

Analysis of the Pedagogical Attributes of Learning Objects

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Abstract. This paper describes the development and deployment of a tool designed to analyse and differentiate the pedagogical attributes of a collection of mature reusable learning objects. The tool was developed using an application of IMS Learning Design together with Pattern Language. The results show that a great degree of variability existed in the pedagogical attributes of learning objects. Similarly the tool allowed the relationships between attributes to be determined. The results of this work will allow analysis of the extent to which different pedagogical attributes affect patterns of reuse of learning objects and inform the development of reusable designs.

Introduction

Over the previous two decades there has been an exponential increase in the number of projects aimed at the development and deployment of reusable learning objects (RLOs) (Friesen 2004). The growth in this area has been driven by the potential of e-learning to address contemporary challenges in higher education such as widening participation, inclusivity, personalised and life-long learning. These projects require considerable investment in time and resources (Weller 2004), but are often justified by the goal of creating reusable materials, thus sharing the costs and benefits involved across a wide community of practice (Campbell, 2003, Weller, 2004). Indeed, a recent study of 27 e-learning projects reported high levels of planning and design for reusability (Currier & Campbell, 2002). However, reusability has never reached its expected potential. Historically, the difficulties surrounding reuse could be attributed to the materials themselves as they tended to be context specific and embedded into one delivery medium, but many of these issues have now been addressed and many papers now describe the design of materials specifically for reuse (Oliver 2001, Boyle 2003), but still reuse of e-learning materials produced by others remains very low. This apparent dilemma was summarised by Mayes in 2003 “*Once all of the technical and even pedagogical issues are out of the way, we will still be faced with cultural, social and organisational factors that will determine the extent to which learning objects are actually reused*” (Mayes 2003 pg 11). Given the reluctance to *reuse content*, recent discussions about reuse have moved their focus to *reuse of learning structures, learning patterns and learning designs* (McAndrew, Weller & Barrett-Baxendale 2006) and it may well be at this level that true reuse can be achieved, thus opening up the benefits of sharing to wide communities of practice. However, learning designs within RLOs are rarely explicit and are often based on the transfer of pedagogical experience of authors from other educational formats. Therefore, it is essential to analyse how these pedagogical designs are expressed within learning objects before examining which best support wide use and reuse. Important sources of evidence for this analysis are contained within the large repositories of mature learning objects that already exist. Thus, the aim of this study was to develop a tool that would allow the analysis of learning objects based on their pedagogical attributes, to deploy this on a set of mature RLOs and to determine how the expression of these pedagogical attributes mapped to patterns of use and reuse. The study forms part of the work of a project entitled “Sharing the LOAD: Learning Objectives, Activities and Designs”. This project, funded as part of the JISC Design for Learning Programme (JISC 2006), sets out to capture and identify real-world learning designs through a series of hands-on workshops and to exemplify a subset of these designs. The project runs under the aegis of the Centre for Excellence in Teaching & Learning in Reusable Learning Objects (RLO-CETL).

The RLOs and Repositories Used in This Study

Definitions of RLOs vary very widely and this can add greatly to the lack of clarity in terms of their roles, values and pedagogy (Friesen 2004). However, RLO-CETL defines RLOs as “web-based interactive chunks of e-learning designed to explain a stand-alone learning objective” (Boyle, Cook, Windle, Wharrad, Leeder & Alton 2006). These RLOs ideally support the development of active learning through the use of learner interactions and self assessments. Within this broad framework, individual RLO authors are given a very active role in developing pedagogical patterns that they consider most appropriate to the educational needs they are attempting to address. This “ground-up” approach, having the tutor at its centre rather than technology, is an imperative whose value is now widely accepted within e-learning (Gibbs & Gosper 2005). In effect, tutors import aspects of learning design from its successful use in other instances of learning such as the classroom. Therefore their learning designs are often not explicitly expressed and analysis is required to determine the mechanisms they have employed to support learning, and how they have balanced the sometimes conflicting demands within the small microcontext of an RLO.

The institutions conducting the Sharing the LOAD project house repositories of mature learning objects that have been developed and used over a number of years and it is these that have been analysed in this current study. These repositories, including the exemplars used in this report can be accessed at the following URLs: <http://www.nottingham.ac.uk/nursing/sonet/rlos/> and <http://www.ucel.ac.uk/rlos>.

Development of the Tool

There have been previous attempts to classify RLOs and to develop taxonomic languages to describe them. However, many of these were not suitable for the purpose outlined above. Some were based on an analysis of the technical attributes or formats of the learning objects, such as the eCornell “Periodic Table of Online Learning Elements” (eCornell 2003). Other taxonomies take a much broader view of the term learning object than that described above and thus classification of the objects, their attributes and pedagogy is undertaken at a far broader level of instructional design than is necessary for this project (Wiley 2001). Therefore it was necessary to construct a tool for use in this study. In developing the tool, attention was focused on IMS Learning Design. IMS Learning Design and the unified language that underpins it has been used as the basis for the analysis and codifying of learning design principles in a number of projects and arenas. It has been applied at a very broad level to describe learning across a range of levels in projects in the development of major initiatives such as the Learning Activity Management System (LAMS 2002), but its application has also been described in specific instances, such as in computer gaming (Burgos, Berbegal, Griffiths, Tattersall & Koper 2006). However, to the knowledge of the authors, it has not been used before to codify learning design at the level of the RLO, as defined above.

The tool that was developed for this project was largely based on the principal level of implementation of IMS Learning Design - Level A (IMS Global Learning Consortium 2003). This defines a learning instantiation under three major headings, *the environment* in which the learning takes place, *the roles* played by those involved in the learning process and the *activities* undertaken (IMS Global Learning Consortium 2003). However, these categories were designed to analyse pedagogy at the level of a class, module or course, rather than the microcontext of learning represented by an RLO. Therefore, it has been necessary to interpret these characteristics for application to the RLO. For each of the categories, a range of pedagogical attributes that reflect the learning design elements of an RLO have been identified. An example of the tool, the learning object attribute metric (LOAM), is shown in Fig.1. The weighting for the scoring criteria used in the LOAM tool was informed by the concept of pattern language. Pattern language was devised by Christopher Alexander (Alexander, 1977) to describe the underlying patterns, their problems and potential solutions, in architecture. Rather than rigidly identifying a specific solution, by examining the underlying fundamental pattern it is possible to create a myriad of varieties of solution to a particular problem. This approach has been used fairly widely in teaching object-oriented programming and UI design (Griffiths & Pemberton 2000, Fincher & Utting 2002) but is so far quite under-used in more general pedagogical design. It was employed here as it allows the definition of an attribute, the potential conflicting forces influencing that attribute and ways in which these forces can be brought into resolution. The scoring criteria for the LOAM tool are shown in Tab.1.

Environment

Within an RLO the *environment* represents two things, the media elements that form the created environment and the background that places the learning object into the broader context of the learner’s experience. The characteristics of the objects were determined by recording the media elements they contain (text, audio, images, animations, video, interactive elements) and the extent of the learning object covered by those media elements. Pedagogical attributes recorded under the umbrella of *environment* included the clarity and focus of the learning *objective*, the *media richness* (quality, variability etc.) and level of coherent *integration* of media elements used to address the learning goal. The background against which the learning was set was analysed by the extent to which materials covered in the learning object were contextualised (*context*).

Roles

The roles that the learner undertakes within an RLO are perhaps more limited than those envisaged by the range described within IMS learning design, but the types of roles undertaken were recorded (recipient, navigator, participant, contributor, self assessor, problem solver). The pedagogical attributes recorded in this area included the level of *self direction* afforded to the learner and the extent to which the learner is required to possess *pre-requisite* knowledge. The role of the tutor within the RLO is largely represented by the role of the content author. Again, although limited, it was represented by the extent to which the content authors embedded levels of *support* and *feedback* within the RLO.

Activity

RLOs contain a number of activities that the learners may undertake. The types and extent of these activities were recorded. Pedagogical attributes recorded in this area included the inclusion and extent of *interactivity*, the inclusion and extent of self assessment, the degree to which the assessment showed *alignment* with the learning goal and the extent to which *navigation* played an active part in the learning design.

IMS Learning Design Framework											
Environment (%)			Roles (%)				Activity (%)				
Text			Recipient of information				MCQ				
Audio			Navigator				Answer Selection				
Images			Active participant				Drag and drop				
Animation			Contributor				Text entering				
Video			Self-assessor				Image selection				
Interactive elements			Problem solver				Image manipulation				
Learning Object Pedagogical Attributes											
Inter-activity	Objective	Integration	Context	Richness	Pre-requisites	Support	Feedback	Self-direction	Navigation	Assess - ment	Alignment
1	1	1	1	1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5	5	5	5	5

Figure 1. The Learning Object Attribute Metric (LOAM) tool.

Validity

The content validity of the tool was addressed by gaining individual feedback from experts in various fields of pedagogical expertise. In addition, group feedback was recorded from a range of stakeholder groups including tutors, developers and students and external project evaluators. The comments of each group were used to refine the tool. Initial use of the tool involved a focus-group approach allowing discussion of weighting of results etc. A number of the objects were coded independently by different researchers and the results compared for concurrence.

Interactivity	Support
<ul style="list-style-type: none"> 1 No interactivity included 2 0-20% of the RLO is interactive 3 20-35% of the RLO is interactive 4 35-50% of the RLO is interactive 5 >50% of the RLO is interactive 	<ul style="list-style-type: none"> 1 No support is included within the RLO 2 Minimal support/instruction is included within the RLO 3 A High level of support/instruction is included within the RLO 4 As 3, but further instruction/support is requestable 5 Support/instruction is adaptive to the needs of the learner
Objective	Feedback
<ul style="list-style-type: none"> 1 No match between content and objective 2 Poor match between content and objective 3 Good match between content and objective 4 Very good match between content and objective 5 Complete match between content and objective 	<ul style="list-style-type: none"> 1 None included 2 Minimal feedback included 3 Good level of feedback included 4 Feedback is responsive to the learner's needs 5 Feedback is adaptive to the learner's needs
Integration	Self Direction
<ul style="list-style-type: none"> 1 Contains only one media type 2 Contains at least 2 media types 3 Contains at least 3 media types with loose integration 4 Contains at least 3 media types with clear integration 5 Contains at least 3 media types with a high level of integration 	<p>In relation to tasks, completion or direction:</p> <ul style="list-style-type: none"> 1 The learner has no control over how they use the RLO 2 1-2 points at which learner can make choices 3 2-5 points at which the learner can make choices 4 The learner can make choices at points throughout the RLO 5 The learner has complete self direction within the RLO
Context	Navigation
<ul style="list-style-type: none"> 1 Only relevant to a specific subject area 2 High level of subject dependence/reusability reduced 3 Some contextual references included, 4 Minimal contextual references made 5 No contextual references included 	<ul style="list-style-type: none"> 1 No navigation 2 Linear 3 Directed, but options 4 Mixed/directed and open 5 Completely open navigation
Media Richness	Assessment
<ul style="list-style-type: none"> 1 No visual or audio elements 2 Media elements are below average quality 3 Media elements are of good quality 4 Media elements are of high quality 5 Media elements are of exceptional quality 	<ul style="list-style-type: none"> 1 None included 2 A Few questions are included (at end?) 3 An appropriate number of questions included 4 A high level of assessment is included 5 As 4, but assessment is available throughout the learning object
Pre-requisites	Alignment
<p>Before undertaking this RLO:</p> <ul style="list-style-type: none"> 1 Learners will require very specific knowledge 2 Learners will require a good subject knowledge 3 Learners will require a general subject knowledge 4 Learner will require only general knowledge 5 Learners will not require any pre-requisite knowledge 	<ul style="list-style-type: none"> 1 No assessment 2 The assessment will not assess the learning goal (No alignment) 3 The assessment covers some aspects of the learning goal 4 The assessment cover most aspects of the learning goal 5 The assessment adequately covers the learning goal

Table 1. The scoring criteria used in conjunction with the LOAM tool

Deployment of the tool

In total 101 RLOs from the partners' repositories were subjected to analysis by the LOAM tool. Each of the RLOs chosen was considered to be mature in that it had been developed using a rigorous methodological framework (Boyle et al 2006), including a range of quality assurance checks. As a minimum, each object scored had been deployed and evaluated for a least one cycle within the course for which it was designed.

The media elements, activities and roles that comprised each RLO were recorded, and the proportion of the RLO containing those elements expressed as a percentage. Group results were expressed as mean and standard error for each category. As pedagogical attributes were scored using an ordinal scale, results were expressed as mode and range. The relationships between the different attributes was analysed using Spearman's rank correlation analysis. As multiple analyses were undertaken, correlations were only considered significant at the 1% level.

Results

Classification

Based on the composition of the media environments, roles and activities, several broad categories of learning objects could be discerned within the mature repositories. Three distinct groups were identified: the "small-sectioned RLOs", which typically were highly focused on a very narrow learning goal and generally consisted of a single media-type aimed at supporting learners who were mainly recipients of information to achieve that learning goal; the "Scenario-based" RLOs which were text-based objects in which the learners' roles were categorised as problem solvers, contributors and navigators; and the "multi-media sectioned" RLOs. The vast majority of RLOs (n=58) classified fell into this last grouping. Typically they consisted of a number of sections or pages that were aimed at constructing a microcontext of learning around the particular learning goal. They tended to be media rich and consisted mainly of text (90±2% of RLO covered), audio (81±3%) and images (63±5%). The learners chiefly adopted the roles of recipients of information (61±5%) and active participants (21±3%). A wide range of activities were included, such as MCQ, answer selection, drag and drop, text entry, image selection and image manipulation. The mode scores for the pedagogical attributes of these learning objects are shown in Fig.2. This shows that they tended to make a deep impression in terms of the environment created by the authors and learning technologists, but that the roles played by learner and content author tended to be more limited. However, these values represent a great deal of variation in the pedagogical attributes of the objects, and these differences might provide evidence and exemplars for how these attributes influence patterns of use and reuse.

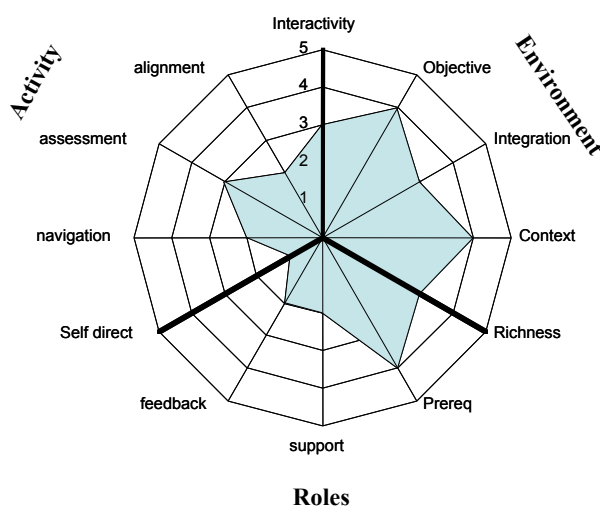


Figure 2. The mode pedagogical attribute scores for the RLO group entitled "multi-media sectioned" RLOs. Attributes are placed under regions of the graph relating to environment, roles and activities, as defined by application of IMS Learning Design principles.

Pedagogical Attributes

The mode score for the *objective* attribute was 4 (n=31). This suggests that the objects generally had a clear and well focused learning goal. However, the range for this attribute from (2 – 5) shows that a fair degree of variability could be seen in the extent to which authors worked to a clearly defined learning goal and the extent to which they chose to make this explicit. Spearman's rank correlation revealed no significant correlation (at the 1% level) with any of the other attributes, other than integration. This suggests that the clarity with which the objective is addressed within the RLO is independent of the other pedagogical decisions made by the author.

The mode score for *media richness* was 3 (n=23). Although examples could be seen at the lower end of the scoring range, most clustered at the top end of the scale, which is indicative of this type of RLO. Spearman's rank correlation revealed significant correlation with other attributes including *integration*, *support*, *interactivity*, *assessment* and *alignment*.

The mode score for *media integration* was 3 (n=34) and again the distribution was skewed to the upper levels of the range. Perhaps, not surprisingly, *integration* was the attribute that showed the greatest degree of correlation with the other attributes, being correlated with *objective*, *context*, *media richness*, *support*, *feedback*, *interactivity*, *assessment* and *alignment* (at the 1%). This suggests that integration is greatly influenced by the range of pedagogical decisions made by the RLO author, and that this is a good indicator of the RLO attributes.

The mode score for *context* was 4 (n=27), showing that the majority of learning objects were context-neutral. This attribute is likely to have a major impact on reusability and therefore it is of interest that this attribute showed a fairly even distribution across the scoring range. Therefore, the degree to which authors chose to contextualise their work varied greatly. Also of significance is that fact that the context attribute showed no significant correlation with any of the other attributes, other than *integration*. This suggests that the extent to which the authors used or avoided contextual references within their RLOs is independent of their other pedagogical choices.

The mode score for *pre-requisite* knowledge was 4 (n=28), showing that the majority of learning objects required little or no pre-requisite knowledge on behalf of the learner. Like *context*, this attribute is likely to have an impact on reusability and once again a complete distribution could be seen across the scoring range. This attribute had no significant correlation with any of the other attributes. This suggests that the pedagogical designs used by authors were not related to the subject-specificity of the objects.

The mode score for the level of *interactivity* within the RLO was 3 (n=30), but the level of *interactivity* present spanned the whole scoring range with a bell-shaped distribution. *Interactivity* was significantly correlated with *integration*, *media richness*, *level of support* *feedback* and *self direction*. Surprisingly it was not correlated with the *assessment* attribute.

The mode score for *navigation* was 2 (n=49). This reflects the linear nature of the vast majority of learning objects in this group. *Navigation* was significantly correlated with the degree of *self direction* within the object. It was also correlated with the degree of *support* the students received within the object.

The mode score for *assessment* within the RLO was 3 (n=20). However, the inclusion and extent of *assessment* varied across the whole scoring range. Some objects contained no *assessment* elements and 4 objects scored 4 on the *assessment* scale. A degree of *alignment* was seen within all objects that contained self *assessment* elements, however the extent of the *alignment* varied equally across the scoring range. This suggests that authors made very different pedagogical decisions about the role of self *assessment* within their learning designs. *Assessment* itself was significantly correlated with the degree of *media integration*, *media richness* and the level of *support*. It was also significantly correlated with *assessment*, *alignment*, suggesting the greater level and embedding of *assessment*, the greater the *assessment alignment* score.

Unlike the attributes that generally fell under the umbrellas of environment and activity, those which were considered to be related to the roles of learners and authors tended to show lower mode scores for this type of RLO (Fig.1). The mode score for level of *support* was 2 (n=41). This partly represents the structure of the learning objects and the degree of decision-making that the learner has to make. This is evidenced by the fact that the level of *support* was correlated with *interactivity*, *self-direction*, *feedback*, *navigation*, *assessment* and *alignment*. It was also correlated with *objective* and *context*. The mode score for *feedback* was also 2. Not surprisingly, this factor was correlated with the level of *interactivity* and the level of

integration. The mode score for the level of *self direction* was 1 (n=34), reflecting the fairly directed nature of the majority of learning objects in this group. This characteristic was significantly correlated with the level of *interactivity* and also the level of *navigation* afforded to the learner. These two characteristics seemed to define the types of *self-direction* included in the objects. *Self direction* also correlated significantly with the level of *support* given within the RLO.

Implications

Therefore the tool allows differentiation of the learning objects based on the pedagogical attributes that they contain. It shows that a great degree of variation within the pedagogical attributes of learning objects can be discerned, suggesting that the learning designs created by individual authors also vary significantly. Some elements of the RLOs analysed were less variable and represented the nature of the RLOs themselves, such as the high level of media richness, media integration and interactivity. Likewise, the lower level of self-direction, feedback and support is related to the nature of the learning design authors have adopted when using this method of interaction with their learners. However, even within the deployment of these attributes there is variation and there is also considerable variation in a number of other key pedagogical attributes such as the level and nature of self-assessment, the degree to which materials are contextualised and the pre-requisite knowledge that learners require to undertake the RLO successfully. These latter two attributes relate to the subject specificity. The variation in the attributes and the patterns of attributes taken as a whole within a learning object (the learning design) should allow us to determine which, if any, of these factors influence reusability. Future analysis will involve the identification of exemplar learning objects for a particular attribute or design and analysis of its patterns of use, evaluation and reuse through the use of tracking data and follow-up investigative techniques. It will also be possible to conduct qualitative studies with the authors of these RLOs to consider the extent to which the pedagogical attributes within their RLOs were explicitly planned.

Analysis of the relationships between the pedagogical attributes may also help us to understand the ways in which authors plan their learning designs. It is of interest that, although many interrelationships could be seen, some attributes that are likely to play an important role in reuse, such as context and pre-requisite knowledge were largely independent, suggesting that authors planned for these factors independently from the other decisions they were taking, whereas others such as integration seemed to be dependent on a whole range of other pedagogical attributes. More detailed statistical analysis, such as components analysis may reveal the extent of these relationships and how each influences pedagogical design and reuse.

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