Quantifying the reuse of learning objects

Kristine Elliott and Kevin Sweeney
Biomedical Multimedia Unit
The University of Melbourne

This paper reports the findings of one case study from a larger project, which aims to quantify the claimed efficiencies of reusing learning objects to develop e-learning resources. The case study describes how an online inquiry project *Diabetes: A waste of energy* was developed by searching for, evaluating, modifying and then integrating as many pre-existing learning objects as possible into a learning design. Development times for the reuse approach were recorded and compared to estimates for the *de novo* development of an equivalent project. Outcomes suggest that considerable savings can be made using the reuse approach; we estimate that it would take up to three times more time to develop the *Diabetes* project by creating new objects. In this case study, gaining permission from owners to reuse objects was not a barrier to reuse. However, in some circumstances, being unable to source pre-existing objects to meet specific requirements, or having to modify objects for reuse, could be problematic.

Keywords: learning objects, reuse, development, e-learning resources

Introduction

One of the major developments in e-learning this decade has been the notion of reuse of digital resources. This approach sees resources created for one particular learning context, made available for reuse in another context. To be available, resources need to be searchable and accessible through the internet (Koper, 2003). Having been derived from object-oriented models of software programming, the basic component of the reuse approach is the learning object; small, discrete blocks of educational content that can stand alone, be aggregated to form more complex learning objects, and/or sequenced to create novel learning experiences. In this paper, we use Wiley's (2002) definition of a learning object as "any digital resource that can be reused to support learning".

Many benefits are expected from the reuse approach, including improved economic and time efficiencies for resource development, and more effective learning and teaching practices. However, the potential of the learning object economy is yet to be realised. Practical difficulties that educators encounter with sourcing and reassembling learning objects, along with socio-cultural attitudes towards collaboration and sharing resources have been identified as potential barriers to the reuse approach (Littlejohn, 2005). Therefore, it is not entirely clear at present whether it is feasible to expect educators to search for, re-purpose and integrate existing learning objects into new teaching contexts, in order to create effective teaching experiences.

In 2004, we began a project to create an online learning environment to enhance the learning and teaching of biochemistry, for second year students undertaking compulsory biochemistry units in their courses of Bachelor of Pharmacy and Bachelor of Pharmaceutical Sciences, at a major Australian university. The learning environment contained a series of five inquiry projects, incorporating learner tasks and resources. The rationale behind the development was to address problems that students had understanding specific biochemistry principles and concepts. More generally, the inquiry projects were designed to promote understanding of the scientific method of inquiry and development of life long learning strategies.

The development phase of this project was used as an opportunity to investigate practical aspects of the learning object approach. Rather than developing the inquiry projects *de novo*, they were created by searching for, aggregating and sequencing as much pre-existing material as possible. The main objective of the study was to quantify the claimed efficiencies of the reuse approach. To do this, the time taken to develop projects using the reuse approach was documented and then compared to time estimates for the *de novo* development of equivalent projects. Furthermore, we sought to identify the types of problems that educators might encounter during the reuse approach.

While data has been collected during development of the five inquiry projects contained within the learning environment, this paper presents the findings of one case study from the larger project; the development of an online inquiry project *Diabetes: A waste of energy* by reusing learning objects.

Method

The process used to develop *Diabetes* by reusing learning objects (LOs) is described below. It is based on Koper's (2003) *top down* approach that begins with a learning design that LOs are searched for, and then integrated into.

Learning design

The first phase involved the development of a learning design, which specified tasks students were required to perform, the resources and feedback supporting student activities, and the sequence in which these events occurred. This phase was an iterative process with gradual refinement of the design over time. While an in depth description of the learning design is not the focus of this paper, it can essentially be described as a template for inquiry projects in which students assume the role of professional scientist to solve real-life problems. The design incorporated a standardised scientific inquiry process that students were guided through in order to solve these problems. Theories of Inquiry learning (de Jong, 2006), Problem Based Learning (Barrows & Tamblyn, 1980), and constructivist philosophy (Mayes & de Freitas, 2004) informed the learning design.

Learning object requirements

With a clear understanding of the tasks, resources and supports composing the learning design, the next phase was to broadly define the LOs required to develop a project that addressed the biochemistry principles of bioenergetics and metabolism. The real-life problem of diabetes was an ideal way of introducing these principles to students (e.g. *Guinevere, a type 1 diabetic, has collapsed at a party – investigate details of metabolism to discover why*). Therefore, LOs were required that would set the context of the problem scenario, present the medical signs and symptoms of diabetes, explain the biochemistry of normal and starvation metabolism, illustrate the pathways involved in carbohydrate and lipid metabolism, indicate the sites of metabolic pathways, demonstrate the role of insulin and what goes wrong in diabetes, and show how diabetes is treated. LOs could also be used to allow students to reflect on, and test their understanding of the content.

Search

To find LOs, repositories such as ARIADNE, BIOME, Bitstream's medical links, CAREO, European Schoolnet, HEAL, LEARNet, MERLOT, TryScience and UCEL were searched, followed by use of the internet search engine *Google*^{TM}. Returned LOs were evaluated for their pedagogical value (i.e. did their content match the learning objectives of the project), technical suitability and compatibility with the interface design. Owners of selected LOs were contacted to obtain permission to reuse their materials. While the time to obtain permission was not specifically recorded for each LO, it was our experience that on average this process took 0.5 hr per LO. If existing objects could not be found that met specific content requirements, then new objects were produced. The time taken to search for, evaluate, and create all LOs used in the project was recorded.

Production

LOs identified for use were embedded into HTML pages, along with original content created by content experts. LOs requiring technical or educational changes were modified at this stage. Generally, the *Diabetes* project consisted of HTML pages containing images in GIF or JPEG format, Macromedia Flash animations and interactive exercises programmed in Javascript. In terms of the larger study outlined in the Introduction, all projects were incorporated into the empty shell of HTML templates used to create *The Virtual Laboratory*, a pre-existing learning environment developed by St Vincent's Institute of Medical Research and the Victorian Department of Education (Brack *et. al*., 2003). This shell was chosen because its structure and function suited our purposes and saved us from having to create another learning environment. A professional multimedia development unit dedicated to the development of educational technologies carried out production. The time spent modifying and embedding all reused LOs into html pages was recorded.

De novo development

An estimate was made of the time it would take to develop an equivalent project by creating all LOs anew, instead of reusing materials. To do this, an experienced web developer and educational designer together reviewed all the LOs in the *Diabetes* project, and estimated the time it would take to develop

them anew. Estimates were based on real development times documented for the production of similar materials by the multimedia development unit. To avoid possible underestimation, a further 20% was added to estimates, resulting in an estimated time range.

Time for tasks such as educational design and writing original content were not included in the estimate because we considered they would be equivalent in both methods of development.

Results and discussion

Learning object use in the project *Diabetes: A waste of energy* is summarised in Table 1. Searches returned a total of 77 LOs that were broadly consistent with our content requirements. Following evaluation, 38 (49%) of these were selected for reuse. Obtaining permission from owners to use their LOs was not an obstacle to reuse. Most owners were willing to share their materials for non-commercial, education use, particularly if appropriate acknowledgement was made. In this case study, permission to reuse was rejected for one LO because the owner requested commercial terms of use that were unsuitable to us. Two new LOs were created because of specific content needs; a schematic diagram showing integration of all the metabolic pathways involved in diabetes, and a close up image of a person monitoring blood glucose levels. Therefore, the final proportion of reused LOs in the project was 95%.

Table 1: Learning object use in the project *Diabetes: A waste of energy*

Returned from search	Selected	Permission to reuse		New	Total
		Rejected	Granted		
77	38	1	37	2	39

The types of LO reused in the development of *Diabetes* are shown in Table 2. By far, images were the major type of LO reused (74%). In this case study, images were used to; set the context of the problem scenario, demonstrate metabolic pathways and chemical structures, indicate sites of metabolic pathways, and graphically illustrate hormone effects.

Table 2: Type of learning object used in the project *Diabetes: A waste of energy*

Image	Interactive image	Animation	Tutorial	Text	Total
29 (74%)	1 (3%)	5 (13%)	2 (5%)	2 (5%)	39 (100%)

Of the 37 LOs reused, 36 (97%) required some form of modification. Changes to enhance the educational value of the object were made to 36 (97%) LOs. This type of modification included addition of introductory text, title, explanatory text, labels or arrows, and was primarily carried out to contextualise the LO within the inquiry scenario. Technical modifications such as changing file formats to one more suitable for the Web (e.g. from TIFF to PNG), were made to 22 (60%) LOs.

Development times for *Diabetes* are shown in Table 3. It took 14 hrs to search for, evaluate and create the 39 LOs in the *Diabetes* project. The time taken to obtain permission to reuse LOs was 19 hrs. The time taken to modify all reused LOs was 15 hrs, which included 8 hrs for technical modifications and 7 hrs for educational modifications. Therefore, in total these tasks took 48 hrs to complete (see Table 3). In comparison, we estimated that an equivalent project developed by creating all LOs anew, would be in the range133 - 160 hrs to develop (see Table 4).

Table 3: Development times (hrs) for the reuse method for the project *Diabetes: A waste of energy*

Search	Permission	Modification		Total
		Contexual	Technical	
14 (29%)	19 (40%)	7 (15%)	8 (16%)	48 (100%)

Table 4: Development time for the project *Diabetes: A waste of energy*

Reuse (actual)	*De novo* (estimate range)
47 (hrs)	133 - 160 (hrs)

Conclusions

In the context of developing the online inquiry project *Diabetes: A waste of energy* by reusing LOs, it was not difficult to find LOs that were broadly consistent with our needs. However, only 49% of returned LOs met our specific requirements. The *search and evaluate* process that was used in this study did not always return suitable LOs the first time around and needed to be repeated. This meant that many more LOs were returned from searches, than were actually used in the final product. The *search and evaluate* process accounted for 29% of development time.

Most LO owners willingly gave permission to reuse their resources for the non-commercial, educational purpose of the inquiry project. However, the time taken to contact and negotiate permissions from owners accounted for 40% of development time. Many owners made specific requests, for example, as to how copyright statements should be worded, or to access the learning environment to see how their resource(s) was being used.

The final proportion of reused LOs in the *Diabetes* project was 95%. There were only two instances when pre-existing LOs could not be found to meet requirements. In this case study, the majority of LOs reused were classed as raw assets (74%), containing no inherent educational context (Koppi *et al*., 2000). However, to create a meaningful learning experience for students, we found that it was necessary to modify 97% of pre-existing LOs for use in the inquiry scenario. The time taken to recontexualise LOs accounted for approximately 15% of development time. Furthermore, technical modifications needed to be made to 60% of LOs, and accounted for 16% of development time. In total, modifications accounted for 31% of development time.

A comparison of the time taken to develop the inquiry project by reusing learning objects, with an estimated range of time it would take for the *de novo* development of an equivalent project, suggests that considerable savings can be made by reusing LOs. We estimate that it would take approximately three times more time to develop the *Diabetes* project with newly created LOs. In this study, the low proportion of LOs returned from searches that were actually reused (49%) would have reduced the efficiency of the reuse approach. Therefore, there is the potential for greater savings as the adoption of e-learning catalogues and repositories becomes more mainstream and searching for LOs becomes more efficient.

While acknowledging that production using the reuse approach was carried out by a professional multimedia unit with experienced and skilled staff, and that development times determined for the *de novo* approach were estimates based on actual times, this study has provided an indication of the type of savings that educators can expect by using the reuse approach. Moreover, it has identified certain circumstances (e.g. being unable to source a pre-existing LOs to meet specific requirements, having to modify LOs for reuse,) that may be problematic for some educators working without the support of a professional multimedia unit.

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Kristine Elliott (kaelli@unimelb.edu.au) and **Kevin Sweeney** (sweeneyk@unimelb.edu.au)
Biomedical Multimedia Unit
Faculty of Medicine, Dentistry & Health Sciences
The University of Melbourne, 3010 Vic, Australia

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