What We Mean When We Say "Repositories"

User Expectations of Repository Systems

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Abstract
As part of a larger project to develop repository tools and resources, the Academic ADL Co-Lab conducted a series of informal surveys, surveying partners, project representatives, and interested parties regarding the functionalities they expected and preferred to find within a repository system. We initially defined a repository as "a system that stores electronic objects and meta-data about those objects." Responses to the survey revealed that many respondents expected repositories to deliver a number of functionalities not included in our strict definition of "repository," but which existing projects or software may have led them to expect.

Introduction
More and more projects within the fields of e-learning and traditional education have identified a need for repositories. Repositories are very much in demand because educators of all kinds are developing digital educational content. Many content creation and educational projects are not satisfied with placing their products on isolated websites, to be discovered and used by users with only unpredictable search engines as their guides. The leaders of these projects hear that repositories can make these pieces of digital content accessible and reusable, providing a location on the Internet where these materials can be stored and discovered, and at times these leaders have made repositories into requirements for their initiatives' project plans or written them into their grants.

Repository systems can do more than store materials, and various repository projects have developed software with a variety of functionalities. These repository projects have packaged their systems with tools that can aid in the development of resources compliant with that repository's content format and meta-data specifications. Other repository systems make use of RSS and trackback, or produce harvestable meta-data. None of these functionalities are covered by our strict definition of the term "repository."

The various functionalities that many recently developed repositories have included are worth investigating. These systems, with their additional functions and tools, have an impact on which benefits users believe repositories will bring to their own projects, and what needs, in addition to the storage, discovery and retrieval of content, they feel repositories will serve.

There are a number of expectations that various communities place upon repositories. **One of the goals of our research – and this paper – is to inform our own development of repository resources by identifying the needs users expect repository systems to respond to and fulfill, thus making creators better able to develop resources that users will respond to and adopt. We also hope that this research will contribute to a broader understanding of expectations toward repositories within communities interested in technology-enhanced education.**

To illustrate what projects are meeting these user needs, and to provide readers with some examples of systems that meet user needs, we have provided some examples of various resources and tools that have been developed in order to meet the needs described in this paper. We should note, however, that most of the resources and tools we describe do not

fit our definition of repositories; many do not store the electronic objects but only manage the creation, maintenance and searching of meta-data. It is the hope of the Academic ADL Co-Lab that "true" repository systems will develop that combine content and meta-data management while meeting the user needs that repository community has long been aware of and which we are continuing to research.

Background

The surveys that this paper draws upon were inspired by the Academic ADL Co-Lab's experiences studying learning repositories, surveying learning repository leaders and administrators, and meeting with those leaders and administrators during our Global Learning Repositories Summit in October 2003.

One of the priorities of the Academic ADL Co-Lab's repository research has been to describe common challenges among repository projects that can be used as a basis for future collaboration. In the interest of community building, and to encourage standards compliance among learning resources and their meta-data, we have sought ways to bring interested parties together.

In October of 2003, the Academic Co-Lab organized and hosted its first Global Learning Repositories Summit, bringing together leaders within the field of learning repositories to define common challenges and describe various approaches to those challenges. From the various presentations and discussions that took place during the conference, it was clear to participants that while repository projects did have a number of challenges in common, the ways in which they approached these challenges arose from the various contexts created through the intersection of user needs and institutional priorities.

The summit was organized around two themes: maintaining quality content and quality meta-data within repository systems. Yet, as the conference members moved from presentations to the more open structure of panel discussions, the range of questions quickly expanded beyond these original themes. Questions ranged from user tracking to repository security, from community building to the indexing of various media. It was clear from the discussions that each repository implementation was trying to meet a variety of user needs.

In *From Local Challenges to a Global Community*, a paper produced by the Academic ADL Co-Lab after the Global Learning Repositories Summit, this author commented that "many know that repositories are needed, but few know what they are," a statement of consequence for any group trying to deliver repository services to educational groups and projects. If users do not agree among themselves what they are asking for when they ask for a repository, how are we to respond to their requests when they use this word? To aid us, and hopefully other project leaders, we surveyed persons from content development projects, digital libraries, and others with a general interest in repositories, to discern what it is users are talking about when they talk about "repositories."

Methods

Over the spring and early summer of 2004, the Academic ADL Co-Lab conducted three surveys. In identifying the population to survey, we chose to send the first two surveys to:

- **Academic ADL Co-Lab's partners** – Including academic institutions, as well as organizations and groups dedicated to the development of technology-enhanced learning.
- **Representatives of content development projects related to the Academic ADL Co-Lab** – Many of these projects had frequently mentioned that the content they were producing would eventually require a repository for its eventual storage for reuse. Their proximity to the lab itself also provided us with the opportunity to make frequent follow-up inquiries.
- **Representatives of projects and institutions engaged in the creation and/or organization of digital content on the University of Wisconsin Campuses** – It was our good fortune that at the same time as we were conducting this research, a meeting was called among representatives of projects either producing materials requiring a repository or developing repositories or repository software themselves.

Our first survey was sent to 56 persons. We received 13 individual responses, our second was sent to 45 individuals and received responses from 12. Our third survey was sent to a mailing list with an unknown number of respondents and received 13 responses. Two persons participated in both the first and second surveys. Thus the total number of respondents to all surveys was 36.

The individuals who responded to our surveys were primarily persons of responsibility within projects that were researching, developing, or delivering e-learning content. Among the respondents whose titles we were able to identify were:

- A company President;
- Four project directors;
- Four assistant or departmental directors;
- Three instructional designers;
- Two coordinators, one of educational production and other of technology;
- One technician;
- Three programmers; and
- Five librarians or information scientists.

This population's varied expertise, and varied long term experience within their fields, provided a useful source of information on the varieties of expectations that are placed upon repository systems, drawing upon the various groups that either depend upon them for material, or are concerned with their development.

The initial survey asked respondents to describe:

- Minimum requirements for a repository system;
- Optional requirements that they would like to see; and

- Various situations (i.e., use cases) in which a repository system would be used and how.

Our second survey drew from the results of the first. From the variety of responses we constructed a list of repository features, and added our own ideas as well. We tried to include in the list every functionality that respondents had listed, adjusting only the phrasing or translating overly vague requests into descriptions of technical features that would deliver the requested functions.

The second survey also presented respondents with a short list of broadly defined issues of relevance to repository users. These included content and meta-data standards, user authentication, user interfaces, and more. Respondents were asked to rank these categories according to their importance with respect to their or their users' needs.

Our third survey combined questions from both the first and the second, but the population of respondents was different. The third survey was sent to the IEEE Learning Technology Standards Committee (LTSC) mailing list. The results from this survey were considered separately from the others as they were drawn from a community with an interest in e-learning standards and thus, we assumed, some agreement regarding the importance of specific standards.

Results Analysis - First Survey

Our strict definition of the term "repository" describes a system that stores electronic objects and meta-data about those objects. In the minds of many respondents, however, a repository should be packaged with a number of functionalities. When asked what the *basic requirements for a repository* would be, respondents gave responses which referred to broader issues such as:

- Meta-data management;
- Content management; and
- Interoperability.

Meta-data Management

Almost all respondents wrote that they expected repositories to store meta-data about the objects they contained. Further expectations that built upon this central expectation included conformance to specific meta-data standards such as the Dublin Core as well as automatic meta-data creation and indexing by subject. From these responses we discerned an expectation among some users that a repository system **provide tools and resources to aid in meta-data creation and organization**.

Content Management

All respondents required that users should be able to upload and download materials. Other comments, again describing minimum requirements, included that the repository should allow for updating of materials and announce updates within the collection. Some wrote that a repository system must be what one respondent called "type agnostic" with respect towards the materials stored within. Among the other requirements respondents listed were:

- Individuals should be able to "create their own collections in unmediated ways," giving them powers to set and restrict access to those collections;
- Unique identifiers for contents;
- Consistent granularity of materials as requirements for a system; and
- Digital rights or licensing-related features.

From this mix of responses we discerned an expectation among many respondents that a repository system should **provide interfaces and tools that facilitate the management of repository contents**.

Interoperability
Many respondents expected a repository system to be conformant with content interoperability standards, as well as being conformant with, or providing crosswalks to, meta-data standards. These attributes of a repository system would permit interoperability with other repository systems, broader distributed search systems, or learning management systems. Some requests referred to specific collections or distributed search systems, making it difficult to generalize expectations. But from these responses we easily concluded that **many expect repositories to interoperate with and be compatible with a variety of library, learning management, and other repository systems**.

Interestingly, two respondents, both from projects that had identified a need for a respository, *could not describe any requirements* for a repository.

It seems that many respondents wanted a system that allows content and meta-data to be created and manipulated in ways that ensures that meta-data's coherence, organization, and usability both within the repository itself and, in some cases, within other systems. This system for maintaining the organization of content and meta-data could be maintained by software that automates or ensures specific management practices.

Respondents were very consistent in their requests for resources useful in addressing problems arising from content or meta-data management. **It can be tentatively concluded that respondents desired techniques or technologies that allowed them to confidently manipulate content and meta-data without compromising the coherence and usability of the collection**.

Some respondents, when listing a repository's optional requirements, described functionalities such as the preservation and versioning of materials, and resource referencing through automatically generated identifiers. Two respondents indicated they believed that a system of unique identifiers would provide those functionalities, as well as other functionalities such as facilitating the development of federated repositories and making easier the discovery of items and collections.

Many requests were unique to individual respondents, reflecting the priorities of their projects, and were thus not statistically significant. A consistent tone among some respondents implied a desire to remove responsibilities for content and meta-data

management from the human-directed to the machine-directed domain. Other respondents requested features that facilitated the viewing of materials in various media and "workspaces" for collaborative authoring of materials. Meeting even some of these needs would require a repository system that provided a "library" of optional functionalities.

Use Cases

The use cases provided by survey respondents, describing various ways in which users might make use of a repository system, revealed that survey respondents imagined repository systems being used frequently by users unaccustomed to the system itself. It can be generally concluded that respondents did not imagine a repository system as a tool to be adopted by an organization or user group already prepared to take on the responsibilities of knowledge management. Expectations and use cases revealed a hope that repository systems would be tools for content and meta-data management by allowing users to take on a variety of roles in the creation and management of materials and meta-data. Many of the respondents who described use cases did so under the assumption that properly authenticated users would be free to create and modify authorized content and meta-data, or create their own collections of materials. A few respondents also suggested that the repository system would be packaged with resources that facilitated an introduction to – or an aid to – content and meta-data management themselves.

These findings show that **respondents wanted tools and resources that helped them as they entered the realm of content management, and would like systems that provide that help**. To provide this help would, however, be relatively complex in practice. Respondents felt very free, when describing minimum requirements for a system, to describe functionalities with technical requirements that might be very difficult to meet. The differences, in terms of technical requirements, between providing a place for storing materials and meta-data (regarded by almost all respondents as minimum requirements for a repository) and meeting wider user expectations is very large. Automatic meta-data creation and indexing, content management, versioning and unique identifiers, are all difficult to facilitate technically.

Results Analysis - Second Survey

When faced with more pointed questions in the second survey, respondents gave results that were easier to organize for comparison and to identify common themes. Survey respondents were asked to rank proposed repository functionalities with regard to whether they were of Very High, High, Low, or Very Low priority. We found that respondents consistently rated a number of issues as being of high priority. These were:

- The use of standards-compliant meta-data;
- Being provided with a meta-data editing interface at the point at which materials are uploaded;
- Automatic meta-data creation;
- Licensing and copyright information being provided by those uploading materials;
- Repository software being open-source;

- Repository software being cross-platform;
- Repository being interoperable with a learning management system;
- Repository being able to interface with another system using one or more interoperability standards;
- Repository allowing users to reference specific versions of materials; and
- Repository allowing generic workflows to be developed and enforced.

While there were strong consistencies in the results we received, we also took note of those areas in which expectations varied the most. There were many proposed repository functionalities that some respondents rated as being of very high priority and others rated as being very low. There was the least agreement among respondents regarding:

- Specific interoperability standards: To our surprise, compliance with the IMS Digital Repositories Interoperability specification[1] was given the highest priority over all compared with compliance with other listed interoperability standards;
- The packaging of development tools within the repository system;
- The need to package repository systems with tools that would ease the development of workflows for either content or meta-data creation;
- Whether the repository system should be able to enforce copyright or intellectual property law through encryption or other technical means, though there was a consensus that a repository should describe a resource's copyright or intellectual property status;
- The need for alerts from the repository system to its users, letting users know whether new materials had been submitted to the repository; and
- The extent to which an unauthenticated user should be able to interact with a repository system. Some felt that only authenticated users should interact with a repository, others felt that unauthenticated users could be allowed to not only retrieve but also upload materials to the repository itself.

While no proposed functionalities received a consistently low rating from respondents, a small number that did receive mixed ratings were on average more often disapproved of than approved. These functionalities included conforming with METS[2] and Z39.50/SRW.[3] Respondents also gave relatively low ratings to functionalities that provided access to content authoring tools as well as to functionalities that permitted

[1] The IMS Digital Repository Interoperability (IMS DRI) model is the product of the IMS Digital Repository Working Group. The goal of the IMS DRI is to provide repository technology to support the 'presentation, configuration and delivery of learning objects.'

[2] The Metadata Encoding and Transmission Standard schema is a standard for encoding descriptive, administrative, and structural metadata regarding objects within a digital library, expressed using the XML schema language of the World Wide Web Consortium. The standard is maintained in the Network Development and MARC Standards Office of the Library of Congress, and is being developed as an initiative of the Digital Library Federation

[3] Z39.50 is an American national standard for information retrieval. It is formally known as ANSI/NISO Z39.50-1995 - Information Retrieval (Z39.50): Application Service Definition and Protocol Specification. This document specifies a set of rules and procedures for the behavior of two systems communicating for the purposes of database searching and information retrieval. As a network application standard, Z39.50 is an *open* standard that enables communication between systems that run on different hardware and use different software.

unauthenticated users to both search and upload to the repository collection. Nearly every proposed feature, however, found some respondent willing to rank it as being of high priority and a majority had at least one willing to rank it as being of very high priority.

Respondents were concerned with how a repository would function in concert with other systems. It is clear that most respondents did not see repositories as isolated sites on the Internet, established in the expectation that visitors use its resources through a single access point. **Respondents imagined a repository system within a technical and practical context with which it would have to interoperate.** There was an expectation among respondents that a repository system should fit into an educational context already shaped by technologies such as learning management systems and by practices that already make use of digital content.

Respondents to the second survey were also given a set of broadly defined issues which we had identified through the first survey as being of almost universal interest. Of these common issues we were interested in knowing which were considered to be of greater and which of less importance. Thus we had respondents rank these nine issues according to importance to the respondents' projects or user needs. Averaging the rankings given by respondents, the issues of importance, from most to least, were:

1. Meta-data standards;
2. User authentication;
3. Meta-data interoperability;
4. Digital Rights Management;
5. User interfaces;
6. Meta-data production process;
7. Content standards;
8. Content interoperability; and
9. Content production process.

In contrast to his own predictions, this researcher was surprised by the consistently low ranking that the issues of user interfaces received from respondents. While the group was of mixed technical background and expertise, there was a common understanding of the importance of what we could call administrative tasks in the functioning of repository systems.

Also of note is the large difference between the importance given to meta-data standards and those given to meta-data production. Respondents focused on an issue related to meta-data export while the process by which that meta-data is produced received less attention, even though the meta-data production process could ensure, or at least have an effect on, the quality of that meta-data.

We also noted the low importance placed upon the repository as a means for ensuring content standards, production, and interoperability. This is intriguing because during our learning repository summit, one common complaint about repositories that many attendees reported coming from repository users was the inconsistency of content. It may be that the number of technical issues that must be faced by an emerging repository can

often eclipse the issue of content quality, or that respondents trusted that these issues would be dealt with through institutional, instead of technical, means.

We also found that two policy issues were of high importance to respondents, even though respondents did not agree on the specific policies that would satisfy user needs. These were digital rights management, and user authentication, which was seen to be the most important of the two.

Results Analysis - Third Survey

Our third survey was made up of two sections, combining sections from surveys one and two. In the first section we asked respondents to describe the minimum requirements and some optional requirements for a repository system. We also asked respondents to describe use cases within which various users would interface with a repository system. In the second section we asked respondents to answer a set of questions about the relative usefulness of various repository functionalities. This second set of questions was very similar to those asked in the second survey.

The results of this survey were useful in a number of ways. In response to the request for use cases we were able to get a number of well described examples from the body of respondents. These use cases revealed an understanding among respondents that a repository must be responsive to changing technical and pedagogical needs among its users. Respondents described situations in which teaching materials, or e-portfolio resources, stored in a repository should be easily repackaged to meet new needs within a changing context. These use cases will be further described in an upcoming paper reviewing repository use cases. In response to the questions regarding minimum and optional repository requirements, we found that respondents were very consistent in their description of a repository's minimum requirements, stating that a repository system must permit the uploading, storage, searching, and retrieval of learning materials and meta-data.

When describing optional requirements for a repository, respondents expressed interest in:

- Object tracking and reporting;
- Digital rights management;
- Personalization;
- Authentication and authorization; and
- Meta-data production workflows.

Interpreting the answers to the second set of questions was difficult because, in contrast to the respondents to the first survey, respondents were generally in favor of every repository functionality that the survey described. To interpret the desires of this seemingly more optimistic population we distinguished those functionalities that more than half of the respondents "Strongly Agreed" were useful in a repository system. These functionalities were:

- Meta-data editing interfaces that could be used both at point of upload and at any time after upload;

- Facilitating the versioning of materials by allowing various versions of a resource to be referenced;
- Requiring authentication for the uploading and retrieval of materials;
- Cross-platform system; and
- Interoperability with authoring tools.

Respondents were also very interested in a repository's ability to import meta-data conformant to various standards and specifications. Because the survey respondents were on the IEEE Learning Technology Standards Committee mailing list we remained conscious of their group affiliations when assessing their responses. We found that:

- Respondents were generally interested in conformance with IMS specifications, Z39.50/SRW, Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH), and the Open Knowledge Initiative (OKI), although we did have respondents who did not feel that the OKI or the IMS specifications were useful to their project or their users.
- Respondents had mixed feelings about METS, but felt that they could use a repository that could import meta-data conformant to Dublin Core, the SCORM meta-data specification, and (of course) IEEE Learning Object Metadata (LOM).
- Respondents were interested in supporting RSS, and very interested in supporting WebDAV[4]

Respondent Expectations and Current Resources and Tools

Drawing upon a variety of respondents we were able to identify a set of expectations that, in general, we could assume interested parties desired in repository systems. While our sample size was small it is still useful for judging the capacity of current projects and tools to meet the expectations expressed by survey respondents.

Through previous research supported by the Hewlett Foundation, we identified many resources that existed for the collection of meta-data about learning resources. We were thus aware of some projects and tools that existed that met the user needs that we discovered through our surveys. It must be stressed, however, that we have not identified a system or set of tools that accomplish all or a significant portion of user feature requests.

Our respondents expressed a strong interest in meta-data standards compliance, and thus, in our interpretation, meta-data interoperability, in the capacity of individual repository systems to exchange data and form larger interoperating networks.

There are a number of projects that take steps to meet this expressed interest. The National Science Foundation-funded National Science Digital Library (NSDL) requires that the individual systems that make up its collection comply with the Open Archives Initiative Protocol for Metadata Harvesting, an interoperability specification that uses the

[4] WebDAV stands for Web-Based Distributed Authoring and Versioning, and provides a way to remotely author and manage content. WebDAV is a protocol standardized by the IETF.

Dublin Core Metadata Element Set. The Campus of Alberta Repository of Educational Objects (CAREO), a major Canadian project providing access to educational resources, uses the CanCore Learning Object Metadata Application Profile. CAREO's goals include interoperability with other repository systems. Similarly, Educational Network Australia (EdNA), another similar meta-data project serving Australian educational institutions, has developed its own metadata and interoperability specification, based upon the IEEE Learning Object Metadata Specification. This specification was developed for the express purpose of ensuring that its records can be easily shared.

There are a number of tools that speak to the concern with the standards compliance and interoperability of meta-data. The NSDL has funded the development of the Scout Portal Toolkit, an open source software package that permits users to establish a meta-data registry. All instances of the Scout Portal Toolkit are capable of producing meta-data compliant with the Open Archives Initiative Protocol for Metadata Harvesting, thus permitting the inclusion of their meta-data in the NSDL's collection. The Canadian POOL project developed a peer to peer architecture for distributed repository systems. This project has developed its own downloadable tool permitting users to establish meta-data registries on their own servers, permits easy creation of a network of interoperating repository systems, each communicating with each other using CanCore compliant meta-data.

From our own contact with many of the projects we researched, we have become aware that there are a number of distinct projects interested in establishing their own portals or collection of educational resources, in spite of the increasing number of larger collections of resources already established. Given that projects are continuing to develop their own collections on their own servers, it is essential that the tools exist to ensure that when they develop these collections, the collections are able to interoperate with each other through the exchange of meta-data.

Some areas in which respondents expressed interest do not seem to be available through the systems and tools currently available. The most used collections and tools do not provide for automatic meta-data creation. Nor do these systems provide tools that enforce digital rights and the intellectual property status of the resources they contain. Some systems describe the legal status of a material within a meta-data field, but this meta-data field has no impact upon the capacity of a user to download or copy the materials they locate.

Many respondents were concerned with the role that user authentication would have in permitting users to submit or retrieve resources from the repository. Within most collections of educational resources, the projects that have established rules restrict the right to submit materials those with an account. MERLOT, a project that relies upon user submissions to build up its collection of resources, allows users with an account to submit resources, while the Learning Matrix, another such collection located on The Ohio State University campus, accepts any submissions but subjects those submissions to review.

Among the tools currently available, the Scout Portal Toolkit allows users to define various user roles within a specific instance of a portal and to assign distinct permission levels to each. This allows the portal administrator to restrict resource submission to a group of persons who require an authentication to perform their task, while restricting the meta-data creation, resource review, and final approval of a resource to other groups who also must be authenticated. The Toolkit is intended to address respondents' concern with authentication.

Also, respondents expressed an interest in systems that would allow users to reference specific versions of a material. Besides the Connexions project, a repository project developed on the Rice University campus, few systems or tools have resources that facilitate easy location of various versions, or the latest version, of a specific resource.

There are a large number of features currently available from projects and tools that store and manage meta-data. There are also projects dedicated to the management of content that have been developing features that meet the needs that many respondents described. The Fedora Project has developed an open sources digital repository management system. In its newest version, the system allows content versioning that permits users to see earlier versions of a resource. It also permits the easy copying and moving of objects among repositories.

However, it is generally true that the features that many respondents favored are being pursued more energetically by projects that create systems and tools that manage meta-data than those concerned with the management of content. In part, this is because the management of content is such a greater technical feat in itself than the management of meta-data, that many of these projects are better suited for dealing with technical issues that permit their systems to function than features that give users access to a greater set of functionalities. Most of these systems, such as the system developed by the DSpace project, based at MIT, are intended to be for the storage and preservation of documents. Many instances of DSpace can be found within libraries.

As noted, many of the functionalities that our respondents requested are available from multiple systems and tools. However, as has been stated above, many of these resources do not fit our definition of repository as they do not store the electronic objects themselves. At some point projects and tools that store and manage meta-data must begin to work with those that store and manage content. Then the great efforts among the former to meet user needs can be joined with the achievements of the latter within the realm of content management. It is our hope that a new generation of repository tools can bridge the divide between these two realms, creating systems that not only describe resources and manage their meta-data, but also aid in the management of the resources themselves.

Conclusions

We conducted our surveys to shape the direction of our own development process, and to give some confirmation to tendencies we had observed in our interactions with user and

repository development communities. But our findings revealed expectations among a diverse user community that are of general interest.

Respondents revealed a familiarity with, and an interest in, a variety of meta-data and interoperability standards and specifications. The variety of views regarding some standards and specifications, such as those respondents who "strongly disagreed" with the statement that the Dublin Core met their or their users' needs, seemed to suggest that respondents were familiar with the standards and specifications available, and are trying to assess their applicability to their projects' needs. This familiarity could arise from an increased concern with repository interoperability.

It is very interesting that respondents recognized the technical context in which a repository system would operate, and interoperate. Today, the oldest and largest learning repositories were developed with the philosophy of "if we build it, they will come." That is, they were developed as websites, the content of which users would be able to access by visiting the site itself. Respondents' concern with interoperability with a variety of different systems related to traditional education and e-learning, and their concern with standards compliance, both suggest that respondents to our surveys know that **a repository system must adjust itself to the technical and practical context in which learning happens, and cannot easily demand that technological and social systems will change in response to it.**

We also found that respondents were interested in repository systems that aided in the management of content. They asked for tools that would aid them in the creation of meta-data, both by establishing workflows for human creation of meta-data, and by providing tools that would automatically create meta-data and index materials. These responses show that our respondents want help as they enter the realms of content management, and would like systems that would provide that help. Similarly, they wanted tools that would manage digital rights and intellectual property.

Expectations regarding repository systems vary widely, but the solutions that various respondents expressed interest in suggested a common understanding of the problems at hand. The initial survey, and the long answer responses to the third, revealed an interest in solutions to problems arising from interoperability, meta-data creation and management, content versioning and management, and digital rights management. The variety of proposed solutions, and the prioritization given to those solutions, revealed common problems cannot always be solved by common solutions.

There were also issues conspicuous in their absence. Only one respondent to the third survey mentioned tools that might aid in ensuring content quality, in this case a user-driven ratings system. Respondents were far more likely to describe tools that solved problems of technical import, or of importance to the scalability and interoperability of repository systems than issues such as interface enhancements, or the development of resources assuring some level of content quality.

Given these issues, it is essential that we not let complex expectations and needs get in the way of the creation of a simple repository system, and that we make users aware of the technical requirements implied by their more elaborate (and case-specific) requests. Our results seem to suggest that to successfully tackle repository development we should take a modular approach, permitting a variety of functionalities to be added to a basic repository system. This would allow the repository itself to adjust to local needs and expectations, while not permitting user desires to slow the development of the initial system itself.

Appendix

Overview of First Survey

Our first survey was made available to partners and interested parties via email. We received 13 responses to a set of questions, the most important of which required written answers. The survey asked respondents for the following information:

- Name
- Organization
- Phone
- Email
- Willing to be contacted?
- Have you head the term "repository" used to describe any sort of computer software that: accepts, publishes, registers, searches, tags, queries, updates (etc.): content, learning content, learning objects, SCOs, assets (etc.)
- Are you currently involved in any content development projects where the need for a "repository" has been identified? If so, please provide a brief description(s)
- Can you describe the minimum requirements that a system must meet to be called a "repository"?
- Could you describe some optional functions that you would prefer to see within a "repository" system?
- (Optional) Please describe as many scenarios as you like in which various kinds of users (educators, administrators, learners, and developers) or systems would ideally interface with a repository? Please include the user's objective in these scenarios and how the repository system would facilitate the achievement of those objectives.

The results from this survey cannot be summarized statistically and the responses we received from respondents can be found described in the body of the paper above. The functionalities requested also informed the questions asked in survey 2 (see below).

Of the 13 responses, 10 provided multiple-line descriptive answers to our questions. Eight provided descriptions of scenarios in response to the optional question.

Results from Second Survey

This survey was made available to partners and interested parties via email, and posted online using the SurveyShare tool. We received 12 responses to a set of multiple choice questions. The questions from the survey and an enumeration of the responses are listed below. Not all respondents answered all of the questions. The first set of questions asked respondents to mark whether they Strong Agreed (S.A.), Agreed (A.), Disagreed (D.), or Strongly Disagreed (S.D.) with the following statements.

In the repository implementation that would meet my or my project's needs, it is important that:	SA	A	D	SD
1. Authenticated users may upload resources to the repository	9	2	0	1
2. Unauthenticated users may upload resources to the repository	0	2	4	6
3. Users must be authenticated in order to search and retrieve materials from repository content	3	6	1	2
4. Unauthenticated users may search and retrieve materials from repository content	2	2	7	1
5. The repository uses standards-compliant meta-data	9	3	0	0
6. The repository uses meta-data compliant with the Dublin Core	3	5	1	2
7. The repository uses meta-data compliant with IEEE LOM	3	7	2	0
8. The repository provides a meta-data editing interface at the point where materials are uploaded	7	5	0	0
9. The repository provides a meta-data interface that can be used at any time	5	5	2	0
10. The repository is packaged with tutorials and tools that facilitate meta-data creation	4	6	1	1
11. The repository is packaged with tools that automatically generate meta-data	4	8	0	0
12. The repository is packaged with tools that automatically index material	6	5	1	0
13. The repository system can alert users when there are changes within its collection	4	6	1	1
14. The repository facilitates the versioning of materials by allowing users to reference specific versions of the materials it contains, including the most recent	4	7	1	0
15. The repository is able to manage and enforce, to whatever extent is possible, its content's licensing and copyright information	6	3	3	0
16. Licensing and copyright information is provided by those uploading materials	4	8	0	0
17. Licensing and copyright information is provided, and changeable, by repository administrators	2	4	5	1
18. The repository software is free	6	5	0	1
19. The repository software is open source	8	4	0	0
20. The repository software is cross-platform	8	4	0	0
21. The repository allows for generic workflows to be developed and enforced	4	5	3	0
22. The repository provides software or server-side services allowing users to use materials without depending on client-side software	7	3	2	0
23. The repository is interoperable with an LMS I or my users regularly use	6	5	0	0
24. The repository is interoperable with authoring tools I or my users regularly use	2	7	2	0
25. The repository system provides access to resources and development tools for content creation	2	2	5	3
26. The repository can interface with other systems (repositories, library systems, etc.) using one or more interoperability standard (choose specifics from below):	8	3	1	0
27. IMS Digital Repositories Interoperability	6	3	1	1
28. Z39.50/SRW	0	4	4	1
29. RSS	5	2	1	1
30. OAI-PMH	3	4	1	1
31. OKI	2	4	3	0
32. METS	1	3	4	1

The second section of the survey asked respondents to rank a set of phrases describing repository system features from most essential to "your or your users' needs" (1) to least essential (9). Ties were allowed.

Rank:	1	2	3	4	5	6	7	8	9
Meta-data	2	3	1	3	0	2	0	1	0

production process									
Meta-data standards	6	0	3	0	1	0	1	0	1
Content production process	0	2	0	0	3	3	1	2	1
Content standards	3	1	1	0	1	3	0	3	0
Digital rights management	6	0	2	0	1	0	0	2	1
Meta-data interoperability	2	4	3	0	1	1	0	0	1
Content interoperability	4	1	1	1	2	0	2	0	1
User authentication	5	2	0	0	2	0	1	1	1
User interfaces	1	2	3	3	0	1	1	0	1

Results from Third Survey.

This survey was made available to members of the IEEE Learning Technology Standards Committee email mailing list via email, and posted online using the SurveyShare tool. We received 13 responses to a set of written and multiple choice questions. The questions from the survey and an enumeration of the responses are listed below. Not all respondents answered all of the questions.

The first set of questions asked respondents to answer the following questions:

- Have you heard the term “repository” used to describe any sort of software that: accepts, publishes, registers, searches, tags, queries, updates, (etc.): content, learning content, learning objects, SCOs, assets (etc.)?
- Are you currently involved in any content development projects where the need for a repository has been identified? If yes, please provide a brief description of the project.
- What is the minimum functionality a system must have to be called a repository?
- What additional repository functionality would be desirable?
- (Optional) Please describe some scenarios (use cases) that you envision a repository supporting. Identify the various kinds of users (educators, administrators, learners, developers, other software, etc.). Please include the overall objective of these scenarios and the role a repository would play.

The second set of questions asked respondents to answer yes/no questions, or to mark whether they Strong Agreed (S.A.), Agreed (A.), Disagreed (D.), or Strongly Disagreed (S.D.) with the following statements.

	No	Yes
Authentication is required to upload resources to the repository	1	9
Authentication is required to retrieve materials from the repository	2	8

In the repository implementation that would meet my or my project's needs,

8) It is important that the repository system provides:	S.A.	A.	D.	S.D.
A meta-data editing interface at the time when materials are uploaded	10	3	0	0
A meta-data editing interface that can be used at any time	11	2	0	0
Tutorials that facilitate meta-data creation	1	11	1	0
Tools that automatically index the full text of the materials	4	6	3	0
9) The repository system can:				
Alert users when there are changes within its collection	5	7	1	0
Facilitate the versioning of materials by allowing users to reference specific versions of the materials it contains, including the most recent	7	5	1	0
Allow for generic content management workflows to be developed and enforced	5	7	0	1
Provide access to authoring tools for content creation	2	7	2	2
Provide access to authoring tools for content creation	2	7	2	2
Interoperate with authoring tools I or my users use	7	6	0	0
10) Copyright and Licensing:				
Licensing and copyright information is provided by those uploading materials	6	6	1	0
Licensing and copyright information is provided, and changeable, by repository administrators	3	9	0	1
The repository is able to manage and enforce, to whatever extent is possible, its content's licensing and copyright information	5	8	0	0
11) The repository software is:				
Open-source	4	6	1	1
Cross-platform	9	3	0	0
12) The repository should be able to interface with other systems using the following standards or specifications:				
IMS-DRI	6	6	0	1
Z39.50/SRW	3	8	0	0
OAI-PMH	4	8	0	0
OKI	2	7	2	1
13) The repository can import meta-data that conforms to the following standards or specifications:				
ADL SCORM	6	5	0	0
Dublin Core	7	4	0	0
IEEE LOM	9	3	0	0
METS	2	6	2	1
IMS Metadata	7	5	0	1
14) The repository system also supports other standards and specifications such as:				
RSS	3	4	2	0
WebDAV	5	1	2	0