REUSABILITY AND REUSABLE DESIGN[1]

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What is Reusability?

This chapter is about reusability for digital learning resources, primarily those that are accessible through a Web browser. Reusability is defined as the ability to use the same resource multiple times in multiple ways and in multiple contexts. Reusability also encompasses the ability of developers to use a resource as a building block in their own work.

Some authors distinguish between "reuse" and "repurposing" but no such distinction will be made here. Reuse can take place when content is being designed and developed or when it is being used by instructors and learners. It could involve making changes to a resource (sometimes called "adapting" a resource) or using a resource "as is" (sometimes called "adopting" a resource). Examples of reuse include:

- A development team creating a library of templates and objects that are used multiple times when authoring and developing content.

- An instructor including an applet written by someone else in an online course.

- A learner searching for and finding a module on a topic she is studying and using the exercises from that module to check her understanding of the topic.

Reusers in the above scenarios benefit in different ways. Designers and developers save time and money by reusing or repurposing existing content rather than re-developing it. Instructors have more and better choices and don't have to develop content themselves. Learners benefit by having more learning resources at their disposal, thus increasing the chance that they can find one that is right for them. Reuse is certainly attractive, but it is not necessarily easy to achieve.

Reusability Requirements

What is needed for reusability? From the perspective of an author, instructor or learner, the ability to reuse a resource boils down to answering four questions in the affirmative:

- Can I find it?
- May I use it?
- Will it work?
- Can I use it in a way that works for me?

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[1] This is a preliminary version of a chapter slated to appear in a second edition of John V. Dempsey and Robert A. Reiser (Eds.) (2002), Trends and Issues in Instructional Design, Merill / Prentice-Hall, Upper Saddle River, New Jersey. This is being distributed solely for use by participants in a Reusable Learning training workshop.

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If the answer to any of the first three of these questions is "no" or "not easily," then reuse is a non-starter. You can't use a resource if you don't know it's there, you can't use a resource for which you do not have appropriate rights and permissions, and you can't use a resource if it won't work. The fourth issue is largely a matter of how a resource is designed.

The design of content for reuse is an important subject, but it should not be forgotten that a lot can be done to enhance reusability by simply ensuring that a resource can be easily found, that proper permissions are granted and that appropriate standards are followed so that the resource can be used without difficulty. These reusability factors will be addressed first, with design issues coming later.

Metadata

The process of finding appropriate learning resources is often called search and discovery, and a fundamental tool for search and discovery is metadata. Metadata is information about a resource. It comes in several different flavors:

> **Basic descriptive metadata (also called bibliographic metadata):** Title, author, description, identifier, subject, keywords, etc.
>
> **Contextual metadata:** Information about learning objectives, intended audience, level of difficulty and other instructionally oriented information. Relationships to other resources can also be considered to be contextual metadata.
> **Rights metadata:** Copyright information, terms of use, and contact information for obtaining permissions.
>
> **Technical metadata:** Format, platform requirements, software requirements and structural information.

Taking a broad view of the notion of metadata, it also makes sense to include

> **Usage information:** Documentation and guides.

Full text search engines such as Google™ have largely replaced keyword searches, but full text searches don't work for non-textual content and are of limited value when searching for content that fits into a particular instructional context, that has specific associated rights, that satisfies a given set of technical requirements or that has adequate associated documentation and usage information. If the promise of e-learning is, as put by Hodgins (2002a, p. 64), the ability to get "just the right stuff to just the right person at just the right time and place in just the right way and with just the right context on just the right device and through just the right medium," then these are all important things to know. It follows that authors and developers should try to provide as much metadata as possible and that learning object repositories should include options to search for resources according to many fields other than title, author and description.

While on the subject of metadata, it should be noted that search and discovery are not the only uses for metadata. In particular, bibliographic metadata is important for cataloging and preservation, which are increasingly critical issues in the digital world (Library of Congress,

2002; OCLC 2001, 2002). Also, modern search techniques depend on page ranks derived from data such as frequency, clustering, and linking degrees – all of which are arguably forms of contextual metadata.

Generating and using metadata

Given the importance of metadata, what techniques are available to authors for generating it and to repositories for using it? In the case of authors, the buzzword is "automated metadata generation" (Cardinaels, Meire, & Duval, 2005; Greenberg, Spurgin, & Crystal, 2005). Few of us are enthusiastic about filling in screen after screen of metadata every time we are involved in developing a new resource, and theoretically this is not necessary. Technical information such as the format or size of a resource can be derived directly from the resource, software used to support the development workflow should be clever enough to know and record information such as the author's name and what learning objectives are being addressed. Such tools do not exist in abundance today, but at the very least tools should be chosen that give designers and developers the opportunity to include rich metadata. Tools that create SCORM content generally do this (Nantel, 2004), and many of them capture at least some technical metadata in the files that are automatically generated as part of the "package" that SCORM uses to transport content from one system to another (Dodds & Thropp, 2004).

Another longtime trend in metadata is standards. By using variations on metadata standards such as IEEE Learning Object Metadata (IEEE, 2002) or qualified versions of Dublin Core metadata (DCMI, 2005), educational digital libraries are able to keep track of contextual and technical metadata. Their search interfaces permit users to not only look for resources by key words but to also search by a combination of criteria such as format, educational level, and copyright restrictions. See (Robson, Collier & Muramatsu, 2005) for examples. Beyond that, many of these repositories are using standards such as the Open Archives Initiative Protocol for Metadata Harvesting (Lagoze, Van de Sompel, Nelson, & Warner, 2002) and various standardized query languages (SRW, 2005; Simon, 2005) to enable federated searches. Users can find resources (or metadata records) in multiple repositories by searching any single repository in a federation.

Rights

The use and reuse of digital resources is increasingly subject to intellectual property rights, including patents, trade or service marks, and copyright. Of these, the one of most concern for reusability is copyright. There are several excellent resources on copyright, fair use, the TEACH Act, and related issues in U.S. Copyright Law (Stanford, 2005a; UT, 2005) and other jurisdictions (e.g. Green & Baulch, 2005; JISC, 2005; Stanford, 2005b). The high level summary for instructional designers is as follows:

- Most resources are copyrighted and fair use generally does not cover the types of reuse of existing resources when creating or distributing new ones.

- Copyright can be used to protect the interests of authors, publishers and distributors who receive money from the sale of content, but copyright can also prevent intended uses. For example, suppose that a university professor writes and posts an applet to a Web site. Copyright law restricts others from downloading and using the applet without permission, so

potential users must go to the trouble of obtaining permission if it is not explicitly granted on the Web site. This takes time and effort and may be difficult or impossible if the author is not the copyright holder.

Granting Permissions

Because obtaining permission takes time and effort, people involved in creating or disseminating learning resources should do their best to grant appropriate permissions in advance. An increasingly common approach to doing this is that taken by the Creative Commons (2005). The Creative Commons has developed licenses that express a small set of standard terms and conditions. The licenses have legal forms, plain English forms and forms for inclusion in a Web page or other resource. Creative Commons licenses can be used to grant the right copy and modify a resource, require proper attribution, or restrict the licensed use of a resource to non-commercial applications. A simple but effective step that authors can take to increase the reusability of their work is to disseminate it under a license of this type. Conversely, repositories that collect learning freely available resources can help their contributors by making a standard set of licenses available. This helps people who are contributing content that does not already have a license.

Managing Rights

Granting rights is all well and good, but learning resources often already come with their own copyright restrictions and licenses. In that case, it is important that potential users be able to see those restrictions and licenses and be given the information they need to request or purchase further rights. This information can be embedded in standard metadata, including Dublin Core metadata (DCMI, 2005) and the IEEE Learning Object Metadata (IEEE, 2003) used by SCORM. Rights metadata can be as basic as a link to a copyright statement or as sophisticated as a standardized XML rights expression (Coyle, 2004; ISO/IEC, 2005; ODRL 2005). In either case it is important not only to express rights by also to identify the rights holder so that potential users know where to ask for further permissions if needed.

Rudimentary but successful experiments have shown how rights management can be integrated into content management systems, course management systems, and e-reserves in academic environments (Colin & Simon, 2004; Dalziel, 2002). In these experiments, the systems not only display rights but also enforce them by denying unauthorized access to resources. In thinking about rights, it is important to separate the notions of expressing and displaying rights, which are necessary for reuse, from those of enforcing rights, which requires different technologies (Collier, Piccariello & Robson, 2004a & 2004b; Duncan, Barker, Douglas, Morrey, & Waelde, 2004). Rights enforcement will not be covered in this chapter.

Interoperability

The basic technical question faced by a potential user is “will it work in my environment?” This is often a question of interoperability, i.e. the ability of two software components to exchange and correctly interpret each others’ data. Many of the standards in e-learning, such as AICC (2005), SCORM, IEEE standards (2005), and IMS (2005) specifications, address interoperability issues. The point of these standards is to allow content to be developed for use by multiple delivery platforms. Content that conforms to these standards has wider applicability and is not locked into a single learning management system (LMS).

Interoperability does not just apply to content for learning management systems. There are even more basic considerations. One is cross-platform compatibility, meaning the ability for a resource to be used on different operating systems, with different browsers, and with different software configurations. A resource that requires a specific version of the Windows operating system has a more limited audience than one that can run on any version of Windows, Macintosh or Unix-based system. Another related consideration is that of requiring specialized plug-ins, software, or tools. Dependencies of this nature can have a severely limiting effect on reuse. Finally, from the perspective of a developer, a major issue is the availability of source code or editable versions of resources. For example, Flash™ content and Java™ applets cannot be edited unless the source code is made available.

The Role of Standards

Interoperability and platform independence can be greatly enhanced by adhering to industry standards. These can either be formal standards--such as those mentioned above for learning content interoperability--or simply formats that have ubiquitous availability and acceptance. PDF™, Flash™, Microsoft Word™ and Microsoft PowerPoint™ are example of such formats. It is a safe bet that content written in any one of these formats can be read by the majority of potential users.

The converse is that is a good idea to avoid reliance on specialized plug-ins and on features that are present in only one version of an operating system or in only one browser, e.g. on active-X controls or on the special capabilities of Internet Explorer. It is interesting to note that less than a year before this chapter was written in May of 2005 one might have argued that Internet Explorer™ was so dominant that content did not really need to be tested in other browsers, at least in the non-educational market. At the moment, however, it appears that FireFox™ is making phenomenal gains[3] and that even in corporate circles a second browser may end up with significant market share. Whether or not this happens, it illustrates the advantage of not being unnecessarily tied to a specific product or vendor.

Catering to Content Developers

If a learning resource is to be reused by developers, then a primary consideration is their ability to modify the resource. As indicated above, this requires making source code available. Repositories can aid in this respect by including links to source code. Rights also play a role because creating and distributing a modified version requires permission, which should either be granted in advance or should be made as easy as possible to obtain by providing appropriate contact information. Finally, developers will need to have appropriate tools to modify and existing resource. Even if a proprietary tool is used to develop a resource, publishing the resource in a standard format will increase the probability that another developer will have the tools needed to reuse the resource.

[3] According to ClickZ stats (http://www.clickz.com/stats/sectors/traffic_patterns/article.php/3500691) FireFox market share jumped from 4.23 in January of 2005 to 10.28% in April of 2005

Reusable Design

Once one gets beyond metadata, rights and interoperability, there is the more complex issue of how to intrinsically design content for reuse. This is called reusable design. Its primary goal is to create content that can be used in as many ways and in as many contexts as possible without sacrificing the quality and effectiveness of the content. Another goal of reusable design is to create content that can be reused in content development and creation processes.

A good way to understand reusable design is to deconstruct learning resources into layers. The ones chosen here are content, context, pedagogy, structure and presentation. Each layer affects reusability in a different way, and associated with each layer are design principles and techniques that can help ameliorate any negative effects. In addition, it is important not to conflate different layers. For example, presentation styles and sequencing should not impose a particular instructional design or be dependent on a specialized context.

Content

At the heart of any learning resource is content. This the information contained in a resource that is intended to affect a change in cognitive state. It's what the resource is about, but it is important to understand that the same content can be presented in different ways. Whenever a resource is designed, choices are made concerning how the content is structured; what words, images and sounds are used; what learning modes are supported; and so on. All of these choices are separate from the content itself.

The content of a learning resource has an effect on its potential audience. A learning resource that tests a learner's understanding of advanced principles in quantum mechanics has an intrinsically smaller audience than a resource designed to give learners practice in basic presentation skills or that teaches how to add fractions. A resource has to be designed within the constraints imposed by its content, but within those constraints choices can be made that maximize reusability.

Context

Content is interpreted with the aid of language, culture, subject knowledge, and other resources, in other words, within a context. Context is what is needed to properly use, understand and learn from a resource.

There is a natural tension between context and reuse. The more that can be assumed about the context of a learner, the easier it is to design an effective learning resource. For example, suppose that a designer has been asked to create training for a new billing system for Company X. The training will likely be more effective if it uses examples, terminology and procedures that are in fact used by Company X. At the same time, this makes it far less reusable by someone in a different company. Assumptions about shared vocabulary, pre-requisites, notation, linguistic abilities, knowledge of procedures, cultural icons – all of these things help people learn but impact the potential for reuse.

There are several ways in which content can be designed so that contextual dependencies become less of an issue.

- The use of language, images, and scenarios should be inspected to make sure that any cultural assumptions are appropriate and contribute to the effectiveness of the resource. If cultural dependencies are unproductive, they should be removed.

- References to external resources should be examined. If they are not generally available online, then it is worthwhile looking for substitutes.

- Implicit assumptions about notation, terminology and background should be teased out. To the extent reasonable for subject at hand, it is good practice to create separate sections for background material or to provide links to existing resources that provide it.

- Content should following Web Accessibility Guidelines (W3C, 2005).

- Multilingual versions of the same resources should be considered. Translation is aided by not embedding words into graphics and by using tools that support authoring in multiple languages if they are available.

Pedagogy

Learning takes place in many settings, including classroom settings, blended learning, online classes, self-study, and mentored learning. Learning resources also embody learning strategies and instructional designs, as is discussed at length elsewhere in this book.

Designing a resource for a single setting or instructional strategy limits its reusability. For example, a resource that requires an instructor to do a physical demonstration will be hard to use in online settings. Similarly, a resource that is built as a drill and practice module may be difficult to repurpose for discovery learning.

As with context, the key to reusable design is to isolate components that require specific pedagogical settings or approaches. If a lab experiment is required, it should be discussed in a separate section rather than sprinkled throughout the entire content. Teacher and student guides should also be kept separate, as should assessments. Assessments can be used in different ways (formative, normative, or as learning material) and can frequently be taken from one resource and used in another. Assessments embedded in the midst of other content are much harder to reuse than those that are self-contained.

Structure

Digital resources are often structured into smaller conceptual and physical units. Conceptual units include “information objects” (Horn, 1993) such as introductions, facts, principles, explanations, examples, assessments and so on. Physical units are things like Web pages, PowerPoint Slides, and paragraphs.

Many types of reuse involve parts of larger learning resources. A learner may want to use only one module in a course, and instructor may want to use only an assessment and a developer might want to reuses only an image or an applet. The physical and conceptual structure of a resource can either help or hinder this.

As an example, consider a resource used for teaching musical notation and suppose it consists of thirty pages that are linked via "forward" and "back" buttons and can only be navigated in order. A developer wishing to use just a few pages would have to remove or edit these buttons, and if an instructor assigned just a portion to a class, the learners would have to somehow get to the right pages and stay there. On the other hand, suppose that the same resource had clearly delineated sections on time signatures, clefs, the values of notes, etc. and had midi examples that could be played independently. A teacher, student or developer would then be better equipped to use just what they needed and to do so with a lot less effort.

LEARNING OBJECTS AND CONTENT MODELS

Examples like the above lead to the principle that reusability is enhanced if digital learning resources are structured into self-contained sections that address single learning objectives.[4] These are often called learning objects (Barritt & Lewis, 2000), although the term is also used to more broadly (Wiley, 2000). The notion of a learning object is tied to the more general concept of a content model that can be used to identify the components of a learning resource according to their granularity and pedagogical characteristics. The most common content model in use these days is that promoted by the Learnativity group (Hodgins, 2002b; Wagner, 2002). Figure 1 below is a variant of this content model. It shows how different levels of granularity are inherently more or less reusable by different reusers (authors, instructors and learners) and helps explain why learning objects fall in the "sweet spot."

The idea of using learning objects is implicit in IMS specifications, AICC guidelines and SCORM. All of these have notions of self-contained units that can be delivered and sequenced by an LMS (or equivalent delivery platform) according to instructions that are encoded with the content but that are separate from the content. In this paradigm, the LMS can be given instructions that determine how learners go from learning object to learning object. Whether using standards or not, it is important to avoid hard-coded navigation among different learning objects. Doing so destroys their self-contained nature and makes it harder to use them individually. Instead, inter-learning object navigation should be put into a frame or enabled using a table of contents on a separate page.

[4] The notion of a learning objective derives from the work of Robert Frank Mager (1997), Robert Gagne (1985), Walter Dick and Lou Carey (1996) and others

CONTENT MODEL (Adapted from the Learnativity Group)				
	Asset (Text, image, video, etc.)	**Information Object** (Fact, concept, principle, process)	**Learning Object** (Self-contained learning resource with a single learning objective)	**Learning Component (**Course, Unit, e-Book)
General Reusability Characteristics from Different Perspectives				
Author	Highly reusable. Authors frequently create libraries of assets for reuse	Easily reused. Authors often "cut and paste" information objects.	Sometimes reusable – saves significant effort when it is.	Usually too big to reuse (unless it can be broken up into reusable learning objects)
Instructor	Easily reused but often of limited value.	Sometimes hard to reuse because of lack of context or presence of extraneous material.	Often reusable and very useful. Can fit into many instructional designs.	Reusable only in parts or when it happens to cover exactly what is needed.
Learner	Assets generally need more context to be useful learning resources	May be just what is needed but often is not useful out of context.	Very useful for a learner who has a specific need. Can be used in self-directed, blended, or mentored settings.	Learners are more likely to use parts than entire learning components

FIGURE I: GRANUALARITY AND REUSE

Presentation

The presentation layer of a digital resource consists of the fonts, layout, graphics, color schemes, sound clips, video clips, buttons and other elements that are used to render the resource. Presentation is what gives a resource its look and feel.

Presentation has two effects on reuse. First, combining resources with different presentation styles produces a jarring and totally unsatisfactory effect. Second, presentation elements may contain contextual information that makes a resource unsuitable for reuse in many settings. Examples include organizational logos or fonts and styles that are appropriate for only one age group.

A very basic way to improve reusability it is to use formats that completely separate content from presentation. HTML, or better, XHTML, does this through the use of Cascading Style Sheets (Lie & Saarela, 1999). Ip, Radford, and Canale (2003) and others have used these techniques with SCORM content. Many other XML content formats do this as well. Using these formats allows presentation elements or "the skin" to be changed without touching the content.

Final Thoughts

Reusability is often considered the Shangri La of digital learning content. Attaining reusability requires use of metadata, management of rights, technical interoperability and an understanding of reusable design. Although techniques involving the application of standards may be considered to be narrowly focused on reuse, most of the recommended practices and techniques involve are just good information management and design practices.

Techniques may be basic, but that does not mean that it is easy to make them into habits. Fortunately, as multimedia content (not just learning content) becomes more structured and lives in increasingly distributed networks, authoring tools and repository software will likely become more attuned to reusability issues. This will result in reusable design becoming easier if not automatic, as has happened with accessible design.

What does this mean for instructional designers? Over time, a premium will be placed on resources that have self-contained components with clear learning objectives and good reusability characteristics. Designers study reusability techniques and apply them in their work. At the same time, instructional designers take a good look at the tools they use, preferring those that make it easy to separate presentation from content, that conform to standards, and that automatically generate as much metadata as possible. Designers should demand repositories that can be searched using instructionally relevant metadata and that do a decent job of exposing rights information. But most importantly, instructional designers should develop a discerning eye for reuse opportunities and a practiced hand at finding and reusing resources rather than building them from scratch. As reusable content becomes more prevalent and easier to find, the benefits to be gained by honing these skills will serve future designers well.

More information, references and examples of reusable design are available at the Reusable Learning site (Robson, Collier & Muramatsu, 2005) and in the references.

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