation. 2008 last year has seen remarkable increase in the ability to track user behavior using web-usage data. These data are the foundation for at least one doctoral dissertation study by Bart Palmer. Data described next were collected 17 July 2008.

User Registrations. The IA now has over 3350 registered users. For the year August 2007 through July 2008, the IA had 1,027 new registrants (+32%). When broken down into Aug-Dec and Jan-May, we enjoyed 519 (+40%) and 508 (+26%) new registrants, respectively.

Project Creation. Over 5,850 projects have been created by teachers—with 1,994 (+58%) being created this last grant-year. Fall project creations totaled 936 (+23%) and Winter/Spring saw a whopping 1,058 (+113%) creations. This is especially important, as described below that project and resource use are also increasing dramatically.

Resource Utilization. A project-resource is one which has been collected by a user and then utilized within the context of a project. The number of project-resources added to new project was 6,620 (+53%), split almost evenly between Fall and Winter/Spring with 3,519 (+40%) and 3,101 (+71%), respectively. Taken as an average, the number of resources per project in the past has been around 2; these new numbers show that this ratio has now increased to 3.3 resources per project for new projects created this year.

Project Usage. Project views are counted each time a page is refreshed. This is a departure from webmetric standard practice because of our particular user-base. For example, with in-class mini-lab use of an IA project, several students can reload the same project on the same computer within the industry-standard 30 minute session. 235,560 (+110%) successful project requests were served. Again, this usage was nearly evenly split between the two halves of the US

academic year with 114,428 (+213%) and 121,132 (+61%). While not all projects are accessed equally, the number of views per project (across all IA projects) this grant-year is 40. The new advances in data collection will allow more detailed analyses should be able to discriminate different usage patterns and allow us to view project views with more precision in the future.

Resource Usage. This metric tracked the number of times each resource was clicked in IA projects. Unfortunately spammers learned they could abuse this data-gathering code and it was removed from production until a fix could be made to the code to reduce the probability of spam usage. Because the fix was implemented in January, the number of resource clicks can roughly be compared between the last two Winter/Spring parts of the year, being 92,126 (-2.54%) for Jan-May 2008. This reduction in numbers has several possible explanations, which are being investigated.

Note that there are far greater project views than resource clicks; this discrepancy also has valid explanations in that our bounce-rate (or number of one-hit-visits) is about 40% for all our pages, but higher (60%) for projects. Meaning that many project hits are the only hit to our site that user makes. This can be due to several reasons like, a specific search in which the visitor finds the IA project does not contain the specific information they are looking for. This can also be understood (as mentioned) in the previous counting of projects, which is overestimate of true project views. The quality and design of projects has now become more specifically discussed in our workshop as a result of these webmetric analyses.

Visits. The additional insight from tools like Google Analytics (<http://google.com/analytics>) has brought us a wealth of knowledge. For example, we understood our usage was probably related to the week and academic cycles in the United States, but we did not know how closely. Figure 5 shows the weekly visits for the grant-year now ending. Notice how summer, Thanksgiving, Christmas, and President’s Day vacations dramatically lower IA usage. The spike in late March 2008 was during several workshops and outreach efforts in major educational conferences where the IA was featured.

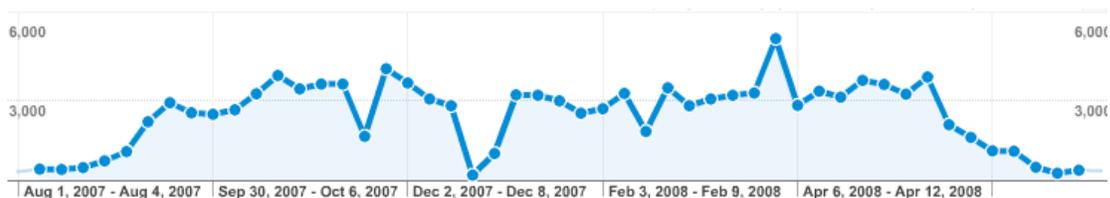


Figure 5: Graph of weekly IA visits from 1 Aug 2007 to 17 July 2008—note the correlation of visits with the US academic calendar.

We have found that analysis of user tracking data can help us better understand our user base and inform our outreach efforts and professional development workshops. This last grant-year has seen a great advance in the use of the IA by teachers and students alike. The inclusion of webmetrics observation and analyses has enhanced our ability to perceive these changes.

The work of this grant in reaching out to pre- and in-service teachers has directly contributed to the increase of IA usage—both in creation and usage of IA projects. Noting specifically the increase of the number of resources per project indicates that our registered users are beginning to “mash-up” content more than ever before as they collect and reuse online educational resources. Our continuing goals of better collection and analyses of these and other metrics are an integral part of research and outreach efforts.

Conclusions

Reflecting over the past several years, we see clear changes in the purpose and vision of the NSDL, from its original conception as a union catalog library to one that is more collaborative, contextual, and participatory (Lagoze, Krafft, Payette, & Jesuroga, 2005). Indeed, we argue that progress toward this “new” NSDL has been hampered by the name ‘library’, as it perhaps conveys more traditional and static notions.

These changes in the NSDL are enabled by the new underlying architecture, FEDORA. This architecture allows the expression of a range of relationships between digital objects. However, from a ‘services’ viewpoint, we believe that the NSDL continues to be primarily driven by technical concerns, leaving out the voices of the users. This is especially true of the K-12 world, which has its own complex set of problems. Much research in schools has documented wide disparities in funding, infrastructure, and vision. Moreover, it shows a wide disparity in the range of teacher literacy skills with regards to new information technologies. In our work, we have noted that while teachers are generally quick to catch the NSDL’s vision, profound changes in their practices is much more elusive.

As an example, we have considered using the NSDL blogging tool, *Expert Voices*, with our teachers. Our experience suggests that, at this point in time, the required login and collaboration patterns are too complex for our users.

For the future, we see at least two critical next steps. First, some notion of community sign-on must become widely adopted in order to facilitate seamless interaction. Unfortunately, the current implementation, Shibboleth, has been slow to catch on, perhaps due to its technical complexity. For example, our own implementation has taken over two years, despite high levels of supports.

Second, future innovations should move along the lines of something like *Facebook*. Like this popular social networking tool, the technical infrastructure should provide a set of baseline services and data, then allow collections and service providers access to an open architecture in order to build on the top of that baseline. These developments could then more easily be shared within the NSDL community. Definitions of such baseline functionality should be done following a user-centered design approach.

Finally, as NSF funding decreases, the NSDL must continue to grapple with various business models. This is a problem whose complexity cannot be overstated. As has already been done, we must look to the Open Source Software community for interesting examples. Of late, the music industry has also developed successful models. For example, Magnatune.com has developed

shareware models for music, which appear to appeal to consumer, musicians, and distributors. It remains to be seen, however, the extent that education can adopt and adapt such for-profit models in supporting a public good.

Acknowledgements

This work was partly supported by grants from the National Science Foundation (DUE 0085855, DUE 0333818, DUE 0434892, DRL 0554440). Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation. We thank the participating teachers and members of the IA research group (Andy Walker, Brooke Robertshaw, Bart Palmer, Kristy Bloxham, Heather Leary).

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