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Abstract

In the past, most developers of Web-based learning materials have tended to focus their activity on the development of content and information. With the plethora of people using the Web for learning, there is now growing interest in the use of design and development strategies that support and enable the reuse of materials in settings beyond the immediate context. Underpinning much of this activity are the concepts of learning objects and reusability. This paper describes a project in the Australian training sector which sought to design and develop a digital repository of learning resources to facilitate their reuse and application in new learning settings. The paper describes the context in which the original resources were created and the development of a system to store and provide access to these resources. The paper concludes with an examination of the utility and functionality of the system and the limitations inherent in the reuse of digital resources supported by such systems.

Reusability

There is currently a high degree of interest within teaching and learning organisations in the development of strategies and processes that will support the reusability of Web-based resources. The Web is replete with products and resources that have been developed for use in single settings and the prospect of reusing these resources in other settings appears to provide many opportunities and advantages to a large number of stakeholders.

There are many projects that are exploring this area on interest. Some of the more prominent projects include those seeking to develop development standards and protocols that support reuse, for example:

- Advanced Distributed Learning Initiative (ADL), a program of the US Department of Defense and the White House Office of Science and Technology to develop guidelines needed for large-scale development and implementation of efficient and effective distributed learning
- Sharable Courseware Object reference Model (SCORM) a set of development specifications for reusable learning objects;
- IMS Global Learning Consortium (IMS) which is developing and promoting open specifications for facilitating online distributed learning activities such as locating and using educational content,

- Dublin Core. An organization that has established a widely accepted technical specification for metadata for the content of digital resources for storage within digital libraries.

The concept of reusability is a relatively new idea in the field of instructional technologies and is being driven by a range of factors relating to economy, administration and learning quality (eg. Shepherd, 2001). Most current work in reusability is focusing on the development of learning objects and within this setting emerging topics of interest include accessibility, granularity, interoperability, scalability and durability of digital resources (eg. Longmire, 2000).

The IEEE Learning Technology Standards Committee (LTSC) describes a learning object as any entity digital or non-digital that can be used for learning education or training. Different people use other interpretations of the term and the definitions tend to vary in terms of granularity, ie. the size of a learning object, and instructional integrity, whether or not the object contains inherent instructional features. For some, an image can be a learning object while for others, since it is devoid of any explicit instructional features, it is more an information object. Hodgins (2002) argues that successful work in this area will enable educators to mix and match content from multiple sources, to develop interchangeable content that can be reused, assembled, and disassembled quickly and easily and will ensure people are not trapped by a vendor's proprietary learning technology.

While there are many projects seeking ways to provide guidelines and frameworks to guide the development of *new* resources, there is still the need for projects that can explore ways to support the reuse of *existing* digital resources. This paper describes a project undertaken in Australia which sought to develop a digital repository that could support the reuse of a broad array of existing digital resources from the National Flexible Learning Toolbox Project in alternative online learning settings.

National Flexible Learning Toolbox Project

In Australia, responsibility for national support of the education and training of the Australian labour force is vested in the Australian National Training authority, body whose brief is to ensure "that the skills of the Australian are sufficient to support internationally competitive commerce and industry and to provide individuals with opportunity to maximise their potential" (ANTA, 1998a). ANTA's agenda has been "to deliver training more responsively and efficiently and to a wider catchment area" (ANTA, 1998). The Authority has long recognised that technological advances have been the catalyst for new forms of educational and training systems and that the demand for, and supply of vocational education and training is increasing. Consequently it has enacted and sponsored strategies to encourage the vocational education and training (VET) providers to support more flexible, technological-based, delivery for domestic and international markets. One of these projects that has grown from an original concept into a well-developed project supporting flexible delivery and learning is the National Flexible Learning Toolbox Project.

The concept of a Toolbox as a building block for flexible delivery and open learning imbues the notion of a set of resources and tools that can be implemented by teachers and trainers to create and implement on-line and computer-based learning environments. The concept is a powerful strategy as a means to create sustainable and scalable materials for technology-based teaching and learning (eg. Hanley, Schneebeck & Zweier, 1998). Since 2000, Toolbox development has been a component of the Australian Flexible Learning Framework. In addition to the goal of producing world class online content, there are goals concerning professional development, policy, research, and infrastructure (see http://flexiblelearning.net.au) and there is considerable collaborative effort to integrate these. Policy for the framework is determined by FLAG (Flexible Learning Advisory Group). This consists of a representative of each of the 8 states and territories, plus

representatives from ANTA, DEST, and from the ACE (Adult and Community Education) sector. In a decentralised system, a public tendering system establishes which areas are to be covered by a toolbox and which organisation, or consortium of organisations, develops a Toolbox. Although some organisations have developed multiple Toolboxes, the development process is widely spread across the country and includes a large number of development agencies.

Quality in online teaching and learning
Developing resources to support quality teaching and learning was a key objective of the National Flexible Toolbox Project. Whereas many online resources are often criticised as electronic replicas of existing print-based resources (eg. Mioduser et. al., 1999), the Toolbox project established some sound principles and processes to support the development of high quality learning settings. It sought to achieve this by promoting design and development processes based on socio-constructivist learning theories and learning through knowledge construction. Such approaches require distinctly different design and development processes to those suggested by the instructional systems design (ISD) approaches which most developers had previously been following.

ISD approaches suggest an instructional and learning sequence which designers can follow in the determination of their learning settings. One such approach is described by Gagne (1972) in which instruction is seen to follow an instructional sequence of 9 events of instruction involving four stages: introduction, the body of the instruction, assessment and conclusion. Designers following such guidelines tend to focus their online learning settings around design strategies that place lesson content and resources at the forefront of instruction. The learning materials are presented as content to be learned and knowledge to be acquired and learners are provided with these resources and various consolidating activities. Such approaches tend to result in learning settings with poorly developed learning designs. Often there is no particular learning strategy presented to engage and contextualise the material. The content is presented in pages which learners are expected to follow and learning is intended to follow. Most contemporary writers now support learning settings with more deliberate forms of learning design. This transmissive approach to teaching is also often evident in settings where discipline-based approaches are employed that replicate traditional teaching and lecturing practices.

The learning designs which Toolbox developers were encouraged to use were those where learning is based on the students' completion of tasks and activities supported by appropriate learning resources and learning supports (Figure 1). Learning tasks play a fundamental role in determining learning outcomes. They determine how the learners will engage with the course materials and the forms of knowledge construction that will take place (eg. Wild & Quinn, 1997). They need to support cooperative and collaborative activities among the learners and must provide opportunities for reflection and articulation. The activities provide the purpose and the context for learners to deal with the content and information (Duffy & Cunningham, 1996).
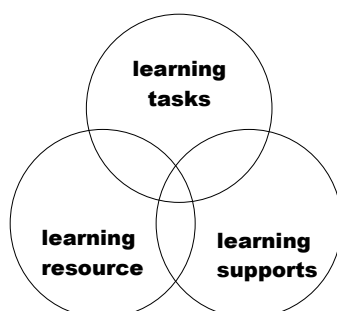
Figure 1: Framework describing critical elements of online learning settings (Oliver, 1999)

Strategies supporting reusability

The design of the digital resources for the Toolbox products, while supporting high quality learning designs, was also intended to support reusability. By encompassing these three elements, learning tasks, learning resources and learning supports, as discrete entities in the design process, resource reusability was enhanced. In particular, this approach encouraged the separation of learning context from the resources. For example, whereas previously a lesson might include instructional activities and sequences together on the same page, by placing the instructional elements on a separate page and providing resources as information and content alone, the content could then be used in other learning settings with alternative instructional elements, rather than being limited to the original context alone.

Although the term "reusability" was not prominent, the need for customisation was consciously recognised as a high priority, because the nationally developed resources needed to be useful (shared) in a variety of locations (allowing for different state geography, laws and practices) and a range of learning contexts. For example, distance, classroom, workplace, and among a variety of learners, for example, pre-employment, workforce skilling, career change. "Product Utility – portable, flexible, customisable" was a very significant requirement and now provides an alignment with the "reusability" movement

Reusability was also enhanced by specific design guidelines provided to developers which provided detailed descriptions of technical specifications against which the resources needed to be developed, strategies to enable the resources to be disaggregated and separated from their original contexts, and the inclusion of appropriate metadata into all Web-based resources. The project had commenced long before ADL had proposed guidelines and specifications for SCORM and as a result no consideration had been given to incorporating these specifications as part of the design process.

By the end of 2001 the Toolbox project had produced discrete sets of learning resources for nearly 40qualifications. Each Toolbox represented about 400 (series 2 and 3 were generally larger, but 400 is OK) hours of learning and typically comprised around 50 Mbytes of digital learning resources. Each of the Toolboxes was distributed on a CD-ROM ready for training institutions to load onto their web platforms. and while this aggregated storage format was designed to enable resources to be edited and customised, the discreteness of each product limited overall reuse of the discrete resources contained within each. The Toolbox Digital Repository Project undertaken in 2002 sought to develop a means to store the disaggregated materials from the various Toolboxes in a fashion which facilitated their discovery and provided a means for users to access resources of interest for use within their own learning settings.

The main drivers, then, for developing the Digital Repository Project were:
>   to enable the usage of each Toolbox's resources in areas other than the particular Training Package qualification that it had been designed for. There are important generic skills (eg work in teams) and knowledge (eg OH&S issues) that appear in many qualifications and reuse is economically attractive;
>   to allow for re-arrangement of existing resources when a Training Package is reviewed (each 3 years) so the existing resources could readily be realigned with the revised qualification

to cater for teachers who felt more comfortable aggregating smaller resources than customising a large product – this is a philosophical position important to some policy makers in the VET system. It's presented as what teachers are used to doing with a range of resources; and
to provide an alternative and easily accessible method of discovery and distribution of the Toolbox resources to increase their overall usage.

The Digital Repository Project

The Digital Repository project commenced in February 2002 and sought to explore strategies by which the various files and resources in the discrete Toolboxes might be stored and accessed by teachers looking to discover resources that could be used in their own teaching settings. After initial explorations and inquiries, it was decided that an appropriate strategy would be to develop a system whereby the resources could be stored in one location and to compile a database from the metadata contained in each. While the use of metadata alone is not sufficient for resource reusability, metadata tags do allow for the location of resources. Content within the National Flexible Learning Toolbox Project contains metadata information, adapted from the Dublin Core elements.
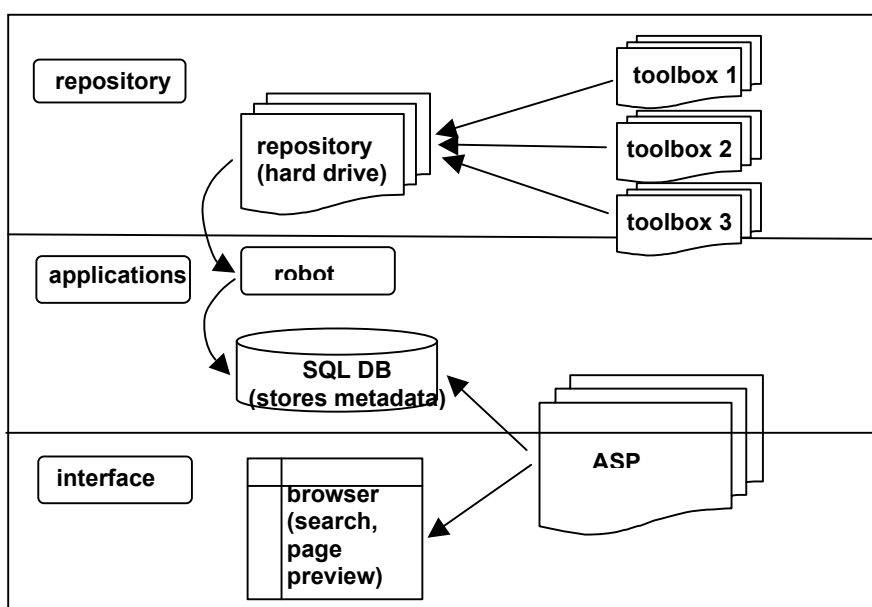
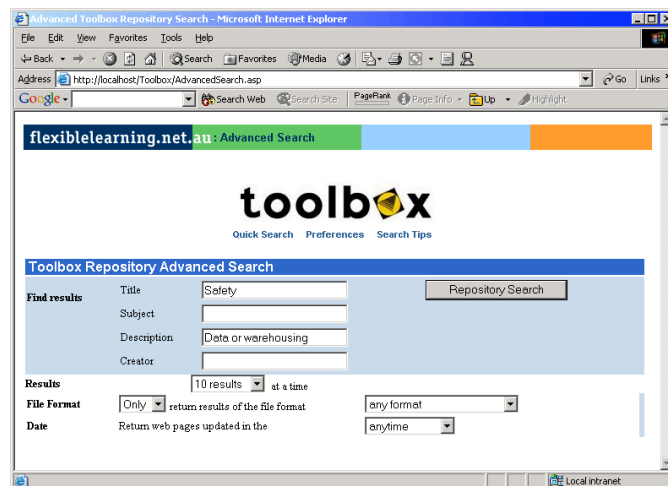**Figure 1:** Toolbox Digital Repository Architecture

It is important to make a distinction between the effectiveness of a search engine and the potential effectiveness provided by metadata usage. When metadata is used in the development of digital resources, it provides a means to identify and retrieve resources based on keyword searches but the effectiveness of the search is based very much on the quality of the metadata and the accuracy of its use. One of the activities in this project was to evaluate the metadata usage within the Toolbox Repository resources.

The software architecture we have chosen to implement the digital repository for the Toolbox Digital Repository Project is shown in Figure 1. The repository consists of a number of interrelated components that deal with the processing of metadata.

The repository contains a copy of each Toolbox CD. Using a 'robot' application, every resource within the repository hard drive is checked for metadata. Resources containing metadata are indexed within a database. Once this database is populated, it is ready for

searching. A search query entered by a user is translated into an SQL statement that returns a record set from the indexed database. This record set is manipulated and displayed within the web browser for the user to peruse. The architecture described here takes full advantage of the Dublin Core metadata standard used to describe educational resources within Toolboxes.

In its current state of development the Digital Repository contains over 130,000 discrete elements from the 2000 and 2001 Toolboxes. A robot has been developed that has enabled the metadata from these elements to be stored in a database which can be searched using an accompanying search engine (Figure 2).

Figure 2: Toolbox Digital Repository Search Engine

When keywords are entered into the search engine, a page (or series of pages) is produced with links to the various resources that match the keyword search. These pages can then be accessed to review the relevant resources so that decisions about their suitability can be made (Figure 3).
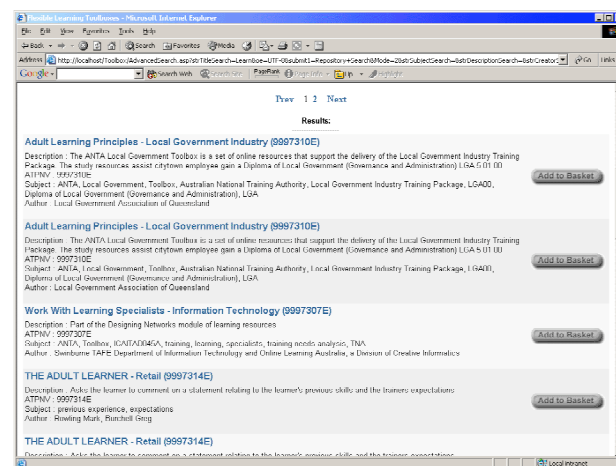
Figure 3: Search Results for the Toolbox Digital Repository

The Digital Repository provides a means then for users to select the items which they would like to reuse using a shopping cart process. Selected items are added to the cart and the user continues to add (and remove) items from the cart. When the user is happy with the items and wishes to proceed, on command from the user the system creates a zip file comprising

the pages selected and the resources (eg. images, graphics) displayed on each page, and allows the user to download this file to the user to facilitate reuse of the items in the user's setting (figure 4).

Outcomes

The development and implementation of the Toolbox Digital Repository project yielded some interesting and useful findings in terms of the strategies employed and the data with which we worked. The outcomes from this project appear to have the prospect of informing others working in similar areas and provide some important insights into the storage and discovery of digital resources in digital repositories. It is possible that other organizations could benefit from this technology or an adaptation of it, so explorations stemming from its use are important indicators as to the likely success of the system and factors influencing its potential use.
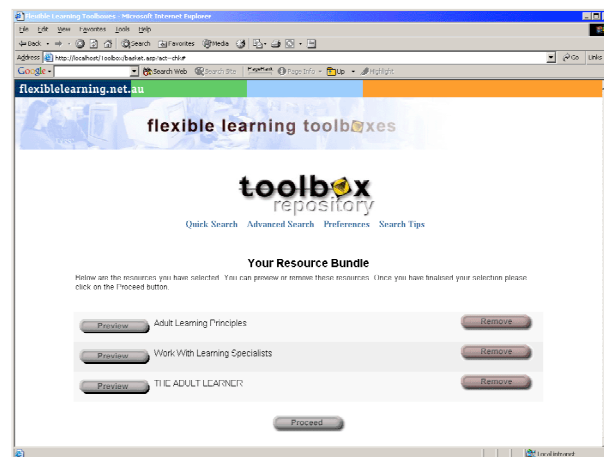
Figure 4: Downloading resources from the Toolbox Digital Repository as a zip file

a. Types of resources in the Repository

The organization and storage of the resources into the Toolbox Digital Repository revealed some interesting details about the files and resources which comprised the Toolbox products. In the first pass, the total number of files within the repository was 134,153. A large portion of these files were ancillary and not be used to convey information to the end user. Of the 134,153 files found in the Toolbox repository, 14674 (11%) contained DC standard metadata. The overwhelming majority of files within the repository were images, with .gif and .jpg file types totalling 78,766 files, or 58.7% of the repository. A large number of these files were banners, buttons, heading and background images and were not expected to contain metadata. The metadata were also a number of other file types that potentially could contain useful metadata information. These include documents (.doc, .rtf, .xls and .pdf), movie (.mov), animation (.fla), and audio files (.mp3, .wav and .rm). One can reasonably assume that a substantial portion of these media files are pertinent to the message conveyed within a course and the lack of accompanying metadata precluded their discovery by the robot.

The theory (and guidelines for practice) here is that these media files could be made available by describing resources accessed via the page within the page's DC.Description element and by duplicating the DC Type element on the page for each of these resources. The variety of media files and forms that are to be found in large scale learning systems suggests strongly the need for systems and processes that encourage and support metadata tagging for all resources. In this project, developers tended only to apply metadata to the pages which contained the various media objects and this was seen as a limitation in facilitating the discovery of useful resources from the Repository using keyword searches.

b. Adding new resources

The Digital Repository supports the addition of new resources. When new resources are added, the robot is instructed to rescan the files to add the metadata descriptions from the new items to the database. This process occurs quite quickly and the system has shown itself to be very stable and scalable.

The ability to retrospectively add metadata at a high level in the Toolbox directory and have it associated with resources lower in the hierarchy provided one of the more interesting (and promising) outcomes. During the project it was possible to add purchase codes and the new Toolbox numbering system to all resources in this way. As the paper is about reuse of existing resources, this is a rather important finding. As the Project progresses, we intend to explore the possibility of re-aggregating groups of pages that together constitute an "activity" or learning object by possibly retrospectively adding a DC.Relation (IsPartOf) to the pages in a subfolder containing an activity.

c. Metadata integrity

The functionality and utility of the Digital Repository relied heavily on the integrity of the metadata supplied by the developers for the individual resources. The quality of the metadata was seen to vary considerably across the resources. Even though the inclusions of the metadata was a contractual requirement for the developers, there were a number of discrepancies observed in the scope and extent of the metadata for the resources in the various Toolboxes. While the bulk of the metadata can be applied through automated processes, the really important metadata for reuse is the content descriptors and relational descriptors. With many resources the content descriptors lacked the detail to be able to distinguish items from others. Clearly the developers need to be guided in the choice of content descriptors, and to establish strategies within the design process that see the provision of metadata as a task of the highest priority and importance rather than as a task to be done simply to meet contractual obligations.

There appears to be a project management aspect to the reusability debate that does not get much attention, given that any agreed system may need to be usable by non-expert metadata authors. It will almost certainly not be within the domain of a single organisation able to impose a strict standard. Dublin Core's 15 (or less) elements seem more "doable" than IEEE's 80 or so in this environment.

d. Metadata extent

There were many files and resources in the various Toolboxes which contained insufficient metadata to be useful. While the products had undergone quite extensive quality assurance processes, it was not possible to view every file and resource and to check that it had appropriate metadata. It is possible however for a robot as used in the project to scan all the files and to report to the QA authorities on the scope and extent of metadata in Toolbox projects. This has been seen as a very useful activity and it is intended in future projects to use such a robot as a QA measure to ensure that developers are providing the metadata that is required.

e. Metadata for media files

The metadata in the resources of the Digital Repository was applied only to the HTML pages. This has meant that many graphics, movies, images etc. could not be discovered since the database included only those resources for which metadata was provided. It is possible to tag all the various forms of resource and it is possible for our system to extract this data for the database. This would be a useful feature to include in any subsequent developments of the system. Another problem was discovered in relation to the metadata provided for pages that were to be displayed within specific framesets. In such instances, the developers

applied the metadata for the various pages to the frameset files. When the files within such Toolboxes were indexed, often valuable pages were not indexed due to the metadata descriptors having been applied to connected rather than to the actual resources themselves. This problem is catered for in the SCORM specifications through

f. Granularity
The Toolbox Digital Repository has the capability to discover discrete pages through the metadata descriptors each contains. The system returns single pages from keyword searches with accompanying graphics and images. Unfortunately, in its current form, the system does not have the capability to return collections of related pages as a single entity. This means that if a topic or issue has been developed in a connected fashion in a Toolbox, the Repository will discover the various pages but the system can not yet provide the functionality that is required to pack the pages in their connected form. The page can be located and when downloaded the various files associated with it are gathered. However, the system relies on the user adding pages linked from a selected page to be added to the shopping cart in order for links to work. Each of the pages will need to be downloaded separately and reconnected by the teacher wishing to use them. The granularity of the Digital Repository is limited to single items whereas in practice, pages are often connected in learning sequences. Solutions to this problem seem to lie in systematic and deliberate use of the Relationship metadata tag which provides the capability for pages to be associated with others. This feature would need to be applied during the development stage and would be a difficult process to automate after the event. It may be possible to provide some form of *hooking* during the phase of adding pages to the shopping cart.

g. Stylesheets
In the current form, when pages are downloaded from the Digital Repository and displayed, their appearances differ considerably and it is very clear that different pages have come from different Toolboxes. A more feature of the Toolbox project has been the requirement for developers to use stylesheets to describe various aspects of the pages being designed. The use of stylesheets in a deliberate and organised from would appear to provide the solution to the mixed look and feel of the pages. It seems possible at the time of download to give users the option to choose from a particular set of styles which could then give the downloaded pages a consistent look and feel. This facility would be a useful future exploration.

Summary and Conclusions
The outcomes from the Digital Repository Project have been interesting in places and challenging in others. The Repository is currently being tested to confirm its usability and to seek to explore how it can support teachers looking to reuse resources from the Toolbox projects. The Project has raised a number of issues in relation to the technical specifications required for resources which are required to have some forms of reusability. The notion of granularity and the need to specify a size for the resources has led us to consider how it might be possible to combine and tie pages. Orrill (2002) describes a taxonomy of learning object types and includes web pages as "Combined- open". The use of this form of classification may assist in this approach.

The project has affirmed the usefulness of Dublin Core metadata and issue surrounding metadata applications leads us to question those systems which include a wide array of metadata elements. Future testing of the Repository will be used to discover the most important metadata fields and the findings will be used to inform the specification provided for metadata for Toolbox projects. The Project has also benefited from the capability of being able to retrofit metadata to resources and as more and more resources are added to the Repository the need for organizing strategies may see the for further work and explorations.

The nest stage of the Project will involve making the resources available to the public and investigating in an obtrusive fashion, the scope and extent of its use by teachers and tutors. It will be important to discover factors influencing the level of use of the system and to seek to implement strategies to maximise this level of use. As more and more Toolboxes are completed and added to the system, it is hoped that the Repository will grow and support the forms of customisation and reuse that sit at the heart of the National Flexible Toolbox Project.

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