Reusable LEARNING

National Science Digital Library
Reusability and Interoperability Workshop

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Eduworks Corporation
E-learning Consulting and Professional Services

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NSF

WORKSHOP SCHEDULE

Day 1	**May 14, 2004 - Friday**
12:00 – 13:00	Registration and Lunch
13:00 – 13:30	Introduction
13:30 – 15:00	Framework for Reusability
15:00 – 15:30	Afternoon Break
15:30 – 17:00	Lab 1: Examining a Resource for Reusability
18:00 – 20:00	Reception and Dinner

Day 2	**May 15, 2004 - Saturday**
7:30 – 8:30	Breakfast on your own (vouchers provided)
8:30 – 9:00	Q & A from Day 1
9:00 – 9:30	Presentation by the GROW project
9:30 – 10:00	Reusability Guidelines
10:00 – 11:30	Lab 2: Reusable Design Guidelines Morning Break at your leisure
11:30 – 12:00	Software Sharability (Light Applets Project)
12:00 – 13:00	Lunch
13:00 – 14:00	Demonstration 1: Interoperability Standards
14:00 – 15:30	Lab 3: Implementing and Supporting Reusability
15:30 – 16:00	Afternoon Break
16:00 – 16:30	Recommendations for the NSDL & Math Conference Group
16:30 – 17:00	Q&A, Evaluations, Wrap-up
18:00 – 19:30	Dinner

Day 3	**May 16, 2004 - Sunday**
8:00 – 9:00	Breakfast on your own (vouchers provided)
9:00 – 12:00	Conference Group on Digital Educational Resources in Mathematics

Please Note

Please strictly observe start times. Lab sessions require Internet access and use of a laptop. Laptops may be shared if needed. WiFi access will be available.

Workshop Leaders can help you with logistical issues and information about the workshop.

NSDL Workshop on Reusability and Interoperability. *Logistics.*

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LOGISTICS

Hotel Information

Wyndham City Center Hotel
1143 New Hampshire Ave, NW
Washington, DC 20037
(202) 775-0800
www.wyndham.com/hotels/DCADC/main.wnt

Costs: Costs for rooms (Friday and Saturday night) will be paid directly through the NSF Reusable Learning project grant. Extra nights are covered only if you are coming from the western U.S. or Hawaii, and if they have been approved by the workshop organizers. Any other charges to the room are your responsibility.

Checkout: Checkout is normally at 12:00 noon. Please check out on Sunday either before the start of the workshop or during the mid-morning break.

Resolving Issues: Please contact the front desk directly for any issues with rooms. If you feel you need assistance, please ask a workshop leader.

Subway and Airport Shuttle: (See the hotel web site for map and directions). If you are flying in to Ronald Reagan, you can take the subway to the Foggy Bottom stop at 23rd and I Streets (about 3 blocks from the hotel), or take a taxi for about $15. If you are flying to Dulles or BWI there are shuttles available to the hotel, $25 from Dulles and $35 from BWI. Taxis are more convenient but more expensive at $45 and $65 respectively. Please take the shuttle if you can, or share a taxi if you are coming with another person. We will cover the cost of subway, shuttle or taxi to and from the airport. We will also cover the cost of parking ($26 per day at the hotel) if you are driving to the meeting rather than flying. However, we will not cover the cost of a rental car and parking for participants who fly to the meeting and rent a car once they are here.

Internet Access: High speed internet access will be provided in the meeting rooms on Friday and Saturday, but not on Sunday (the costs are very high in this hotel).

High speed internet access in your room and local calls are free if you have signed up for "Wyndham by Request" (www.wyndham.com/wbr/benefits/main.wnt), and if you provided your Wyndham number to the workshop organizers in advance. Otherwise, these costs are your responsibility.

Meal Information

The workshop will provide the following meals. *All meals are in the hotel.* Please see the workshop schedule for times.

Lunch, Friday
Reception and Dinner, Friday
Breakfast, Saturday Voucher provided for the hotel restaurant.
Lunch, Saturday
Dinner, Saturday
Breakfast, Sunday Voucher provided for the hotel restaurant.
Coffee breaks

Reimbursements

The workshop will reimburse travel expenses up to the amount that has been pre-approved.

1. Download a copy of the reimbursement form from the workshop logistics page. Go to www.reusablelearning.org/nsdlworkshops/, select the May workshop, and click on the Handouts link.

2. Either scan your receipts for travel including airline (e-tickets are OK) and ground transportation receipts or prepare your receipts to be faxed (taping them to an 8.5"x11" piece of paper and copying them before faxing is suggested).

3. Complete the reimbursement form.

4. Email the completed form and the scanned receipts to nsdl@resuablelearning.org. You may also fax the completed form and receipts to (541) 754-7718. Faxes work but are sometimes hard to read, however scanning and email is much preferred.

Deadlines: Please submit your reimbursements as soon as possible so that we can process them together. **Reimbursements submitted by June 10 will be paid in June.** Others will be paid on a time-available basis. Note: We will not issue your reimbursement until we have received your workshop evaluation.

Costs Covered: Unless other special arrangements have been made, the only costs reimbursed will be transportation to and from the workshop up to the pre-approved amount.

1 BACKGROUND: THE REUSABLE LEARNING PROJECT

This workshop is part of the *Reusable Learning* project. The project is concerned with *digital learning resources*, i.e., resources in digital format that are intended for use in learning. These include Web-based content, digital documents, applets and software, simulations, data sets, interactive learning environments and multimedia resources.

The project's goal is to increase the value and impact of digital learning resources by making them easier to reuse, or to modify for reuse, in multiple contexts and in multiple learning environments. The project is targeted at individuals and teams who design, develop and create learning resources and at organizations that aggregate and disseminate them.

The Reusable Learning project is developing the following:

1. A general framework for examining the reusability of digital learning resources.

2. Guidelines for increasing the reusability of digital learning resources. These are patterned after the guidelines for accessibility produced by the W3C Web Accessibility Initiative (www.w3c.org/wai/).

3. Suggested policies that will help digital libraries collect, identify and disseminate content that has good reusability properties.

4. Guidelines for using particular sets of tools for producing reusable content. These will cover common commercial authoring tools as well as discipline-specific tools.

5. Reference sets on standards, tools and technology as they relate to the reusability of digital learning resources.

6. Workshops on reusability and interoperability. A series of these is being developed and offered as part of the National Science Digital Library initiative (www.nsdl.org) to projects funded through that program.

Web Site

The Reusable Learning project Web site is www.reusablelearning.org. The site is expected to be reasonably complete by early 2005.

Project Staff

The project director is Robby Robson[1] of Eduworks Corporation. He is joined by Geoff Collier[1] and Brandon Muramatsu[1]. Advisors include Len Simutis, Eisenhower National Clearinghouse, Flora McMartin, MERLOT and Lang Moore, MathDL.

[1] Bios are available at: www.eduworks.com/Bios/Bio-Robson.html, www.eduworks.com/Bios/Bio-Collier.html, and www.mura.org

NSDL Workshop on Reusability and Interoperability. *The Reusable Learning Project.*

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2 WORKSHOP TAKEAWAYS

2.1 Reusability Framework

The starting point for this workshop will be a framework for reusability of digital learning resources. The framework combines educational, technical and other perspectives from the reusability literature. It identifies five factors that affect reusability:

- **Granularity:** Granularity captures the size, decomposability and the extent to which a resource is intended to be used as part of a larger resource. The granularity of a resource determines what "reuse" means, and frames any discussion about its reuse.

- **Design.** Design refers to the content, presentation, structure, pedagogy and context of a resource. These are the intrinsic aspects of a resource that affect reusability.

- **Interoperability.** Interoperability measures the extent to which a digital resource will "plug and play" on different platforms, or can be modified using different tools.

- **Rights.** Intellectual property rights, attribution and the ability to access and modify source code all impact reusability.

- **Metadata.** Metadata enables people to find resources that meet their needs and to properly use them once found.

2.2 Reusable Design Guidelines

This workshop will introduce you to a set of guidelines for designing and creating reusable content. These are targeted at educators and development teams who contribute content to NSDL collections. The guidelines are patterned after *Web Accessibility Initiative* guidelines developed by the World Wide Web Consortium (W3C, 2004).

2.3 Interoperability and Standards

Interoperability is a technical subject that touches on software and standards. This workshop will include an overview and demonstration of interoperability standards and how they are used in authoring and delivery platforms. It will also include a discussion of interoperability for software applications.

2.4 Implementing and Supporting Reusability

Many NSDL collections (or services) aggregate, maintain and disseminate content. Most content is not developed by the collections themselves. This workshop will discuss collection policies and actions that can help support reusability *at the collection* level.

2.5 Additional Resources

The Reusable Learning project is developing and will maintain the following resources and reference sets at www.reusablelearning.org.

- **Reusability Framework:** The reusability framework will be updated and maintained on the Web site.
- **Reusable Design Guidelines:** The Web site will include an exposition of the guidelines, techniques for following them, and illustrations of the guidelines using sample digital learning resources.
- **Interoperability Specifications and Standards:** Definitions, references and brief explanations of the interoperability specifications and standards most relevant to the problem of reusing content on multiple learning delivery platforms. These will include the Sharable Content Object Reference Model (SCORM) and some IMS[2] specifications such as Question and Test Interoperability.
- **Standardization:** Terminology and references that help explain the distinctions among specifications, standards, profiles, reference models, open standards, consensus standards, conformance and compliance and that will delve into the Byzantine world of standardization and standards bodies.
- **Authoring Tool Guidelines:** Guidelines for using common authoring and multimedia development environments to create learning content that is easily modifiable by others and that adheres to interoperability specifications and standards.
- **Learning Delivery Platforms:** This treats software applications which organize, manage, deliver and track the usage and results of digital learning content. Course management systems and learning management systems are examples of such applications. The reference set will discuss what these systems do, what standards they use, and how to design content for their use.

Note: Appearance of a product on the Reusable Learning Web site does not constitute an endorsement or recommendation to use a product.

[2] IMS is short for the "IMS Global Learning Consortium." IMS came from "Instructional Management Systems" but this term is no longer used.

3 REUSABILITY AND REUSABLE DESIGN

3.1 Introduction

In the oral tradition stories and parables were passed from person to person and generation to generation. As they were told and retold they were updated, modified and fitted to new cultures and new contexts. In many cases, only parts of the old teachings found their way into new ones. This is the process of *reuse* and *repurposing*, and it has been going on since before the advent of the written word.

Today, reuse is familiar to the educational world based on printed media. The educational marketplace overflows with text books, lesson plans, activity books, kits, and other materials designed specifically to be reused many times in many different places. The existence of an educational marketplace itself has contributed to improved access and better quality by providing distribution channels, creating competition and enabling the financial returns needed to invest significant resources in the development of good content.

Compared to oral teachings, printed material is cheaper and faster to distribute and there is less chance that distribution will alter the content. With digital content, the cost and time required for distribution approaches zero and the fidelity is close to absolute. In entertainment, this has led to such widespread reuse and sharing that the entertainment and publishing industries are using technology and the courts to prevent it. In education and learning the digital sharing effect has evolved more slowly.

There are many reasons for this. As pointed out in *The Gutenberg Myth* (Brandon, 1998), single technological breakthroughs rarely have the impact attributed to them. Other technological advances are required to support the transition, and sociological changes must also take place before there is a fundamental impact on the culture.

In the case of digital learning resources, there are many problems to be overcome before we can expect widespread reuse and sharing. Learning tends to be highly contextual, and context is not as easy to disseminate as data alone. The specialized nature of learning resources sometimes requires specialized formats and specialized software to interpret them. Interactive resources seem harder to break up into smaller components than those consisting solely of text and graphics, making them less convenient to reuse than a book. Validity and trustworthiness are important issues for educational material, militating against the emergence of peer-to-peer educational file sharing networks. The simple metadata (title and author) and full text searches that seem adequate for searching and discovering entertainment and news content may not suffice for educational content. There are also elements of the academic and educational cultures that discourage a high degree of reuse.

However, we should not be discouraged. The concept and potential value of reuse is clear to most educators, and there are no fundamental technological barriers to reusing and repurposing educational content. Furthermore, there are reasons to believe that increasing the reuse of digital learning content will have a positive effect on quality and access. That does not mean that reuse will occur without taking any proactive steps, but it does imply that there is value in digging deeper into what makes reuse easier.

This document sets the stage by discussing what is meant by reusability and reusable design in the context of the Reusable Learning project. Following that, a framework is presented that analyses reusability in more depth.

3.2 Reuse of Digital Learning Resources

When discussing reuse we must first ask "What, how and by whom?"

3.2.1 What

This Reusable Learning project is concerned with *digital learning resources*, defined as anything in digital format that is intended for use in learning. The specific types of resources targeted are those that are accessible through educational digital libraries. These include online courses or modules; interactive applets; multimedia resources; simulations; data sets; and objects that are specifically designed for use in constructing other resources.

3.2.2 How: Adoption and Adaptation

In a typical interaction with a digital library a teacher might search for and discover a resource and then use it in class or assign it as homework. This is considered reuse if the context has changed, e.g. if the resource was created for one class and used in another[3]. Note that if the learning resource is "large" (such as a course) then only a part of it may be reused. For example, a teacher may want to show a particular simulation in class. Learners can also use resources by conducting their own searches and engaging with the content they find. It is not clear whether this is reuse or just plain use, but the effect is the same. In this document anyone reusing content will be called a reuser.

The above type of reuse is often called *adoption* because a resource is being adopted for use without any changes being made. A slightly different kind of adoption occurs when a reuser incorporates a learning resource into a Web site or other learning environment via a link. This is different because the part or all of one digital learning resource is being combined with another digital learning resource. The reuser is now acting as an 'assembler' of existing content.

A type of reuse that is very different from a reusability perspective is *adaptation*. This occurs when a learning resource is modified (or re-deployed) before it is used. Adaptation is an authoring process, and indeed authoring teams often reuse their own materials, but the most challenging situations occur when content from one source is adapted for use in another. As an example, a professor might find an applet and incorporate it into a Web site by downloading the source code, changing the look and feel to match her site, recompiling the code, and putting it on her own Web server[4].

3.2.3 By Whom

Although the educators and authoring teams are the key reusers, we should not forget about three other very important players.

First, the *learners*: Digital learning resources can be used by audiences far more diverse than those for whom they were explicitly designed, as is demonstrated by usage statistics for the MIT Open Course Ware Initiative (Diamond, 2003). Even if their access to content is mediated by educators, the diversity of potential learners and the importance of providing

[3] Reuse is sometimes called *repurposing.* Although there is no standard definition of *repurpose,* it is fair to assume that repurposing implies some change in purpose as well, e.g. a virtual laboratory created for doing chemistry experiments is used to generate examples for a mathematics class. We will generally just use the word *reuse.*
[4] At least one NSDL project is creating applets that can be called with a variety of parameters, essentially making it possible to modify them without touching the source code.

more universal access to education leads us to rate use by unforeseen and culturally divergent audiences as a very important type of reuse.

Second, the *collections or repositories*: For resources to be reused they must be discovered and identified as appropriate. Widespread reusability in education cannot be achieved without significant contributions from educational digital libraries. Collections and repositories can support reusability by developing and implementing appropriate policies and technologies.

Finally, the *authors* of the resources that are being reused: If the goal is create more reusable learning resources, then the authors are the ones who must take us there. To do that, they must practice reusable design.

3.3 Reusable Design

A digital learning resource is *reusable* if it can be used or adapted for use in multiple learning contexts and in multiple learning environments. This has its challenges. Even without a need for modification, intellectual property rights, dependence on context and the usual technical problems with digital content are barriers to reuse. The need to modify content intensifies these challenges.

A natural question to ask is whether quality must be sacrificed for the sake of reusability. A very similar situation arose when accessible design started getting some play. Designers viewed it as an imposition that would require more work and limit their choices. By now, most designers acknowledge that many of the principles of accessible design are just principles of good design that also enable important advances such as displaying content on mobile devices. The same is likely to happen with the concept of reusable design.

The goal of reusable design is to create resources that lower or remove the barriers to reuse as much as possible without reducing learning effectiveness.

That is not to say that there is no tension between reusability and design. For example, academic authors often refer to approaches, examples and notation established earlier in a course. They feel this is needed to properly develop ideas and understanding, but these 'hard-coded' references make it harder to reuse just parts of the course. Similarly, designers of educational Web sites may build logic into the server that guides students to different sections depending on results of quizzes or stated preferences. This may make for a more interactive and effective learning experience, but it renders the Web site impossible to reuse without the same server technology.

In almost every case there are ways to improve reusability without losing the educational value. In the first example, sections can be made more self-contained by replacing links to other sections with links that pop up important definitions, examples or notations. In the second example, standards can be used that enable the same type of logic to be performed by most delivery platforms. Nonetheless, it must be acknowledged that, as in the case of accessibility, designing for reuse does initially take some extra effort and some shifts in approach.

The remainder of the Reusability Framework is devoted to explaining the five factors of granularity, design, interoperability, rights and metadata and how they impact reusability.

NSDL Workshop on Reusability and Interoperability. *Reusability and Reusable Design.*

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4 REUSABILITY FRAMEWORK

4.1 Factors Affecting Reusability

Reusability of digital learning resources can mean reuse with or without modification. It can also mean different things for different types of resources, as is illustrated by some examples:

- *A college professor selects a text book for a class.* She may anticipate using all of it, parts of it or just the exercises. She does not anticipate being able to copy portions of the book and publish them in another book because that would violate copyright.

- *A keynote speaker prepares to give the third version of the same talk*. He may start with a PowerPoint presentation and intend to use almost all of its content, altering some presentation elements (such as the opening slide, the footer and the date) and updating a few slides.

- *A student selects a JPEG from a library of scanned astronomical images*. She will most likely paste it into a report as is. Alterations would likely ruin the image.

- *A mathematician writes an applet that allows students to alter some parameters in a differential equation and view the resulting level curves.* This applet may be shown in class during a lecture, used as part of a lab, provided as supplementary material, or incorporated into an online quiz. It might also be appropriate for several different courses (not just in mathematics) but may require a particular version of a Java™ virtual machine or a viewer for a particular computer algebra system. The license associated with the applet may restrict certain types of reuse (e.g. commercial).

These examples make it clear that there are multiple dimensions to reusability. For the purposes of the framework presented here, five factors are identified:

- Granularity (or aggregation level)
- Design
- Interoperability
- Rights
- Metadata

These represent a distillation and unification of reusability from the perspectives of learning theorists, instructional designers, technology designers, content developers, standards developers, digital librarians and policy makers. References to some of these perspectives may be found at the end of this document and on the Reusable Learning project Web site.

Each of these factors plays a different role. The granularity of a digital learning resource determines what is meant by "reuse" and frames any discussion of reusability. The design of a resource, which includes instructional and structural design, determines its suitability for adoption and adaptation as well as its usability from the perspective of different learners. Interoperability affects the degree to which a resource will actually work, rights affect its permitted uses and metadata affects the ability of a resource to be discovered by someone wishing to reuse it.

4.2 Granularity

The granularity of a digital learning resource refers to its size, decomposability and the extent to which it is intended to be used as part of a larger resource.

A related term is *aggregation level*, which is used in IEEE Learning Object Metadata to describe "the functional granularity" of a learning object. The LOM Standard (LOM, 2002) is widely used in the learning technology community and is incorporated into other specifications and standards that will be discussed later. LOM offers the following scale for aggregation level:

1. The smallest level of aggregation, e.g. raw media data or fragments.
2. A collection of level 1 learning objects, e.g. a lesson.
3. A collection of level 2 learning objects, e.g. a course.
4. The largest level of granularity, e.g. a set of courses that lead to a certificate.

A point made by the LOM scale is that file size may not be tightly coupled with granularity. For example, an image (LOM aggregation level "1") may be several megabytes in size, whereas a lesson that incorporates that image using a link (LOM aggregation level "2") may be only a few kilobytes.

4.2.1 Granularity and Content Models

Granularity, or aggregation level, is important in defining and determining reusability. For an image, reusability means the ability to use the entire image in another setting. For an entire online course, reusability often refers to the ability to use parts of the course.

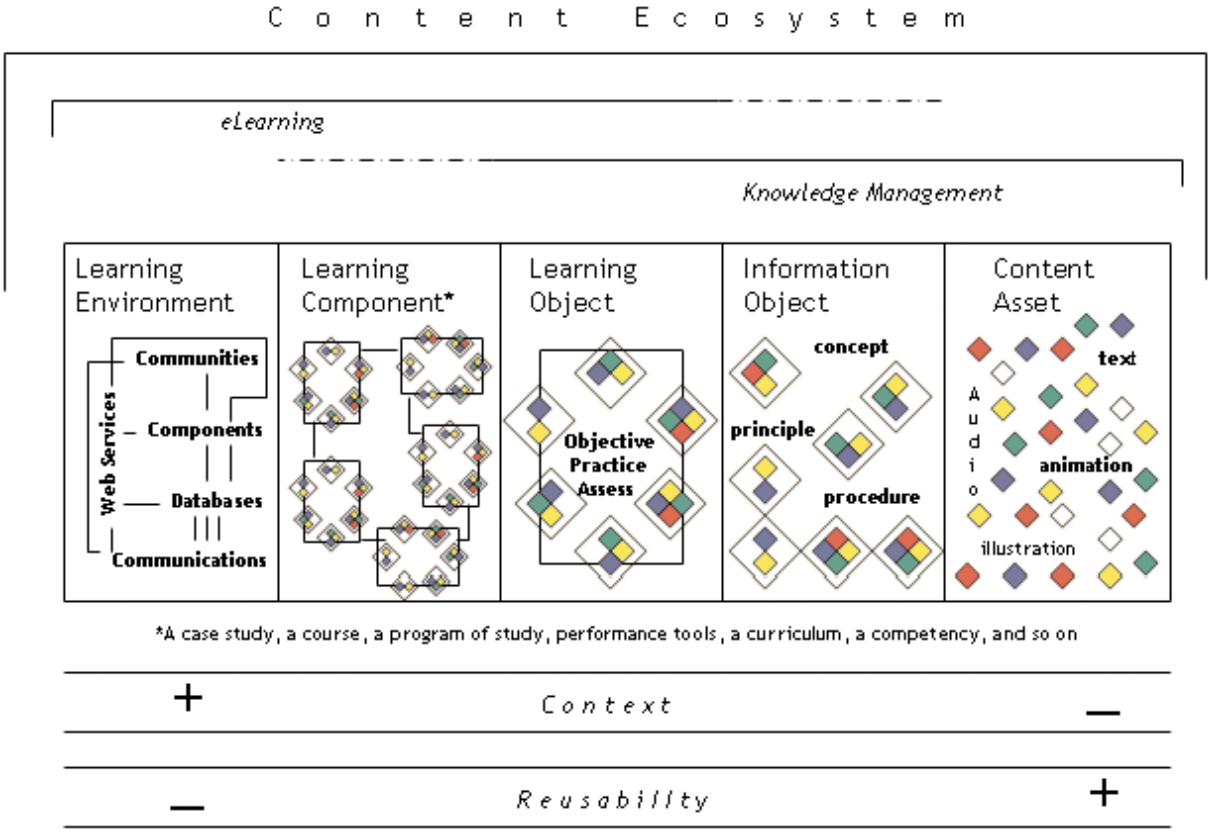
The Learnativity Foundation (www.learnativity.org) has developed a *content model* or *aggregation model* (Wagner, 2002) that is useful for describing granularity.

LEARNATIVITY AGGREGATION MODEL (Wagner, 2002)	
Granularity	Explanation
Content Asset	Raw media: Images, text snippets, audio clips, applets, etc.
Information Object	A text passage, Web page(s), applet, etc. that focuses on a single piece of information. It might explain a concept, illustrate a principle, or describe a process. [Single] exercises are often considered to be information objects.
Learning Object	In the Learnativity content model a Learning Object is a collection of Information Objects that are assembled to teach a single learning objective [see below].
Learning Component	A learning component is a generic term for things like lessons and courses that typically have multiple learning objectives and are composed of multiple learning objects.
Learning Environment	"Learning Environment" is a catch-all phase for the combination of content and technology with which a learner interacts. Thus a course written in a course management system is a learning component, but a deployment of the course in a live Course Management System at a particular institution (with a particular enrollment policy, help center, library reserve system, etc.) is a learning environment.

Table 1: Learnativity Aggregation Model

This model blends pedagogic and technical perspectives. The idea of an information object is based on earlier work on learning and structured writing by Robert Horn (Horn, 1993). The term *learning objective* (used to define a learning object) is an instructional design concept that derives from the work of Robert Frank Mager (Mager, 1993), Robert Gagne (Gagne, 1985), Walter Dick and Lou Carey (Dick & Carey, 1996) and others. A learning objective is a single measurable (or verifiable) step on the way to a learning goal. Learning objectives say what a learner is expected to do or learn and how an acceptable level of achievement will be verified. They can come from the psychomotor, affective and cognitive domains and can range from knowledge and comprehension to synthesis and evaluation (see Bloom's taxonomy (Bloom, 1956)).

Themes found in Clark's writings (Clark, 1989) and in a corporate training white paper published by Cisco Systems (Barritt & Lewis, 2000) are developed in the Learnativity model. It has gained considerable acceptance in both the training and education communities. The following diagram, reprinted with permission from (Wagner, 2002), shows the above in graphical format.



A Content Model for Designing Learning Objects

Figure 1: Learnativity Content Model

4.2.2 Granularity, Decomposability and Reuse

Each level of granularity has a different inherent ability to be decomposed into more granular pieces, and each level of granularity has different inherent expectations for reuse. In addition, reuse often refers to components of resources rather than to the entire

resource. It is therefore necessary to scope judgments concerning reusability to the granularity of the resource being examined. The following table is intended to aid in this regard.

DECOMPOSITION AND REUSE AS A FUNCTION OF GRANULARITY		
Granularity	Decomposability	Reuse
Content Asset	Indecomposable	Content assets are reused as is, possibly with modifications in presentation and style.
Information Object	Decomposable into content assets.	Information objects are normally reused as self-contained units. In authoring situations, sometimes content assets are extracted and reused as well.
Learning Object	Decomposable into content assets and Information objects	Learning objects are meant to be reused as self-contained units. Sometimes information objects or content objects are extracted from a learning object.
Learning Component	Decomposable into learning objects	Learning components can be reused in their entirety, but it is suspected that most reuse of learning components uses on parts of them, usually learning objects.
Learning Environment	Decomposable into content, technology and processes that support learning	Components of a learning environment can be reused, but learning environments are not themselves reusable objects in the sense being discussed here.

Table 2: Decomposition, Reuse & Granularity

4.2.3 Granularity and Standards

Several common learning technology standards deal with aspects of granularity. The Learnativity model maps onto the LOM aggregation level scale with both assets and information objects being assigned an aggregation level of "1", Learnativity learning objects having aggregation level "2", learning components aggregation level "3" and learning environments aggregation level "3" or "4."

The most widely implemented set of specifications intended to allow learning content to be developed independently of a particular delivery platform is the Sharable Content Object Reference Model (SCORM), a collection of specifications and standards that is documented and maintained by the Advanced Distributed Learning initiative (www.adlnet.org). SCORM include a content aggregation model that features

- Assets
- Sharable content objects (SCOs)
- Content aggregations

SCORM assets are content assets and information objects in the Learnativity model. SCOs are self-contained learning objects or learning components that meet additional technical requirements needed for interoperability with learning delivery platforms. A SCORM content aggregation contains assets, SCOs, information on the order in which these should be delivered, and metadata about entire aggregation and its individual components. In the Learnativity model, a SCORM content aggregation could be a learning object or a learning

component. SCORM uses a technical specification developed by the IMS Global Learning Consortium (www.imsglobal.org) to define the format for content aggregations.

4.3 Design

Digital learning resources can be viewed as consisting of multiple layers, shown in the following table.

Layer	Definition
Context	Language, cultural knowledge, subject knowledge, relations to other learning resources and other factors that are needed to properly interpret the resource.
Pedagogy	How a digital learning resource is used as part of a learning strategy or instructional design
Structure	How a digital learning resource is structured into assets, information objects, learning objects, etc. and how these are navigated or sequenced
Content	The information that is contained in a resource and that is intended to affect a change in cognitive state
Presentation	How a resource is rendered and what visual and auditory elements will be used to render it

Table 3: Five Layers of a Digital Learning Resource

Being aware of the effect of each layer on reusability will help guide design choices and reducing interdependence among layers will enhance reusability.

4.3.1 Context

Learning makes use of language, relies on culture, requires prior knowledge and experience and depends on the situation in which it takes place. If the dream of technology assisted learning is to get just the right stuff to the right person at the right time in the right way (Hodgins, 2002), then context is what determines the value of a learning resource.

At the same time, contextual dependencies limit the potential audience of a resource. Inherent contextual dependencies make it harder to use an object in multiple settings and in multiple ways (Robson, 2003; Gibbons, Merrill, Recker, Walker & Wiley, 2003). Thus context is the friend of learning and the enemy of reuse. For this reason, every effort should be made to reduce contextual dependencies when it is possible to do so without reducing the effectiveness of a resource.

Another way to say this is that the pedagogy, structure, content and presentation of a resource should be as free from dependence on external context as possible. An explanation that cannot be understood without referencing a specific text or external online resource is best replaced by one that may require specific knowledge but that does not require a specific source. An image, example or test question that clearly depends on cultural knowledge for interpretation should, if possible, be replaced by one that does not. A document consisting of a list of assertions may be useful for some instructional methods but will be more reusable if enough scaffolding is provided to make it useful to anyone who reads it. A large resource will be more useful for adoption and more disaggregated into information objects and learning objects for adaptation if it does not require a lot of inside knowledge to discern the boundaries among presentations of facts, statements of opinion, content intended for a student, remarks made for the benefit of an instructor, exercises, etc. Even for a well-crafted resource, explicitly providing the metadata to identify the

substance and nature of components will make it easier to reuse than will relying on context.

4.3.2 Pedagogy

A learning resource is more valuable if it can be used for as many different types of learning as possible. It therefore helps to separate any instructional or learning strategy implicit in a resource from its structure, content and presentation. The pedagogical setting and instructional use of a resource are part of its context but are singled out because we are talking about learning resources, not arbitrary digital content.

As an illustration, consider an educational Web site broken into sections that include some explanatory material, some exploratory material and an online quiz. Suppose that the site is intended for use by middle school children under the supervision of a classroom teacher who will guide the students through the material in a particular order. This is the pedagogical layer.

The intended pedagogical context and instructional design can show up in the choice of graphics and fonts (presentation), in references to the teacher embedded in the Web pages (content), and in the navigational scheme (structure). If material from the site is to be reused or repurposed for use by students learning on their own, or by parents helping their children, or by adult learners, then changes will have to be made to all of these elements. Here are some ways this can be made easier by keeping the pedagogical layer separate.

Reusability will be enhanced if a separate screen is used for navigation and there are no "previous" and "next" buttons or hyperlinks among the sections. This will allow other navigational schemes and instructional designs to be imposed on the same underlying content. For example, someone adapting the middle school site for adult learners might add a pretest and design a system wherein the learner doesn't see sections passed on the pretest but can see the remaining sections in any order desired. The IMS simple sequencing and learning design specifications provide standardized ways to separate pedagogy from structure and to implement these types of designs.

If entangling the structure of a resource with its instructional approach is bad for reusability, incorporating an instructional design into the content is even worse. If the premise for all of the content in the middle school Web site is a hands-on experiment that requires materials and supervision only available in a classroom, it will be hard to use any of the content at home. Another problem could arise if the content is targeted at teachers, rather than at learners. Providing a separate teacher's guide and dividing hands-on experiments into separate sections increases the separation of content from pedagogy.

Finally, the reusability of the site will be greatly enhanced if the presentation elements do not scream "middle school classroom." Optimally, the presentation layer is kept separate from all others so that repurposing is easy, but for straightforward reuse it is best if sections of the site can be linked from other resources with other audiences and designs without the presentation and style getting in the way.

4.3.3 Structure

As has already been discussed, many reusers of learning components only use parts of them. For both adoption and adaptation it is advantageous for a resource to be easily disaggregated at least into learning objects. Content that does not have this property is derogatorily referred to as "monolithic" in the learning technology community. On the

technical side, there are excellent technologies (metadata, learning technology content standards and XML) that aid in separating out the structure of a resource. These will be discussed later.

4.3.4 Reusing Structural and Pedagogical Layers

Separating the structure of a resource from its other layers not only increases the reusability of the content but also allows the structure itself to be reused. The same is true of its pedagogical design. In other words, a well-structured and well designed resource can become a template for others.

Structural and design templates are needed to make optimal use of libraries of content assets, information objects and learning objects. This is reflected in the following quote taken from a Morgan and Keegan white paper (Ruttenbur, Spickler & Lurie, 2000) written for the corporate training world:

> "By analyzing the learner's objectives and existing skill level, courses will be assembled on the fly that address exactly what the learner needs to know without wasting time working on areas in which the learner is already proficient or uninterested. This level of personalization will be achieved by using small chunks of information, or learning objects, to assemble a course from the ground up using pre-existing templates. The reusability of these learning objects will make this level of customization feasible in terms of both time and expense."

The same ideas are reflected in the "timeline tool" developed at the University of British Columbia (UBC, 2003), in ideas for Flash templates being promoted by the GROW project (GROW, 2004), and by (Dalziel, 2003) who reports on an implementation of the IMS Learning Design specification (IMS, 2004). This specification provides a means to express the design of a learning experience in a standardized and machine interpretable way. The goal is to create reusable designs that can be populated with appropriate activities, just as is reflected in the earlier work from the corporate world cited above.

4.3.5 Presentation and Content

Content, and the way it is presented, is the "stuff" of a digital learning resource. Pedagogical designs and structure can also be reused, but much of the focus on reusability is on content.

If content is to be adapted, it should be separated from its presentation. This means it should be possible to easily change font styles, layouts and branding elements such as logos and color schemes[5], or to render the same content on different devices. If graphical elements and branding are hard-coded into the content, then extra effort is required to remove or replace them. The next section discusses how to achieve the separation of presentation and content that is needed for reusability.

4.3.6 Separating Presentation from Content Using Styles

Suppose you are creating an HTML document and would like to start a new section called "Rebuttal." Here are two contrasting ways to do this:

[5] The combination of logos, background, fonts and layout is often called a "skin" in the learning technology community. Many commercial content development tools store skins as separate from the content.

1. Put in blank line, format the word "Rebuttal" on a single line in a larger bold font, and insert another blank line after it. In HTML this would look like:

Rebuttal

2. Apply a style sheet with the style "section_title" defined. In HTML, this requires creating a separate style sheet document containing a line like ".section_title {font-size: larger; font-weight: bold;}" and formatting the section title as

    Rebuttal

The difference between these two approaches is that the information passed to the browser about the word "Rebuttal" is syntactic in the first approach and semantic in the second. In the second approach, additional and separate information (a style sheet) allows the browser to convert the semantics into syntax. This permits the HTML document to be completely reformatted simply by changing the style sheet. Furthermore, applications other than a browser could render the document correctly provided they have a way to interpret the concept of a section title. A device that reads the content might know to pause and say the phrase "new section" before reading the word "Rebuttal."

4.3.7 Separating Presentation from Structure Using XML

Styles separate presentation from content and their use is applicable to word processors and to mark-up languages (such as T_EX) as well as to HTML. But they do not completely solve the problem of identifying the components of the content. For this it is necessary to separating presentation from structure.

A good way to separate presentation from structure is to use eXtensible Markup Language (XML). An XML document can be viewed as a set of containers. The document is the largest container. Every container other than the document is properly contained in a larger one. Everything inside of a container is either content or another container.

Each container in an XML document is identified by an opening and closing pair of tags. Tags provide semantic information about the content in the container and scope the meaning of any containers that are nested within them. Thus an XML document might be divided into sections which, in turn, contain titles, bodies, footnotes and references. The fact that a title is inside of a section makes it the section title, whereas if the title were only inside the document container, it would be the document title.

An XML document is an example of "structured data." XML is by no means the only way to represent structured data, but it is a standardized and increasingly prevalent way. XML has several advantageous from a reusability standpoint:

- An XML document can be disaggregated into semantically meaningful chunks.
- The presentation aspects of an XML document can be determined by the nature of the component being presented. In other words, different styles and rendering methods can be assigned to different types of structures. This separates presentation from content in an even more meaningful and flexible way than applying styles directly to the content itself.

- In XML, the structure of a document is expressed through a set of tags and the rules for the tags are controlled by a separate document (either a Document Type Definition (DTD) or Schema). If two products use different labels for the same information, it is easy to do a re-labeling. Thus if one product creates content with "Exercises" and another product uses the term "Practice Questions," it is relatively easy to write a translator that allows the products to correctly interpret and render each other's content.

Comment on HTML and Word Processors: HTML is designed for marking up the presentation of a document. Word processors were designed for the same thing. The addition of style sheets in HTML allows a good degree of separation of presentation from content, and someone adept with a product like Microsoft Word™ can do the same. Still, neither HTML nor most world processors were designed to separate presentation from structure. Fortunately, there is now an option to use XHTML, which is an XML dialect that newer browsers will be able to transform into HTML and display. Similarly, commercial world processors will be (or are) able to create XML output. This is not specific to learning content but will increase the potential for reuse.

4.3.8 Design and Granularity

As might be expected, the focus of design depends heavily on the granularity of a learning resource. The following table indicates what design considerations are most important as a function of granularity:

DESIGN AS A FUNCTION OF GRANULARITY	
Granularity	Important Design Considerations
Content Asset	The key design issue for content assets is separating presentation from content. Contextual dependence should be avoided.
Information Object	For information objects, separation of content from presentation is important, and it is also important to avoid cross references that entangle the content with the structure, pedagogy and context.
Learning Object	The considerations for information objects apply to learning objects. Additionally, there is a danger of hard-coding navigational elements and unnecessarily tying the object to a particular pedagogical approach or assumed context.
Learning Component	As the aggregation level increases, reuse shifts to component reuse. Therefore issues of separating pedagogy, structure and content become more crucial for reuse. Pedagogical approach and contextual dependence become the limiting factors for reusing or repurposing learning components in their entirety.
Learning Environment	Learning environments may be designed for a specific context and pedagogical approach or may be more general. The more general ones are those that are reusable. For them, it is important to avoid cross-linking of components of the environment.

Table 4: Design and Granularity

4.4 Interoperability

Interoperability is defined by the IEEE Standard Computing Dictionary (IEEE, 1990) as "the ability of two or more systems or components to exchange information and to use the information that has been exchanged." From the user perspective, interoperability is the ability of systems to work together, to "plug and play" without any hassles. The

interoperability of a digital learning resource is the degree to which it can run properly on multiple systems and can successfully be used in its potential audience's computing and learning environments. It also refers to the ease with which an author or developer can modify a resource for adaptation.

4.4.1 Standards and Interoperability

Standards are crucial for interoperability. In practice, there are two kinds. The first are standards that are authored and maintained by organizations such as

- The World Wide Web Consortium (W3C)
- The International Organization for Standardization (ISO)
- The Digital Library Federation (DLF)
- The IMS Global Learning Consortium (IMS)
- The Aviation Industry CBT Committee (AICC)
- The IEEE Learning Technology Standards Committee (IEEE LTSC)
- The Advanced Distributed Learning initiative (ADL)
- And many, many others (AMMO)

All of these organizations are different in composition, process and legal standing but have the common characteristics that

1. Groups of individuals, companies and other "stakeholders" work together[6] to produce technical specifications that anyone can obtain and use

2. The specifications are maintained by the group that produced them and there are mechanisms by which the "marketplace" can participate or give feedback

Although it is not accurate to call all of these "standards[7]", it is common to do so and will be done here.

The second type of "standards" arises from the proliferation of a particular product or group of products in the marketplace. Examples include Microsoft Word™, Flash™, and Portable Document Format (PDF). Although almost anyone can open and use a Word file, and the Acrobat Reader and Flash plug-ins for Web browsers are ubiquitous and freely available, the intellectual property behind these formats is owned and maintained by single companies. It is acceptable to call these "standard file formats" or "standardized formats" but it is best to avoid calling them "standards."

4.4.2 Basic Content Interoperability

The first requirement for (re)use of a digital learning resource is that it be able to work in as many relevant computing environments as possible. Issues that impact reusability include:

- Software that behaves differently (or does not run) on different platforms[8]

[6] Rules vary: participation can be by invitation only, by members only, or by anyone. Membership can be for individuals, for organizations or for nations. Fees can be non-existent, minimal, or many thousands of dollars per year. Almost all organizations of this type use a consensus process, but definitions of consensus, rights of appeal, due process, etc. can differ.

[7] There is a formal distinction between a "specification," which tells you what to do, a "de facto standard," which is a specification that a community has agree to use and a "de jure standard," which is a specification that has been approved as a standard by an accredited standards body such as the IEEE or ISO (the International Organization for Standardization).

[8] "Platform" is used to denote a combination of hardware, operating system and software environment.

- Web content that behaves differently in different browsers and operating systems
- Java applets that behave differently on different platforms
- Specialized plug-ins that are available for a limited number of platforms

Since digital learning resources run on desktop and notebook computers[9], these issues are unavoidable. Nonetheless, it is possible to achieve a reasonable degree of cross-platform functionality. Web content authoring tools can be configured to produce HTML that runs fairly well in most browsers, and many Java applets work quite well on different platforms. Word processors, spreadsheets and image editors have versions that run on a variety of platforms and can convert files back and forth without too much loss of functionality. Formats such as Flash, PDF or QuickTime™ can be read using free plug-ins that are readily available and install themselves when needed (if an Internet connection is present).

4.4.3 Interoperability for Specialized Software

Specialized software presents a lot of reusability problems. For some examples, look at the references to system requirements for Chime (Martz, 2002), WebEQ (Design Science, 2004) and TI-Navigator (TI, 2004). Applications with small markets are rarely as well-supported as standard applications (such as spreadsheets and word processors) and often are developed for only one platform. It is best to stay away from content that is written in a proprietary format that can only be understood by a non-standard tool.

It should be noted that some communities have developed formats such as TEX and MathML that are far from standards in the world at large but that are widely supported within a given community of practice and can safely be used, with the understanding that doing so will limit reusability outside of the community in question.

4.4.4 Course Management and Learning Management Systems

Course management systems (CMS) are being used more and more in education. According to *Campus Computing 2002* (Green, 2003), over one-third of college courses used a CMS/Learning Management System tool in 2003 and almost half of the institutions participating in a 2003 survey reported strategic plans for deploying a CMS/LMS. The spread of these platforms raises two interoperability questions for authors and users of content:

- Can content be ported between course management systems?
- Can content be developed that will run in any course management system?

These questions are addressed by "standards" produced by the IMS Global Learning Consortium (IMS, 2004) and by the Sharable Content Object Reference Model (SCORM) that has been produced and is maintained by the Advanced Distributed Learning initiative (ADL, 2004).

4.4.5 Authoring Tools

Digital learning resources are produced with the aid of general purpose authoring tools and (possibly) tools that are designed specifically for producing learning content[10]. Learning

[9] The situation with handheld devices is quite similar: Palm OS™ is competing with Windows CE™ and proprietary operating systems in cellular devices.

[10] Common general purpose authoring tools include Microsoft Word & PowerPoint; Macromedia Dreamweaver, Flash, Authorware, Fireworks and Director; Adobe Photoshop, Illustrator and PageMaker. Tools designed specifically for authoring learning content include DazzlerMax, Elicitus, IBT Web Authoring, Lectora Publisher, ReadyGo, and many others. There are also products such as HotPotatoes and QuestionMark Perception that can be used for

Content Management Systems[11] and Course Management Systems also provide environments for producing digital learning resources by assembling existing assets and objects.

The most important interoperability requirement for an authoring tool or environment is that it be able to ingest and publish content in standardized formats. It does not matter what format is used to store content internally.

4.4.6 Software "Sharability"

It is not uncommon for educators to develop instructional software tools which they wish to share with other educators who will adapt them for their own purposes. Frank Wattenberg[12] suggests several requirements for the effective sharing of software.

- A clear statement of use restrictions, if any. Ideally there would be no restrictions. If the creator intends to allow modifications, the rights statements should include permission to modify the software (See section 4.5 on Rights for more on this).
- All necessary files packaged with the software in an easily accessible / downloadable form. If modification is allowed, this would include the source code.
- Complete technical and functional documentation. (See section 4.6 on Metadata for more on this.)
- Software that is designed to be flexible. This might include, for example:
    - Software components that provide parameters to change their behavior. This allows modification / adaptation of use without requiring modification of source code.
    - Software components designed to be used with general purpose tools, for example spreadsheets. This allows the software to be reused by more people because of the wide availability of these tools.
    - Java applets, Shockwave, and other browser-based components that are "scriptable" – designed to be used with Javascript and forms.
- Stability – the units in question are housed in and maintained by a dependable Digital Library.

See the "Light Applets" project for an example of sharable software developed with these guidelines in mind (Wattenberg, Stewart & Alejandre 2002).

4.4.7 Interoperability for Learning Environments

The interoperability discussed so far is for content, but interoperability is important for learning environments as well. Learning environments rely on what is called "enterprise software," i.e., software that supports the operations of a school, college, government agency, hospital, or corporation. In the academic world, enterprise software includes databases, Web and file servers, student information systems, financial management systems, human resource systems, facilities management systems, library information systems and, more recently, course management systems.

Among the most important enterprise systems in an educational organization are those that manage the learning process. Interpreted narrowly, these include student information

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authoring quizzes and products such as RoboDemo and Viewlet Builder that are specifically designed for authoring "software simulations." See (Nantel, 2004) for a review of learning content authoring tools.

[11] See (Chapman, 2003) for information and a review of learning content management systems.

[12] These requirements for software 'sharability' were adapted from information provided by Frank Wattenberg of the Department of Mathematical Sciences at the United States Military Academy.

systems and course management systems. Interpreted more broadly, these also include library systems, digital libraries, knowledge and content management systems, portals, Web content development environments, authentication and directory services, and other technologies. Interoperability among these systems is not highly developed. "Single sign-on" has been achieved at many institutions, but the data exchange between course management systems and student information systems is often managed on an ad hoc basis and interoperability among other components is still in its infancy. The IMS Global Learning Consortium (IMS, 2004), the Open Knowledge Initiative (OKI, 2004), the Schools Interoperability Framework (SIF, 2004) and other organizations are creating standards, but it is still early in the adoption cycle.

4.4.8 Granularity and Interoperability

As with all other aspects of reusability, the meaning of interoperability depends on the granularity of the resource in question.

Interoperability for a raw media file means the ability of others to open it, possibly edit it, and certainly display it. Interoperability for a course refers to its ability to run in a variety of learning environments as well as to the ability of an instructor to modify or select parts of its contents for reuse.

The following table shows how interoperability expectations, and the appropriate standards, vary with granularity:

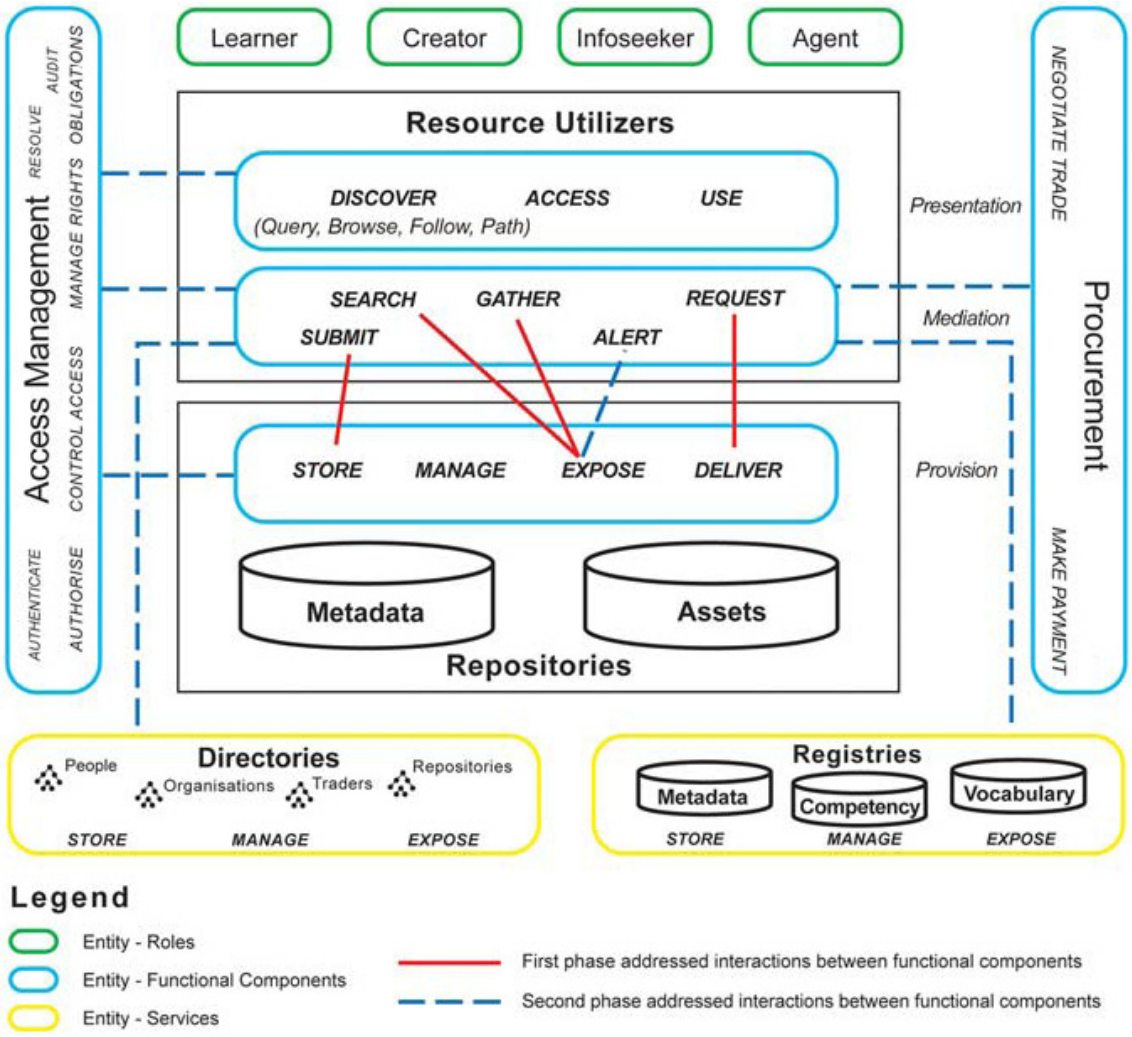
STANDARDS & TOOLS AS A FUNCTION OF GRANULARITY		
Granularity	Standards	Tools
Content Asset	Text and pure HTML are standardized formats for content assets, although HTML produced by most authoring tools is not standards conformant. XHTML is an improvement. Interoperability is improved by associating appropriate metadata to a content asset.	Content assets are usually edited and displayed using common authoring suites, plug-ins and browsers. For widest use, it is best when no plug-in is needed, or when a plug-in is freely available, automatically downloaded and widely in use, e.g. Flash™ or Acrobat Reader™. Products, plug-ins and formats can be community-specific, as in those needed to produce and display MathML.
Information Object	Information objects are similar to content assets. For applets, Java™ is considered a standardized format by some, although it has many platform and versioning issues. There are specifications and standards that specifically address test questions.	Information objects are similar to content assets in that they generally require a single application to edit and a single plug-in or application to display. The products involved are usually not specific to learning, although it is possible to use learning-specific authoring tools to produce information objects. Look for products whose output can be edited by more commonly available tools.

STANDARDS & TOOLS AS A FUNCTION OF GRANULARITY		
Granularity	Standards	Tools
Learning Object	SCORM and IMS specifications are relevant to learning objects. Learning objects whose structure is expressed in XML, even if proprietary, can usually be transformed for use in other environments. Metadata is always important.	Working with learning objects may require authoring and editing tools that are built for that purpose. As with information objects, the output is paramount for interoperability. On the delivery side, learning objects that are not tracked require standard server technology, but if data is to be exchanged between the learning object and the delivery system, then products like course management systems and learning management systems must be used to have any degree of interoperability. Assessment engines are also important for learning objects that include quizzes.
Learning Component	Learning components are similar to learning objects.	Learning components are similar to learning objects although they may rely more on course management technology. If a learning component (e.g. a course) can only run on a particular course management system, it is not very interoperable.
Learning Environment	The standards relevant to learning environments are those relevant to IT infrastructure.	Learning environments must integrate with registrar systems, library information systems, content and knowledge management systems, etc.

Table 5: Standards, Tools & Granularity

4.4.9 Collection Interoperability

Another area of interoperability is interoperability among *collections or repositories* of resources. Standardized metadata, harvesting protocols and search and retrieval protocols play an important role in collection interoperability. The following diagram from the IMS Digital Repository Interoperability specification[13] (IMS, 2004) indicates the scope and complexity of the problem, even for a single repository.



Much of the NSDL standardization work (NSDL, 2004) has addressed this type of interoperability. Collection interoperability will not be a focus of this document, although some topics discussed will be relevant.

[13] IMS DRI specification version 1.0, January 30, 2003, Information Model, Figure 2.1: Functional Architecture.

4.5 Rights

Regardless of its technical and pedagogical appropriateness or the quality of its design, a resource cannot be reused if doing so would violate the terms and conditions imposed by copyrights, licenses, or contracts. In the academic community, it is also an ethical obligation to give proper attribution to authors, regardless of whether it is a legal condition of use[14]. And finally, access to source code may be a needed by anyone wishing to modify an existing digital learning resource for reuse. This identifies three issues that fall under the general category of *rights:*

- Copyright
- Attribution
- Modifiability

These issues must be examined from the perspectives of at least three different roles:

- An author or developer creating an original work (or the copyright owner)
- A collection acting as a content aggregator and distributor
- An educator who wishes to modify and reuse existing content

There are other important roles as well, including those of a publisher, commercial distributor, institutional policy maker and learner, but these are not central to the type of reuse that is most relevant to the NSDL.

The next few sections discuss the different rights issues from different perspectives. The final section contains a table that summarizes the discussion.

4.5.1 Copyright and Terms of Use

In the United States and many other countries, a digital resource is copyrighted the moment that is created. At U.S. educational institutions, copyright may belong to the author, to the institution (or state if it is a state-run institution), or something between. Look under the e-Learning policies tab on (Edutools, 2004) to explore some of the variety.

In general, copyrighted material cannot be modified, used in a class, or incorporated into other learning content without permission of the copyright holder. A major exception in the United States is the "fair use" exemption to the U.S. Copyright Act of 1976. This allows the use of copyrighted works for teaching and scholarship, but its applicability depends on the character of the use, the nature of the work, the amount being used and the effect on the market for the work. At best, fair use applies only to small portions of a digital learning resource and does not generally apply to situations where an educator wishes to incorporate existing resources into their own content. For more information on fair use, see (Stanford, 2004).

Another exemption in the United States is granted by the Technology, Education and Copyright Harmonization Act, or TEACH Act, passed into U.S. law in 2002. This permits the Internet to be used as a medium for delivering copyrighted multimedia content. However, it applies only to instructor controlled classes at accredited educational institutions and has additional policy and protection requirements, see (NCSU, 2004). The TEACH Act does not apply to self-study and overall has limited applicability.

[14] In Australia, attribution has become an enforceable right, see (AGD, 2001) Section 7.

Author Perspective: If the goal of an author is to enable reusability, it is a poor strategy to rely on exemptions to copyright laws[15]. A better alternative is to explicitly attach rights and conditions to a resource that allow the desired type of reuse. This can be done using an appropriate ready-made Creative Commons license (Creative Commons, 2004) or by giving appropriate notice with the work. A typical Creative Commons license might allow copying and distribution provided proper attribution is given and that it is for non-commercial use.

Collection or Repository Perspective: To enable reuse, collections have to manage rights, including distribution rights if a resource resides in a collection as a file rather than metadata pointing to a file. It helps for collections to maintain rights metadata and to be able to search and display the rights associated with a resource so that reusers can decide what to reuse.

Reuser Perspective: The most interesting intellectual property rights issues arise when someone wants to modify and reuse a digital learning resource. Anyone in that position hopes that the work is licensed in a way that grants permission to modify and redistribute. If it is not, they must make judgments about fair use and possibly seek permission. If payments or conditions apply and the resource is being combined with other resources, there may well be unanswered questions concerning what rights and fees apply to the new aggregation and as to whether a new (or *derived*) work has been created. Derived works have their own copyright and terms of use, of which reusers should be aware.

Note: Although it is generally legal to create a hyperlink to another Web site, there are circumstances under which this can be a copyright violation. Linking to a logo, or using a trademarked word as a link, is problematic. "Deep linking" (linking to anything other than a site's home page) may be objectionable, and "framing" (putting site inside a frame that re-brands it) or "in-lining" (using an image as part of your site via a hyperlink) are other potential problems. See (Stanford, 2004, Ch. 6) for a discussion.

4.5.2 Attribution

Attribution is the lifeblood of the academic and research world. Rewards in the academy depend on it and, more importantly, attribution is important for preserving the history and heritage of methods, ideas and procedures. Reuse with attribution is considered to be part of scholarship, whereas "using others' ideas and words without clearly acknowledging the source of that information[16]" (Indiana, 2004) is the definition of plagiarism. The success of any attempt to promote reuse in the academy is predicated on the ability to ensure that proper attribution is given to the materials being reused. See (Alberta, 2004) for references to plagiarism and "Cyber-plagiarism."

Author Perspective: It is in the interests of most authors and institutions to ensure that they are properly attributed. It is recommended that attribution be made a condition of use through an appropriate notice or license. It is also recommended that a proper citation to the work be included in the work or in its metadata in order to help reusers.

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[15] It is also not recommended that content be *placed into the public domain*, which is an act that removes all restrictions on use but that is irrevocable and relinquishes all control as well.

[16] This definition is taken from Indiana University's Web Site on Plagiarism (Indiana, 2004). It can also be found *without attribution* on www.legal-definitions.com, at www.sa.sdsu.edu/htc/Plagiarism.pdf, www.curry.edu/library_curry/tutorial/plagiarism.html, three of the first ten sites found using the search string "plagiarism is using others' ideas and words " on Google™ on January 12, 2004. (This verifies claims made verbally by Professor Suzanne K. Damarin of Ohio State University in October, 2003.)

Collection or Repository Perspective: Academic Web sites on plagiarism are often associated with libraries. There is an assumption of responsibility on the part of collections to proactively promote proper attribution through policies and education. At a minimum, collections need to provide proper attribution (through metadata) themselves.

Reuser Perspective: Plainly and simply, the burden of attribution lies with the reuser.

4.5.3 Modifiability

It was once the case that if a text document could be opened it could be edited. Now documents can be protected against modifications and formats such as PDF™ make documents hard or impossible to edit. Web pages can be copied and edited if "view source" (available on most browsers) reveals the complete source of the page, but this may not work for pages that are produced by Web content management systems or using middleware such as Cold Fusion™, PHP, or Active Server Pages. Flash™ separates the source code from the compiled version that is delivered to a Web browser and readable using the Flash™ plug-in. Java™ and other programming languages also keep the source separate from the complied version. This leads to a situation where it may be easy to adopt resource but impossible to adapt it.

Author Perspective: An author can choose to make source code available or not. If reusability is the goal, then the code should be made available. There are many open source distribution models, including ones for which a Creative Commons license can be obtained. For reusability, licenses that allow modification are essential.

Collection or Repository Perspective: Typically digital collections do not make source code available. To support reusability, collections need to enable retrieval of editable versions or of the source code, as is appropriate. This entails maintaining technical metadata that informs reusers of what tools are needed to modify a resource and managing rights to ensure that reusers have permission to modify resources they retrieve.

Reuser Perspective: An educator who wishes to modify existing content must make sure that it is in a modifiable format or that the source code is available and that he or she has the tools needed for editing and aggregating content.

4.5.4 Digital Rights Management

The entire field of managing rights in a digital networked environment is quite new. Digital rights management (which means managing rights by digital means) is currently associated with technologies that prevent unauthorized copying of entertainment media. However, the field is evolving in ways that could be more applicable to academic and research settings.

Specifications and standards are emerging for *expressing* rights independently of enforcing them (Robson, 2003). Such standards are needed so that rights can be displayed by collections. Collaborations and demonstrator projects are exploring how rights can be associated with digital resources in ways that persist when the resources are moved from a repository to an authoring tool or course management environment (Dalziel, 2003). As rights management evolves, it will become an important part of a reusability framework.

4.5.5 Rights Matrix

The following table summarizes the rights issues and perspectives discussed in this section.

Reusability and Rights: Issues and Perspectives			
	Copyright	**Attribution**	**Modifiability**
Author	To aid reusability an author (or owner of the original copyright) must grant permission to copy, distribute and modify the original work. One way to do this is with a Creative Commons license.	Authors can require attribution as part of a license. It also helps to include a statement showing how a work should be attributed.	It aids reusability if authors make available an editable version or the source code to a resource and if they grant permission to make modifications.
Collection	Reuse depends on the ability of collections to manage copyrights and licenses.	For reusability, collections should include proper attribution in metadata and promote proper attribution.	Collections should make editable versions or source code available. Technical requirements for editing a resource should be part of the metadata for a resource.
Reuser	Reusers must pay attention to copyright and license restrictions.	Reusers should properly cite and attribute work.	Reusers must have the proper tools and must pay attention to license conditions when editing and reusing resources. They may also be creating derived works, so the reuser should be aware of the copyright implications.

Table 6: Reusability and Rights

4.6 Metadata

Providing adequate and accurate metadata greatly enhances reusability because it helps the resource be found and used. The types of metadata most important for reusability are:

- **"Basic" Descriptive Information** (also known as *bibliographic* metadata). Basic descriptive information enables the resource to be found and used. It should include a resource's title, author, description, identifier and key words.

- **Contextual information.** Contextual information is used to find resources for a specific context. For educational applications, this includes information about the grade level and intended audience of a resource.

- **Rights Information.** Rights information describes permissions and terms of use.

- **Technical information**. Technical information includes the format of a resource and what software or systems are required to use or modify the resource.

- **User information**. User information includes software documentation (online, printed or in the form of help screens), instructor guides, and other information that helps a resource be properly and effectively used.

Many NSDL collections offer search or "advanced search" capabilities that allow resources to be selected on the basis of bibliographic, contextual, rights and technical information. Standards developed by organizations such as the Dublin Core Metadata Initiative (Dublin Core, 2004) and the IEEE Learning Technology Standards Committee (LTSC, 2004) allow metadata records to be created that can be easily incorporated into collections and used by learning delivery platforms. Information on metadata usage within the NSDL can be found through (NSDL, 2004).

4.6.1 Metadata and Granularity

As with all other aspects of reusability, the granularity of a resource affects which kind of metadata is needed. This is shown in the following table:

METADATA AS A FUNCTION OF GRANULARITY	
Granularity	Important Design Considerations
Content Asset	Basic descriptive and rights information will allow assets to be cataloged and reused. Technical information may also be important. In practice, content assets are often labeled only with a title and identifier.
Information Object	Basic descriptive information is important for information objects, but it may also be important to say something about the educational level and style of an information object. It may also be important to facilitate proper attribution by including the identification of the author(s) within metadata.
Learning Object	Contextual information becomes very important for learning objects. A title and description may not be enough to determine what they are about and who they are for. Guides for instructors and learners may be needed, and for adaptation, technical information and documentation become important. It is always a good idea to be explicit about terms of use.
Learning Component	Many learning resource catalogs list courses and modules and only provide basic descriptive information. More detailed contextual information is helpful, as is information that guides the user. It should be noted that most metadata associated with a learning component applies to the component as a whole and not to learning objects, information objects or content assets contained within it.
Learning Environment	Information about a learning environment is rarely encoded using a standardized metadata record. Nonetheless, it is important to provide a description, information about intended users, rights and technical information, and proper documentation.

5 LAB 1: EXAMINING A RESOURCE FOR REUSABILITY

In this exercise we will examine the reusability of the resource The Josephus Problem by Doug Ensley[17] from the MathDL Digital Classroom Resources. Here are the steps:

1. Go to the resource and become familiar with it. To access the resource, go to www.mathdl.org, click on 'Search' and enter 'Josephus problem' in the search box.

2. Determine what part(s) of the resource are

   - Content Assets
   - Information Objects
   - Learning Objects
   - Learning Components
   - Learning Environments

3. Discuss your conclusions with others at your table.

4. Thinking about how this resource might be reused:

   a. Determine if this resource is intended for reuse only as is or if it can be downloaded and modified by an author.
   b. Think about the potential audience for this resource

5. Analyze the deeper reusability of the resource by

   a. Identifying the design layers of the resource (see section 4.3)
   b. Identifying how well or poorly the layers are designed and separated
   c. Identifying interoperability issues (see section 4.4)
   d. Thinking about how you might reuse this resource
   e. Determining the rights associated with this resource (see section 4.5)
   f. Identifying the metadata associated with the resources and determining if it is accurate and adequate

6. Discuss your conclusions with others at your table. This will be followed by a group discussion.

[17] The full link is:
www.mathdl.org/offsite.html?page=http://www.ship.edu/~deensl/mathdl/Joseph.html&content_id=41520.

NSDL Workshop on Reusability and Interoperability. *Examining a Resource for Reusability.*

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6 REUSABLE DESIGN GUIDELINES

Most content is written by people who are not experts in instructional design, technology or standards.

Yet a few simple things can be done to greatly enhance the reusability of the digital learning resources they produce. The purpose of this section is to present some of these in the form of guidelines. These guidelines are generic and are intended to be modified for individual collections to accommodate their character and the tools and practices commonly used in the communities they represent.

6.1 Form of These Guidelines

These guidelines are loosely patterned after the World Wide Web consortium's Web content accessibility guidelines (www.w3.org/TR/WCAG10/). Each guideline has two parts:

- **Guideline.** This is a statement of the guideline, with a brief description and application. Some guidelines only apply to certain types of resource, for example resources that are being made available for modification. Each guideline is given a priority. The following priority scale is used.

  [**Priority 1:** Must be satisfied to ensure reusability.]

  [**Priority 2:** Should be satisfied to increase reusability.]

  [**Priority 3:** More sophisticated guideline that developers may address in order to enhance reusability.]

- **Techniques.** These explain how the guideline applies in typical situations. Each technique may contain one or more examples demonstrating how a developer or collection may satisfy the technique.

The guidelines are provided in a separate document. A Web version will be maintained at www.reusablelearning.org/guidelines/.

6.2 Status of These Guidelines

The guidelines presented here are an early draft. They will continue to be refined throughout 2004 and 2005.

NSDL Workshop on Reusability and Interoperability. *Reusable Design Guidelines.*

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7 LAB 2: REUSABLE DESIGN GUIDELINES

The purpose of this Lab is to become familiar with the Reusable Design Guidelines that have been developed by the Reusable Learning project. Here are the steps:

1. Review the guidelines and checkpoints and ask for clarifications. For this it is good to start with a printed copy of the guidelines. Electronic copies are available from www.reusablelearning.org/guidelines/.

2. Evaluate a resource

    a. Access and view Jules Verne Voyager Jr. at www.dpc.ucar.edu/VoyagerJr/jvvjrtool.html

    b. Apply the guidelines and determine which techniques it meets. Use the guidelines form supplied during the workshop to record your evaluation.

    c. Discuss the evaluations with the larger group.

3. Evaluate a second resource:

    a. Select a resource from your own collection or project, or from an NSDL collection of interest to you. Some suggestions are given at the end of this document.

    b. Apply the guidelines and determine which techniques it meets. Use the guidelines form supplied during the workshop to record your evaluation.

4. Evaluate the guidelines.

    a. Identify guidelines or techniques that are missing

    b. Note any problems with wording or interpretation

    c. Discuss tailoring the guidelines (which are by nature general) to the mathematical community

NSDL Workshop on Reusability and Interoperability. *Reusable Design Guidelines.*

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8 SCORM

SCORM is short for *Sharable Content Object Reference Model.* It consists of a set of specifications and standards[18] maintained and documented by the Advanced Distributed Learning initiative. SCORM addresses interoperability between content and the platforms that deliver the content.

This section focuses on SCORM because it is the most widely adopted grouping of content interoperability specifications and standards. SCORM derives from work done by the Aviation Industry CBT Committee (AICC), the IMS Global Learning Consortium, the IEEE Learning Technology Standards committee and others. SCORM is widely adopted by learning management systems, learning content management systems, authoring environment, assessment engines and course management systems[19]. WebCT and Blackboard both claim support for SCORM, as do products like Angel and Desire2Learn (WCET 2004). There are also open source projects such as RELOAD that provide SCORM tools. The following table shows some estimated adoption rates[20] by various categories of products.

Estimated Adoption Rates	**Corporate LCMS / LMS**	**Authoring Tools (Corporate & Academic)**	**Course Management Systems**
AICC specifications for content / LMS communication	80% – 90%	60% - 70%, including the products most commonly used	20% - 30%
SCORM	100%	70% - 80%, including the products most commonly used	40% - 50%
Various IMS specifications	No Data Available	No Data Available	60% - 70%

Table 7: Rough Estimates of Adoption Rates of Standards

8.1 What Problems Does SCORM Address?

SCORM is designed to separate learning content from learning platforms. This allows content to be developed once and run on any platform, much in the way that a movie recorded on a DVD can be played on any DVD player.

The desire to separate content from learning platforms is market driven. As long as content is tied to a single platform, customers are locked in to that platform. If they want to make a change, their choices are to re-develop their content or to stay with the same system. Lock-in disappears if content can be developed once and run anywhere. This also increases the potential market for any given piece of content and enlarges the pool of content that can run on any given learning platform, adding value to both content and learning platforms.

[18] Technically, *profiles* of specifications and standards.
[19] See (Collier, 2002), (Hall 2001) or (Masie, 2003) for definitions of these product categories.
[20] Data is based on Brandon-Hall reports (Chapman, 2003) (Nantel, 2004) , on private communications of results of surveys done by Thomson / NetG and Recombo, on the WCET Edutools site (WCET 2004), and confidential data available to the authors. The data are largely self-reported and lump "conformance," "certification," and "support" together. The table should be interpreted as *qualitative only*. SCORM refers to SCORM 1.2 and not to the newly released SCORM 2004. "IMS Specifications" refer to those that are *not* part of SCORM 1.2. The data for IMS specifications required interpretation of reports on (WCET, 2004).

8.2 Packaging and Metadata

Two immediate requirements must be met if content is to be separated from learning platforms. First, a mechanism is needed to transport the content (the equivalent of the DVD and the standards that make it writable and readable). Second, a learning platform must be able to discern and display metadata about content when it is loaded into the platform (the equivalent of the menu showing the scenes and "bonus content" on a DVD)

SCORM (versions 1.2 and 2004) addresses these problems using the IMS Content Packaging specification and the IEEE Learning Object Metadata standard[21]. Here are some details.

IMS Content Packaging: An IMS content package is Zip file that contains two parts:

1. A collection of learning resources (files)

2. An XML file called the *manifest* that contains

    a. A list of available resources and pointers to them. These could include files in the package or external links.

    b. One or more sets of instructions for structuring the available resources into a coherent learning experience.

    c. Metadata about the package and resources.

Learning Object Metadata: Learning Object Metadata (LOM) is a descriptive metadata standard that can be used to describe the following aspects of a learning resource:

- General information about the resource (e.g. title, description and aggregation level)
- Information related to its lifecycle (author, date and version)
- Technical requirements and characteristics (e.g. size and platform requirements)
- Educational characteristics (e.g. age level, type of the resource and learning time)
- Rights (whether there is a cost and other restrictions on use)
- Relationships to other learning resources
- Classification according to an arbitrary taxonomy

Metadata is familiar to the digital library community. All fifteen elements from unqualified Dublin Core can be mapped to and from LOM elements.

8.2.1 IMS Versions and Course Management Systems

SCORM uses versions of IMS Content Packaging and IEEE LOM that fit its particular needs. Current and previous IMS versions are implemented in course management systems and other technology independent of SCORM. The combination of IMS Content Packaging and LOM solve the problems of exporting, transporting and importing learning resources as long as the resources are not required to interact with student data or other aspects of the learning environment.

[21] More precisely, SCORM metadata is a *profile* of the IEEE LOM data model standard (IEEE 1484.12.1 - 2002) and an IEEE *draft* standard (1484.12.3) for an XML binding for LOM.

8.3 Learning Functionality and SCORM

The ability for content to communicate with the learning management system may not appear to be particularly valuable if we are dealing with content such as a text document, a PowerPoint™ presentation, or an interactive tool that does not keep track of its interactions with a learner. Here the role of the learning platform is to allow content to be stored, located and launched, and these issues are addressed by metadata and packaging standards described above. However, huge investments are being made in learning content and tools that track interactions with learners and the learner's progress. There is considerable value in being able to communicate this information to the learning management environment. To take advantage of these investments across all learning platforms requires a standard for communication between content and the learning platform.

A concern with separating content from learning platforms is the loss of learning functionality. With traditional computer based instruction, the software *is* the content. This is true for training program like *Mavis Beacon Teaches Typing*® and for standard computer games and simulations. These programs have the ability to track user interactions and to adjust their behavior accordingly, for example by presenting more challenging problems after mastery of easier ones has been demonstrated through a test. If content is to be developed independently of learning platforms, then this type of learning functionality requires clear standards for communication and coordination between the content and the learning platform as the content is running.

The approach taken by SCORM is based on work done by the Aviation Industry CBT Committee (AICC) in the late 1990's. The overall setup assumes that a student is interacting with a learning platform through a Web browser window. The learning platform delivers content to the student's desktop, either in the same browser environment or in an external window, but the parent window is always owned by the learning platform.

In the SCORM model, learning content is broken down into discrete chunks. These were called lessons in the original AICC work and are called *sharable content objects* or SCOs in SCORM. The learning platform is responsible for delivering SCOs one at a time. While a SCO is running, it can communicate with the learning platform. The information it can communicate includes

- The student's identity and certain preferences
- Time spent in the SCO
- Results of tests and test questions
- Information about the student's achievement on the SCO and the student's mastery of learning objectives, including ones not addressed by the current SCO)
- "Bookmarks" that keep a student's place in a SCO

When the SCO is finished running, it signals the learning platform and passes control back to it. The learning platform then delivers another SCO.

This flow is summarized in the following sequence of steps:

1. The Learning platform delivers a SCO to student
2. The SCO runs in student environment and communicates with learning platform
3. The SCO signals that it is finished
4. The Learning platform delivers new SCO

8.3.1 The SCORM API and Data Model

The above flow is implemented through two standards[22]. The first is an API, or *application programming interface* that uses JavaScript™. The API defines a set of JavaScript™ functions that allow content to communicate with a learning platform. The second is a *data model* that determines the type and format of information that may be communicated.

The way this works is as follows:

- When a SCO is designed, it uses the functions specified in the API standard. These functions will not work unless the SCO is loaded into an environment created by a SCORM learning platform.

- When a SCORM learning platform sets up a window environment on the student's desktop, it includes an "adaptor" that has functions exactly matching the functions in the API standard[23]. These are fully working functions that would cause the learning platform to send and receive data if they were invoked, but without a SCO loaded into a window, there is nothing to invoke them.

The situation at this point is very much like having a DVD player and a TV plugged in and ready to go but with the cable between them disconnected.

- In order to connect the JavaScript™ in the SCO to the functions in the adaptor, the SCO contains additional piece of code that searches for the adaptor and makes the connection. This is requirement for a SCO. Since it is the SCO that finds the adaptor, the SCO is required to signal the learning platform that a connection has been made. This is done by invoking one of the API functions.

- It is also a requirement that the SCO signal the learning platform when it terminates. This is also done through the API.

We are now ready to walk through what happens when student wants to take a SCORM course using a SCORM learning platform:

1. A student initiates a session with the learning platform. This establishes the identity of the student to the platform. The platform is assumed to have access to the student's records, preferences, past history with courses taken on that platform etc.

2. The learning platform sets up a browser window environment that allows the student to interact with it. This is enabled with a SCORM API adaptor.

3. The student selects a course. The course is made up of SCOs.

4. The learning platform now decides which SCO to load. This could be done in two ways:

    a. On the basis of a request made by the student, e.g. by selecting a SCO from a table of contents provided by the learning platform, or

[22] More precisely, as of this writing one an IEEE standard (IEEE 1484.11.2-2003) and the other is a draft IEEE standard (1484.11.1) anticipated to become a standard by the end of 2004.
[23] Often, the adaptor is a Java™ applet with the API functions as methods.

   b. By taking into account which SCOs the student has completed, what results have been obtained, what bookmarks have been set etc. (The rules for doing this will be the subject of the next section.)

5. A new SCO (or the last SCO seen at last point bookmarked) is loaded into the student's window environment.

6. The SCO connects to the adaptor provided by the learning platform.

7. The student starts working through the SCO. At various points the SCO may request information or transmit information to the learning platform.

8. When the student is finished with the SCO, the SCO terminates and the learning platform determines which SCO to deliver next, going back to step 4.

9. The student may terminate the process at any time using controls provided by the learning platform.

8.3.2 Sequencing

There is still one piece missing from SCORM as it is described so far: the rules by which a learning platform decides which SCO to deliver next. This is not a problem for courses with single SCO or that allow students to select SCOs from a table of contents. But rules are needed if the same type of instructional design strategies and adaptive behaviors are to be defined for SCORM content as have long been implemented in stand-alone educational software. The latest version of SCORM addresses this using a relatively new IMS specification called *Simple Sequencing.*

IMS Simple Sequencing views courses as consisting of a tree of *activities*. Activities may be attempted, may be completed and may report results. An activity (unlike a SCO) is not required to report results: Simple Sequencing allows for "non-communicative" content.

Simple Sequencing also uses the concept of a *learning objective*. Learning objectives can be measured and completed. Multiple activities can affect the state of a single learning objective, and one or more learning objectives can affect whether or not a student engages in a particular activity.

Using IMS Simple Sequencing, a learner starts at the root of an activity tree and progresses through it according to a set of rules that can depend on the status and history of every activity and learning objective. The rules can require a student to take the next activity, choose from among a set of activities, or take a linearly sequenced set of activities with the option of going either backwards or forwards. The rules can limit the number of attempts made for an activity, and there are provisions for randomizing or selecting a given number from among a set of activities. Simple Sequencing rules also define how results from multiple activities are combined into a single result.

8.4 Implications of SCORM

SCORM has significant implications for the design of both learning resources and course management systems.

- *It is fundamental to SCORM that navigation be controlled by the learning platform. This requires larger resources to be broken up into self-contained sections. This is also implicit in the IMS Content Packaging specification.*

  Sections must provide their own internal navigation, but navigation between them is the responsibility of the system that delivers them.

- *From an instructional design perspective, as well as from a sequencing perspective, these sections should ideally treat a single learning objective.*

  In other words, sections should be learning objects in the Learnativity sense, see Section 4.2.1.

  In SCORM, quizzes and tests are a type of content like any other content. They are not a feature of the learning platform. T*he same applies to chat rooms, bulletin boards and other learning activities that are often provided by course management systems.*

  This is counter to the way traditional course management systems are architected.

- *SCORM (or IMS Content Packaging) requires a lot of metadata.*

  IMS Content Packages permit metadata at every level. SCORM requires that metadata be provided at least for SCOs, especially if content is to be modified, disaggregated and re-aggregated. SCORM makes several elements mandatory for SCO metadata. These include technical format, version, status and rights metadata, all of which are seldom provided with current learning content.

9 Demonstration 1: Interoperability and Standards

The purpose of this demonstration is to show how SCORM works. The steps shown will be:

1. An off-the-shelf authoring tool will be used to create new content. The tool will be used to:

    a. Incorporate content assets and information assets from external sources.
    b. Author a "pre-test" that generates a score. The score will be saved in a variable and the content will be designed to branch to different parts dependent on the pre-test score.
    c. Show how variables associated with SCORM and AICC specifications can be accessed
    d. Create a SCORM 1.2 content package that contains a conformant SCO

2. The content generated by this tool will then be imported into a learning management system that supports SCORM 1.2. This import will use the IMS Content Packaging specification that is part of SCORM 1.2

3. A second piece of content, called the SCORM Detective, will be imported (or pre-imported) as well. The SCORM Detective is available from the SCORM portion of the ADL Web site. It is written in Flash and allows you to exercise the various communication commands.

4. The SCORM Detective and the content authored during the demonstration will be run in the learning management system, showing how SCORM communication takes place.

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10 FOSTERING REUSABILITY IN THE NSDL

Reusable design guidelines address content, but NSDL projects are more typically involved in the management of collections and in providing services to a community of practice. The question then arises:

What can NSDL projects do to foster the creation and support the dissemination of content that is designed for reuse?

This section collects some ideas and observations from a variety of sources.

10.1 Removing Barriers to Reuse

A frequently asked question is: "*How much online content is being reused in educational settings*?" From all reports, the answer is "*not much*." A better question is, "*Why? And what can be done about it?"*

There are barriers to reuse that the NSDL can address:

10.1.1 Rights

Reuse cannot happen without permission. People must be confident that they are permitted to use the content they find though NSDL collections and portals. Here are some possible steps to take in this direction:

1. *Post policies and information about rights.* The intent is to increasing the rights awareness of people and organizations whose content is referenced by the NSDL. Most universities have (or reference) sites that discuss rights, but most emphasize what needs to be done by faculty or students using content and few address authoring for reuse or adaptation / modification of existing content.

2. *Review the licenses and rights associated with content from other sources and generated by NSDL projects.* This is a necessary step for any steps that involve displaying rights information or enforcing a rights policy. Later we will raise the issue of having reusable content sections within some collections, in which case review would apply only to those sections.

3. *Recommend (or require) that appropriate Creative Commons licenses be used for all content referenced by (or generated by) NSDL projects.* This is a policy that would have a good effect but might be extremely hard to agree upon and enforce.

4. *Maintain, expose and allow searches on rights metadata for all NSDL resources.* The Dublin Core rights element points to a URL with rights information, whereas LOM rights expresses whether there is a cost and could either contain a reference to rights information or rights information itself (Duval & Hodgins, 2002). A better approach, being taken by Edusource in Canada, might be to use a standardized rights expression language (Robson, 2003) that ensures rights and conditions can be displayed in a human-readable format on NSDL sites.

10.1.2 Interoperability

There are technical barriers to reuse, even without the need to modify the content. If content is to be modified, or even ported to other servers by the content owners, then still

more interoperability factors come into play. Potential NSDL-wide steps to remove technical and interoperability barriers include:

1. *Recommend platforms and software*[24]*.* The NSDL could develop and maintain a set of recommended technical requirements for users and producers of NSDL content. This would include

   a. Brands and version numbers of operating systems and browsers
   b. Brands and version numbers of plug-ins
   c. Brands and version numbers of end-user applications, including software that is specific to certain disciplines.

   The desired effect would be that content conforming to the NSDL profile could be assumed to be usable by NSDL users and that NSDL users whose systems conformed to the NSDL profile could assume the could use NSDL content. However, recommending software and platforms is tantamount to endorsing some software providers over others, and the task of agreeing on the recommendations itself would be quite difficult.

2. *Recommend standards.* The NSDL could develop a recommended set of standards for interoperability. These could include

   a. Learning technology interoperability standards and specifications (e.g. SCORM)
   b. Standards for formats, such as XHTML

   A recommended set of standards of this nature would address some cross-platform issues and would be useful for content that is intended to be adapted for use in course management systems. Recommending standards might be a lot easier than recommending products.

3. *Maintain, expose and allow searches on technical metadata.* Interoperability might be helped by an NSDL policy to maintain better metadata on requirements (e.g. using the Dublin Core format element or LOM technical category).

4. *Review resources for interoperability.* This will be discussed in Section 10.1.4 on reusable design.

10.1.3 Metadata

The NSDL has an extensive set of metadata policies and practices. There are some areas which might be emphasized in support of reusability.

1. *Mandatory Support for Metadata.* The NSDL could develop a policy or metadata profile that *mandated* collections to support

   a. Basic descriptive metadata (probably covered under existing policy)
   b. Educational metadata elements
   c. Technical metadata
   d. Rights metadata (as in Section 10.1.1)

[24] It is interesting to note that the Aviation Industry CBT Committee, which has played a significant role in the development of e-learning interoperability standards, got its start in 1988 by creating guidelines and recommendations for the platforms used in aviation training centers so that they could run training content produced by any aircraft manufacturer.

2. *Links to Documentation.* NSDL collections could require links to be provided to software documentation and other usage information.

10.1.4 Reusable Design

The Reusable Learning project is intended to promote the creation of digital learning resources that have better reusability properties. There are several ways that NSDL projects can take advantage of this work.

1. *Recommend (or require) adherence to Reusable Design Guidelines.* Many significant educational communities could be reached through NSDL projects. The Reusable Learning project Reusable Design Guidelines and Web site are meant to be resources for this.

2. *Establish portions of collections for:*

    a. *Modifiable content.* Content in this portion of a collection would be downloadable in an editable format, with appropriate permissions granted.
    b. *SCORM content.* Content in this portion of the collection would be SCORM conformant. The collection would decide if this was to be self-reported or reviewed.
    c. *Reusable Learning Objects*. Content in this portion of a collection would satisfy both structural and instructional design criteria (determined by the collection).

10.1.5 Sociological Barriers

Legal, technological and pedagogic barriers to reuse may be far easier to overcome than sociological factors within the culture of education. In the experience of the workshop presenters, factors that are often mentioned include:

- Absence of a culture of sharing and reuse
- Lack of recognition and rewards for developing or using digital learning resources
- A need for professional development in teaching with digital learning resources

The NSDL could take some steps that might help overcome these barriers:

1. *Strive to be a role model for sharing and reuse.* The NSDL projects could engage in purposeful sharing, modification and recombination of each other's resources. Perhaps courses should be labeled like automobiles: 70% of the content in this course was derived from the NSDL!

2. *Track the reuse of content.* Defensible and practical metrics are needed if content development is to be rewarded. Adoption and adaptation rates could serve as one such metric. Note that this would ultimately necessitate having persistent unique identifiers for NSDL digital learning resources.

3. *Provide professional development opportunities that go beyond posting guidelines.* For example, the NSDL could host online course or seminars on reusable design.

10.2 Existing Policies

Many of the issues identified above are being addressed by the NSDL Core Integration team, by NSDL Standing Committees and by the NSDL Program. The 2004 NSF Request for Proposals contains tracks that focus on selection criteria and on end-users, as well as on establishing more support for communities of practice. Efforts to define "Web metrics" will provide data on reuse.

11 LAB 3: IMPLEMENTING & SUPPORTING REUSABILITY

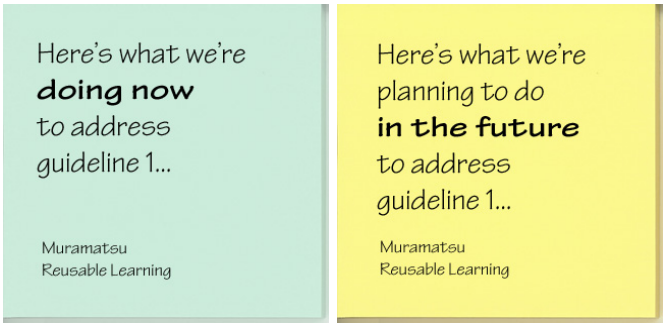
The goals of this Lab are to:

- List technologies, activities, services and policies you have in place to support each Reusable Design Guideline
- Identify technologies, activities, services and policies that should be put into place to support each Reusable Design Guideline
- Start to formulate an action plan for your project
- Discuss action plans for the Conference Group on Digital Mathematical Educational Resources and for the NSDL

Identify Current and Future Practices, Draft Action Plan

1. For each Reusable Design Guideline, make a note of what you are *currently doing* and what you could be *doing in the future* to enable end-users to meet and take advantage of that guideline.

2. Record each action on a sticky note, using green sticky notes for things you are doing now and yellow notes for future plans. On each sticky note include your project name and the action.



3. Place each sticky note on the flip-chart page (posted on the wall) corresponding to the guideline it addresses.

4. Walk around and observe / take notes on all suggestions.

5. Draft an action plan for your project.

Discussion – Current and Future Activities

Discussion of the collective current and future activities and services that the collections/projects plan to address the Reusable Design Guidelines.

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(NOTES)

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13 Glossary

This section defines a few important terms. It starts with a list of references to existing glossaries and then defines some terms that are needed to get started with the material presented in the workshop.

13.1 Key Terms of Reference

Adaptation:	Use or reuse of a digital learning resource in which changes are made, presumably to fit a new context or application.
Adoption:	Use or reuse of a digital learning resource without changing it.
Aggregation:	A digital learning resource that is composed of other digital learning resources.
Aggregation Level:	The degree to which a digital learning resource is made up of other digital learning resources. The higher the aggregation level, the deeper the hierarchical structure of a digital learning resource.
Assets:	"Learning content in its most basic form is composed of Assets that are electronic representations of media, text, images, sound, web pages, assessment objects or other pieces of data that can be delivered to a Web client." Term defined by SCORM 2004.
Author:	Person(s) creating a digital learning resource. This term is used loosely and could apply to developers, designers, and other contributors. The digital learning resource need not be new – it could be derived work or an aggregation of existing works.
Collection:	An entity that provides and maintains access to a set of digital learning resources organized around some theme. The term collection can refer to an organization or to a set of resources. Collections usually provide additional services to their users, e.g. search, discovery, cataloging, validation or reviews. The objects in a collection are often metadata records referencing digital learning resources, but some collections maintain some or all of their resources on their own servers.
Content Asset:	Raw media: images, text snippets, audio clips, applets, etc.
Decompose: (Decomposability):	Split a digital learning resource into more granular pieces. Decomposability is the ease with which this can be done.
Digital Learning Resource:	Anything in a digital format that is intended for use in learning.
Granularity:	The size, decomposability and the extent to which a resource is intended to be used as part of a larger resource. More granular digital learning resources are smaller and do not have sub-

	components. Less granular digital learning resources are larger and are composed of smaller pieces. Also see *aggregation level.*
IMS:	Short for the IMS Global Learning Consortium, a membership-based consortium that develops specifications for interoperability among learning systems and learning content
Information Object:	A text passage, Web page(s), applet, etc. that focuses on a single piece of information. It might explain a concept, illustrate a principle or describe a process.
Interoperability:	The extent to which a digital learning resource will "plug and play" on different platforms. Interoperability also refers to the ease with which two software components can exchange and correctly interpret each others' data.
Learning Component:	A generic term for things like lessons and courses that typically have multiple learning objectives and are composed of multiple learning objects.
Learning Goal:	The skills and concepts that a learner is expected to learn and the performance level that a learner is expected to achieve.
Learning Environment:	A catch-all phase for the combination of content and technology with which a learner interacts.
Learning Management System (LMS):	"A suite of functionalities designed to deliver, track, report on and manage learning content, student progress and student interactions. The term "LMS" can apply to very simple course management systems, or highly complex enterprise-wide distributed environments." Term defined by SCORM 2004.
Learning Object:	A collection of Information Objects that are assembled to teach a single learning objective.
Learning Objective:	A single measurable (or verifiable) step on the way to a learning goal. Learning objectives say what a learner is expected to do or learn and how an acceptable level of achievement will be verified.
Repository:	Technology and services that allow digital objects, or metadata about digital objects, to be maintained and accessed.
Repurposing:	Using a digital learning resource in a way or in a context other than that for which it was originally designed.
Reuse:	Using a digital learning resource in a context or setting other than that in which it was originally used. Note**:** This document uses the term *reuse* generically to include repurposing.
Reuser:	Person(s) wishing to reuse a digital learning resource.

Rights:	What a user can legally do with a digital learning resource. Rights are granted by governing laws and by the terms and conditions of contracts.
SCORM:	Acronym for Sharable Content Object Reference Model. SCORM consists of a set of specifications and standards maintained and documented by the Advanced Distributed Learning initiative.
SCORM Run-Time Environment (RTE):	"Provides a means for interoperability between Shareable Content Object-based learning content and Learning Management Systems." Term defined by SCORM 2004.
Shareable Content Object (SCO):	"A collection of one or more Assets that include a specific launchable asset that utilizes the SCORM Run-Time Environment to communicate with Learning Management Systems (LMSs). A SCO represents the lowest level of granularity of learning resources that can be tracked by an LMS using the SCORM Run-Time Environment." Term defined by SCORM 2004.
Specification:	A detailed and precise description of functionality, methodology and practice.
Standard:	A specification (see above) that is recognized as the accepted way to achieve a technical goal either because it is widely adopted or because it has been accredited by a formal standards body.

13.2 References to Other Glossaries

A large number of glossaries covering learning objects, e-learning, metadata and standards already exist. Some are listed here

13.2.1 Glossaries focused on standards and technical issues

The CETIS Encyclopedia:
http://www.cetis.ac.uk/encyclopedia/

Learning Systems Architecture Lab Glossary:
http://www.lsal.cmu.edu/lsal/resources/scaffold/glossary/

LionShare Glossary & URL directory:
http://lionshare.its.psu.edu:8080/wiki/Glossary

Macquarie E-learning Centre of Excellence COLIS project glossary:
http://www.melcoe.mq.edu.au/faq/

UK Online Learning Network Metadata Glossary:
http://www.ukoln.ac.uk/metadata/glossary/

13.2.2 Glossaries focused on e-learning

American Society for Training & Development Learning Circuits Glossary:
http://www.learningcircuits.org/glossary.html

Brandon-Hall Glossary of E-learning Terms:
http://www.brandonhall.com/public/pdfs/glossary.pdf

CELEBRATE Glossary:
http://eunbrux02.eun.org/ww/en/pub/celebrate_help/glossary.htm

Cisco Systems E-learning Glossary:
http://www.cisco.com/warp/public/10/wwtraining/elearning/pdf/elearn_glossary.pdf

DLESE Glossary:
http://www.dlese.org/documents/glossary.html

Dr. Thomas D. Wason's Glossary of Terms for Metadata, Taxonomies and Digital Libraries:
http://wason.home.mindspring.com/TDW/Glossary.htm

Dublin Core Metadata Glossary:
http://library.csun.edu/mwoodley/dublincoreglossary.html
EduSource Suite of Tools Glossary of Terms:
http://www.edusource.ca/public_documents/eduSource Glossary 290903.doc

Internet Time eGlossary:
http://www.internettime.com/itimegroup/eglossary.htm

The Le@rning Federation Glossary (Australia):
http://belts.sourceforge.net/systemadmin/glossary.html

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Learnativity Terms and Buzzwords:
http://learnativity.org/terms.html

Learnframe Glossary of E-learning Terms:
http://www.learnframe.com/aboutelearning/glossary.asp

NLII CMS Glossary:
http://educ3.utsa.edu/pmcgee/nlii/NLII_glo.rtf

NLII Learning Object Glossary:
http://educ3.utsa.edu/pmcgee/nlii/glossary/

Transforming e-Knowledge Glossary:
http://www.transformingeknowledge.info/glossary_f.html

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14 Sample Digital Learning Resources

- The Josephus Problem by Doug Ensley from the MathDL Digital Classroom Resources. http://www.mathdl.org/offsite.html?page=http://www.ship.edu/%7Edeensl/mathdl/Joseph.html&content_id=41520
- The pH Factor), a K-12 resource from the Miami Museum of Science. http://www.miamisci.org/ph/default.html
- Dietary Manager Training: Documenting the Nutrition Care Process by Kristy Norenberg, A Flash™ resource that is part of the Wisconsin Online Resource Center. http://www.wisc-online.com/objects/index.asp?objID=DTY1703
- Human Genome Project, "Exploring Our Molecular Selves" online multimedia educational kit, a publicly available resource produced by the NIH with various other sponsorships. http://www.genome.gov/Pages/EducationKit/online.htm
- CELEBRATE Learning Object Walk Through, Contains multiple resources. http://eunbrux02.eun.org/ww/en/pub/celebrate_help/lo_walk_through.htm
  An applet from Cyberchase called "Airlines Builder". http://pbskids.org/cyberchase/games/perimeterarea/perimeterarea.html
- A Sample WebCT course: Go to http://wiscinfo.doit.wisc.edu/webct/training/sample_course.htm and follow the instructions. Select the course "LIS 651: Cataloging and Classification."
- A Sample Blackboard course: Go to http://www.suce.syr.edu/Programs/Courses/distance/online/sample.html and follow the instructions. This is a course designed to introduce new users to Blackboard.
- Jules Verne Jr., exploring our planet.http://www.dpc.ucar.edu/VoyagerJr/jvvjrtool.html
- Hearing Conservation, environmental safety and health. http://www.skillsoft.com/demo/esh_gotrain.asp
- PowerPoint 2000: Introduction: Working with ClipArt, Tables, and WordArt http://www.elementk.com/e-learning/htm/freecourses.asp#
- We don't need no education. We don't need no thought control. http://www.magic-tab.com/a/wall/index.php

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