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Learning designs and learning objects: Where pedagogy meets technology

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Abstract. This paper discusses an Australian project where online learning materials with problem-based learning designs are being developed in a form which facilitates their inclusion in digital repositories and learning management systems. To that end the products are being developed as properly formed SCORM compliant IMS content packages. This paper discusses issues associated with the design of online resources characterised by quality learning designs and their subsequent redevelopment as IMS content packages.

1. Learning Objects

The term *learning object* is one of the current buzzwords within the learning technology community and its use proliferates in much of the current discussion. This is quite an intriguing action given that so few people actually agree on what precisely constitutes a learning object. Whilst few people agree on what a learning object looks like, most agree with the concept as a solution for the current problems with discovery, reusability and interoperability of learning resources.

Among the many definitions of learning objects we read, are:
- self-contained modules that can support some discrete forms of learning,
- any entity, digital or non-digital, which can be used, re-used or referenced during technology supported learning [1];
- digital resources that can be used for any learning purpose [2]; and
- a small learning module which serves a learning objective [3].

The major problem which seems to exist in all of this discussion is the reference to learning. It is clear that within themselves, the conception and description of these entities are related more to technical details and system architectures eg. size, form etc. than any learning attribute [4]. The current specification and standardisation associated with learning objects stem mainly from technical and development specifications with learning features noticeably absent.

The apparent disconnection between most of the current work from learning issues appears to come from a number of factors in current work:
- The notion of learning objects draws mainly from needs associated with reuse, interoperability and repackaging;
- The desire to remove context from the content of objects improves reusability but limits inherent learning potential;

- Learning objects tend to be inadequately defined and relate to information and content presentation without any particular learning support;
- There is uncertainty and doubt in issues concerning the scope and size of learning objects [5];
- The researchers developing technical standards often display basic misunderstandings of contemporary conceptions of meaningful learning [6]; and
- The activity tends to be yet another example of technology rather than pedagogy leading the research agenda.

A number of researchers have attempted to create learning objects that satisfy the reusability requirement and that are also pedagogically rich. In such instances, the developers set very firm guidelines concerning size, form, and assessment [7]. Learning objects in these instances take the form of discrete elements able to support very targeted learning outcomes eg. rules, facts, procedures. With such learning objects, researchers are anxious to remind users that the use of these objects in a meaningful learning environment is still very dependent on the learning design associated with their use. Even in this very precise form, the objects themselves are still dependent on other factors in order to be seen as components of a meaningful learning environment.

2. Pedagogy and Learning Objects

Contemporary understandings of meaningful learning environments suggest that the forms of learning design that best support learning are those which are based on some type of problem-solving activity on the part of the learner. Contemporary conceptions of learning have been formed from the research into such learning areas as activity theory, situated cognition, authentic learning and social constructivism [8]. The emergence of instructional technologies coupled with these understandings of learning has led to the growing use of a variety of powerful learning environments across all sectors of education. In these uses there are many effective learning designs apparent including collaborative learning, problem-based learning, role-playing etc. [9]. These settings are ripe for the application of learning objects but often, it is these settings which have the least potential use for the objects that are derived from current activity. Much of the learning object activity is leading to the development of resources suited to learning designs that differ widely from those supported by contemporary understandings.

There have been a number of attempts to marry contemporary work with learning designs to that occurring with learning objects. Contemporary learning environments tend to be very resource rich and rely on access to a variety of digital learning materials. The literature describes various attempts to establish repositories of learning resources eg. [10], [11]. Digital repositories tend to provide a means for teachers to discover and access learning resources but these resources often fall short of contemporary views of learning objects since they typically comprise materials for learning taken directly from their local contexts. True learning objects, as defined by SCORM conformance, contain many more features and properties than these resources as a consequence of their ability to track learning and support discovery, reuse and interoperability.

This paper describes a large project in Australia which has been involved in the design and development of large scale online learning materials and which has used a number of strategies to support the reusability of the learning resources within. This project, the Flexible LearningToolbox project, has been characterised by the use of quality

learning designs coupled with deliberate strategies to facilitate the discovery and access of resources [12].

3. The Flexible Learning Toolbox Project

The Flexible Learning Toolbox Project commenced in 1997 and has continued as an ongoing series in which online resources for national curricula in the vocational education and training sector (VET) have been developed by teams throughout the country. Descriptions of the resources can be accessed at http://www.flexiblelearning.net.au/toolbox. Across the past 8 years over 90 separate Toolboxes have been developed, each representing around 400 hours of quality online learning [13].

A typical Toolbox contains complete online learning resources for a series of discrete modules that comprise a larger qualification, for example a Certificate or Advanced Diploma. The resources are created to specifications that require metadata be applied to the various resources and over time, have moved to IMS and SCORM conformance. Despite the fact that traditionally SCORM standards have led to the use of narrow learning designs, in the Toolbox project, the standards and specifications have been successfully applied to strong learning designs based on student-centred models of learning.

3.1 Early Stages

The early stages of the Toolbox project were undertaken at a time when the notions of reusable learning objects had not yet been formalised. Our developers were encouraged to consider reuse through the application of metadata descriptions to all resources and the use of learning designs where instructional elements were separated from the underpinning content and course information. The instructional designers were encouraged to use activity and problem-based learning designs which required learners to access information as part of a problem-solving process usually en-route to developing a product or artefact. This approach was intended to create resources with strong potential for reuse across a broad set of contexts. The Toolbox resources that were developed were all described with metadata and the development processes enabled the large numbers of resources to be disaggregated. The various resources however were all marketed and delivered within their original contexts and there was little evidence of teachers and trainers using or resusing any of the resources.

3.2 . The Digital Repository

In 2002 a project was undertaken to build a repository that would facilitate the organised storage and discovery of the vast number of discrete resources that had been produced to date. The development of a central store of the resources from the Flexible Learning Toolbox Project was an activity that sought to value-add to a very powerful set of learning resources [14]. The Digital Repository Project sought to develop a prototypical form of a repository that could be used to explore issues associated with the reuse of resources from the Toolbox project

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 and since the resources within the Flexible Learning Toolbox Project contained a

considerable degree of metadata information, this provided a strong support for any system looking to support resource discovery and access. The software architecture that was chosen to implement the digital repository is shown in Figure 1.

The repository took nearly 2 years to build and was completed in 2003. The repository had a number of unique features, foremost of which was its ability to facilitate advanced searches on the resources' metadata descriptors, a shopping cart type selection process of resources, and the download of a zip file to the user containing the selected resources (Figure 2).

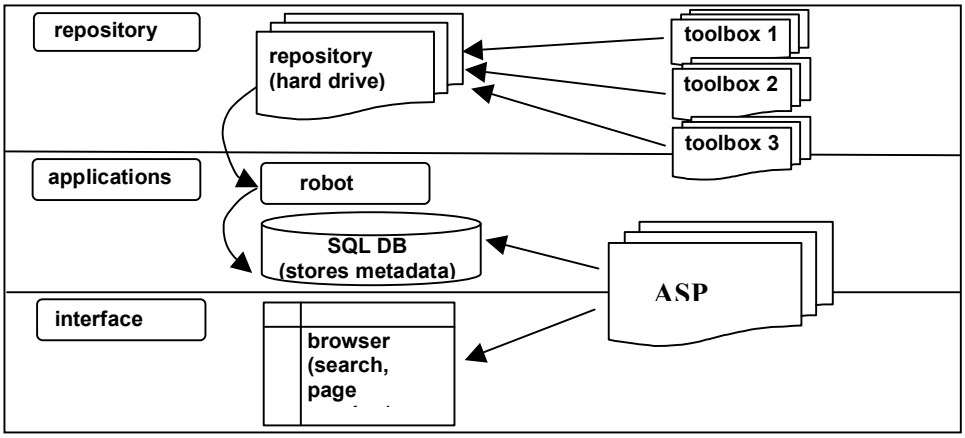

Figure 1: Toolbox Digital Repository Architecture

Testing of the Repository revealed a number of issues that potentially limited the utility of the tool and its ability to facilitate the reuse of the digital resources it contained.

a. Resources in the Repository In the first pass, the total number of files within the repository was over 130,000. A large portion of these files were ancillary and not be used to convey information to the end user. Of all the files found in the Toolbox repository, 14674 (11%) contained standard metadata. The overwhelming majority of files within the repository were images, with .gif and .jpg file types totalling 78,766 files (nearly 60%). The approach used of storing individual files had led to an inappropriate grain size in many instances.

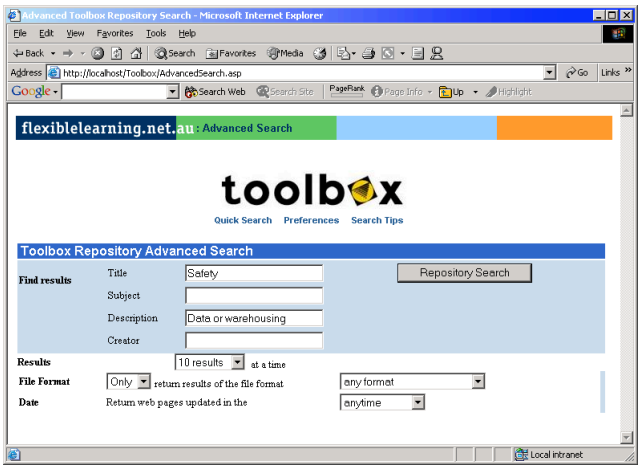

Figure 2: The Toolbox Digital repository

b. 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. With many resources the content descriptors lacked the detail to be able to distinguish items from others.
c. 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.
d. Metadata for media files The metadata in the Toolbox resources had been applied only to the HTML pages. This meant that many graphics, movies, images etc. could not be discovered since the Repository could only discover those resources for which metadata was provided.
e. Granularity The Digital Repository returns single pages from keyword searches with accompanying graphics and images. Unfortunately, in its developed form, the system did not have the capability to return collections of related pages as a single entity.
f. Stylesheets When pages were downloaded from the Digital Repository and displayed, their appearances differ considerably and it was very clear that different pages have come from different Toolboxes [13].

These issues and others revealed quite quickly that the way the resources had been organised and collected in the Repository was going to limit the capacity of the system to support and promote resource reuse and it became evident that there needed to be a change to the development approach if the resources were really going to be able to serve the 2 planned masters, the original Toolbox context and future reuse in other settings.

3.3 SCORM and Content Packaging Toolboxes

Given the unsuitability of the approach we had used with individual resources in the Toolbox Repository, an alternative solution promoting reusability was sought. The Toolboxes all tended to use contemporary learning designs based on knowledge construction [12] and the nature of the SCORM standard had until this point suggested that these resources might be difficult to build with SCORM [15]. As a trial activity to judge how SCORM might be applied in the design and development of Toolboxes, an activity was undertaken to produce a SCORM conformant Content Package using an existing Toolbox, The chosen Toolbox was built around an activity-based learning design and provided a sound model to test the processes by which Toolboxes might be designed and developed using SCORM

A sample of the Grange Care Services Toolbox is available via the Internet at http://flexiblelearning.net.au/toolbox/series6/602.htm. The first noticeable aspect of the Grange Care Services Toolbox is the front page which is a Flash animation. The Flash animation allows the learner to enter either the home care or residential services components of the toolbox. Here, we immediately discovered the impact of the SCORM rule that disallows navigation between SCOs. To adhere to this SCORM rule and keep the Flash animation, one would have to treat the entire Toolbox as one SCO. This is not only inelegant but defeats the purpose of SCORM: creating reusable learning objects. To produce a SCORM conformant toolbox, we could remove the navigation contained within the Flash object and transfer the navigation to a manifest file that accesses separate SCOs.

There were a number of ways to create SCORM conformant content with this Toolbox. For example, it was possible to determine that the Grange Home Care area was one big learning object, and all other resources were assets. This way, the manifest file would contain the index HTML page of Grange Home Care as the only SCO. While this approach may have passed the SCORM conformance test, it did not provide a learning object of a suitable size for reusability.

Another approach to building SCORM conformant content is to produce small content packages and combine those to produce a larger content package. Within the Grange Care example each task (nursing duty statements) within the unit could be considered a content package, containing individual tasks as SCOs. Each day of the week could also be a content package, containing sub-manifests that define duty statements. This idea could carry on recursively, incorporating duty statements as a content package, until eventually we encompass all learning content.

From a theoretical point of view, this was an ideal solution. By creating content packages at a low level, we would have learning objects that were readily reusable, and because they were a content package they should be also be meaningful. Using the smaller content packages we created a larger content package that could be disaggregated by future users. Unfortunately, under the current definition of SCORM (1.2), the implementation for sub-manifest aggregation was awkward at best.

The solution we chose for Grange Care was to create multiple SCOs and join them using the organisation section of the Manifest. Figure 3 shows the division of SCOs for our Content Package. At the lowest level we created a SCO for duty statements. This SCO contained assets that define how to complete a particular duty comprising sequential tasks. This represents the smallest reusable object. We used an individual duty statement, together with others, to form different sets of duty statements, each for a specific set of circumstances.

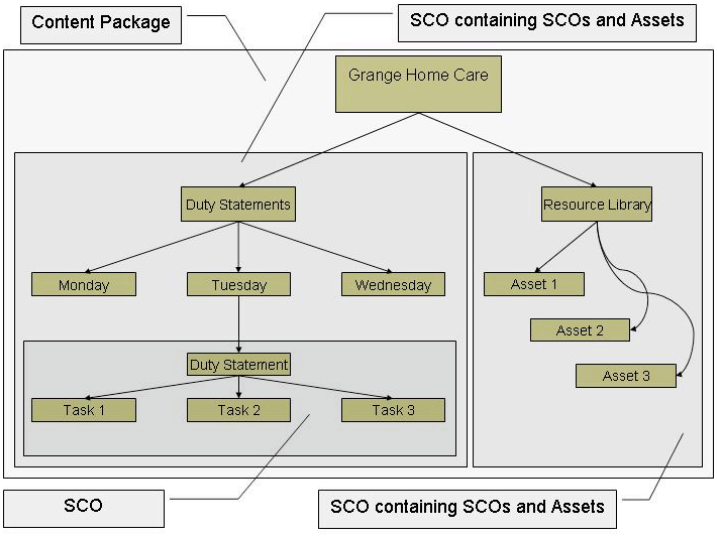

Figure 3: Multiple SCO layout

The activity to establish whether Toolboxes could easily be made SCORM comformant appeared to be very successful. The end product was a fully conformant product which still retained the student-centred learning design. The activity appeared to demonstrate many opportunities to be derived with little cost in terms of functionality and

limitations of learning design. The outcome added weight to the general thinking that subsequent Series of the Toolboxes all be developed to be SCORM conformant.

4. Summary and Conclusions

All future instantiations of Toolboxes are now being built as SCORM conformant Learning Objects but not SCORM conformant Toolboxes. The 1.2 version of SCORM we were using had some limitations and shortcomings: for example, the technical implementation of the aggregation and disaggregation of packages is not ideal. However, the limitations on SCO sequencing and navigations are enhanced in SCORM 2004. SCORM conformance is not difficult to reach. The major components required are: standard and readily available API functions applied to SCOs; metadata used to describe the learning resources; and a well formed manifest file.

As an extension to the Digital Repository project, we have taken a number of the earlier Toolbox projects and created SCORM conformant content packages from them. The revised Digital Repository is now populated with nearly 300 learning objects created from the Toolbox products. Whilst some of the learning objects are quite large in size, they demonstrate that it is possible to create SCORM conformant content packages from existing online resources based on a multitude of different learning designs.

Our experiences with retrospectively creating SCORM conformant forms of the Toolboxes have demonstrated that despite our initial misgivings that this standard may have limited our capacity to develop online resources using problem and activity-based learning designs, in the end this was not the case. While the use of this form of learning design is able to be supported by current SCORM specifications, its use in this form does appear to generate larger learning objects than applications with more conventional learning designs.

We are now addressing the problem of the grain size of the LOs by exploring instructional design strategies that enable a higher level of disaggregation of reusable resources. In some instances this involves separating instructional elements from informational elements and in others creating more modular forms for the learning resources. Designing the learning setting with reuse in mind can change aspects of the instructional design process.

The intention in our further work is to explore strategies that will see us developing learning objects of varying levels of granularity. For example, exploring ways to locate some dependent and reusable resources external to the Learning Object to facilitate its use in other LOs without the need for multiple copies. This will enable the larger units of study which currently are delivered as single learning objects, to be formed from smaller objects (assets) which themselves can be used as discrete entities outside the Toolbox context. When this occurs, we expect the levels of reuse and repurposing of the Toolbox resources to grow rapidly. We are also exploring the packaging of Toolbox resources using SCORM 2004, and simple sequencing procedures.

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