EVALUATING LEARNING RESOURCES FOR REUSABILITY: THE "DNER & LEARNING OBJECTS" STUDY

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Abstract

The DNER&LO study gathered data about 27 elearning projects, mapping the categories of content being produced, and approaches to reusability and interoperability. Eighteen were chosen for closer study and evaluation, based on availability of content, and on covering a wide range of content categories. Appropriate reusability evaluation criteria were developed specifically for the study, in four areas: aggregation level; reusability; subject specificity; and vertical reusability. Developing the criteria definitions in the light of real, varied content illuminated the present lack of a widely used, authoritative elearning terminology. Although the projects were planned before reusability was a widely promoted goal, they showed high levels of awareness of, and willingness to plan for, reusability and interoperability. The content itself, evaluated according to the criteria, showed good potential for reuse, or for being made reusable. Any gaps between the awareness levels of developers and actual reusability of content supported the idea that planning, and budgeting from the start for the complex process of developing reusable resources is imperative, if the potential of learning technology for sharing resources is to be fulfilled. Gaining support from sources such as the UK's CETIS is one way to ensure available expertise is utilised.

Keywords

learning object, learning resource, information object, information resource, collection, unit of study, module, course, evaluation, criteria, interoperability, reusability, metadata, higher education, United Kingdom, DNER, JISC, standards, specifications, virtual learning environments, content management systems

Introduction

The DNER & Learning Objects (DNER&LO) study was commissioned to ensure that educational content funded by UK higher and further education (HE/FE) funding and strategy body JISC (Joint Information Systems Committee) could made be reusable within content management systems such as virtual learning environments (VLEs). The initial part of the study involved collecting data about, and evaluating, a particular set of JISC-funded content, with regard to reusability and interoperability. In order to do this, DNER&LO first needed appropriate evaluative criteria to apply to the content. Although much work is being done worldwide on interoperability for educational technologies, there was no definitive, externally defined set of evaluative criteria available. The learning technology field is young and evolving at a rate of knots. The meaning and usage of such terms as "learning object", "granule", "unit of study", "reusable" and "interoperable" continue to be the subject of debate. This paper presents the criteria

developed specifically for this particular set of content, and the process by which they were developed. However, it must be emphasised at the start, that this paper, and the DNER&LO project as a whole, are not intended to define terminology or evaluative criteria in any final, authoritative manner. What follows elucidates the DNER&LO's process of defining terms and developing criteria for evaluating and classifying content, in the hope this will be of use to others attempting similar work, whether they be developing or evaluating elearning resources.

Background: The JISC, the DNER & Learning Resources

The UK's DNER (Distributed National Electronic Resource) existed as an entity from the nineties until mid-2002. Funded by the JISC, its remit was to "provide an easily accessible, comprehensive information resource for use by learners, teachers and researchers within the UK higher and further education community." (JISC, 1999a). The collections strand of the DNER was, in the beginning, based on traditional library resource provision, offering information materials such as electronic journals and digital images, and utilising interoperability measures such as the Z39.50 protocol for electronic catalogues, and Dublin Core metadata for description and discovery of digital information resources.

Responding to the increasing prevalence of web based teaching and learning technologies, in 1999 the JISC invited funding proposals to begin developing the DNER for teaching and learning, stating that "[t]he DNER will provide the dissemination vehicle for the delivery of electronic resources including learning and teaching material." (JISC, 1999b). The projects that were funded under this call are collectively known as the 5/99 projects, and came under the newly formed JISC Teaching and Learning Programme. Twenty-seven of these produced content, as opposed to carrying out studies or developing infrastructure or interfaces to information such as subject portals and indexes. The content was wide ranging in educational approach, subject matter, and format, including economics simulations, image, text, and learning object databases, online tutorials based around museum collections, and much more.

As the 5/99 projects got under way, developments in the delivery of online teaching and learning continued apace. The concept of sharing and reusing elearning content came to the fore, bringing with it the idea of granular learning objects, and standards and specifications specifically for supporting the interoperability of teaching and learning materials and technologies. It was becoming clear that in order to maximise the usefulness of DNER content, it needed to be made accessible to, and interoperable within, content management systems. In 2001, the JISC funded DNER&LO (a collaboration between the University of Hull, the University of Strathclyde, and Newark and Sherwood College) under the Teaching and Learning Programme to carry out the necessary groundwork for meeting this objective.

When DNER&LO began in January 2002, the DNER itself was undergoing a radical restructuring as the new JISC Information Environment (JISC, 2002a) was brought into being. By June 2002, the JISC (2002c) stated that the DNER no longer existed as an administrative entity, and that its remits were to be distributed amongst the relevant JISC programmes. JISC funded projects for developing infrastructure and content, past and present, are now referred to as JISC development projects, rather than the DNER.

Introduction to DNER&LO: Aims and Outputs

The aim of DNER&LO was to ensure that content currently under development, particularly within the 5/99 projects, would be usable and reusable within elearning across UK HE/FE. Of the six major project outputs designed to meet this aim, the first two were concerned with examining the 5/99 projects' content, mapping content types, and identifying issues pertaining to the use of this content as reusable, interoperable learning objects. This paper presents the results of this part of DNER&LO's work.

Methodology

Once the 27 content-producing 5/99 projects were identified, the part of DNER&LO presented here consisted of four main strands:

1. Examining and gathering data on the relevant content.
2. Developing the criteria with which to evaluate this content.

3. Evaluating the content according to these criteria.
4. Collating and analysing the data and evaluations.

These strands were worked through in several iterations, as each informed the others. A criterion for evaluation which seemed appropriate in theory, often needed to be adjusted to make sense when applied to the actual content. Once it had been revised, the entire list of content had to be re-evaluated according to the new criterion. As part of this process, it sometimes became clear that some other facet of information about the content needed to be sought and recorded. Inconsistencies also showed up in collating and analysing the data.

Gathering the data

An initial listing of content types was drawn up using publicly available information about the projects. These were organised into categories and sub-categories. There was a range of vague, undefined terminology used by the projects themselves for these categories, e.g.: teaching and learning package; learning and teaching unit; module; learning resource. As aggregation levels were defined, they were used as the top-level content categories (see below under 5.2.1 Granularity and Aggregation Level), with content sub-categories beneath them, e.g. “digital images” or “case studies”.

An informal survey of all 27 projects was then carried out. Because of the wide variance in content type and stage of development among the projects (many were not completed, and some had barely started), individual emails were sent to each, based around a format which included questions about what approach had been or was being taken to issues of interoperability, metadata, reusability and teaching & learning applications such as VLEs. Projects that did not have content publicly available were asked if DNER&LO could examine any content in development. Finally, specific questions with regard to the particular project’s content were asked. Of the 27 projects, one was not emailed; its content was minimal, completed and simple enough not to need further investigation. Of the remaining 26, two did not respond.

Developing the evaluation criteria

Input was sought on various difficulties encountered here from the wider HE/FE community, via the CETIS Educational Content Special Interest Group discussion list. Evaluation criteria were developed for the following content attributes relating to reusability:

1. Granularity and aggregation level.
2. Reusability.
3. Subject specificity.
4. Horizontal / Vertical reusability.

Information on actual and planned use of metadata was also gathered.

Initially, interoperability was to be one of the criteria. IEEE defines interoperability as: “The ability of two or more systems or components to exchange information and to use the information that has been exchanged.” (IEEE, 1990). This means that interoperability is not a property of a resource; rather it is a property of the relationship between systems in a particular context. It is impossible to evaluate the ‘interoperability’ of content. However, Campbell and Currier (2002: p.5) noted that, by evaluating and recording the factors outlined in the evaluation criteria it should be possible to gauge a resource’s potential to interoperate with elearning systems.

Evaluating the content

Eighteen of the 27 content producing projects were selected to be looked at in more detail, and to have their content evaluated according to the criteria. The 18 were selected on the basis that they would be able to provide content (including content in development) for use in DNER&LO Output 5: Exemplars/prototypes demonstrating the surfacing of DNER content in VLEs. A secondary consideration was that overall they cover a wide range of content sub-categories. For example, HOTBED was included, because it was the only project developing digital sound content, in spite of the possibility that no actual content would be available before the end of DNER&LO.

Collating and analysing the data

The data gathered and evaluations carried out were summarised in two spreadsheets, and analysed.

Findings

The 5/99 projects: an informal picture of their approach to interoperability

This section presents a general overview of the findings of the informal survey of all 27 5/99 projects.

Metadata issues
Under section '2.6 Cataloguing and Metadata Standards', the 'DNER Standards & Guidelines to Build a National Resource' (Grout & Ingram, 2001) states:

> "Projects MUST EITHER use the Dublin Core as a basis for their metadata standard OR provide a mapping to Dublin Core metadata which explains the relationship between the metadata standards they are using and the Dublin Core."

Additionally, under section '2.5.7 Capture Standards: Learning Materials', it states:

> "Projects MUST be aware of the following and implement where viable;
> * The IMS Meta-data specification to describe learning materials."

Projects working within certain areas were also required to adhere to standards and specifications relevant to their area, e.g. VADS (Visual Arts Data Service) guidelines for visual images in the arts, and MDA guidelines for museum resources. It should be noted, however, that the first draft of this DNER guideline document appeared in February 2001, well after many of the 5/99 projects had begun. Therefore, some projects would not have initially planned or budgeted for these activities. This is apparent in the wide range in levels of understanding, and stages of planning, evinced amongst the projects in this initial survey. However, this range is also reflected in the varied priorities among the projects, e.g. HOTBED, which prioritised support for performance-based study, and, as such, had not considered networked use.

Of the 27 projects, 14 (52%) mentioned Dublin Core; nine (33%) that they were hoping or intending to implement IMS Meta-data; and seven (26%) stated that they were planning to use metadata but gave no details. There is some overlap between the first two categories; it is plain, however, that most projects had taken on board the need for applying metadata to their resources. In order to find out exactly how this was panning out in reality, DNER&LO later recorded actual implementation of metadata, and planned implementation, for the 18 projects examined in detail:

Metadata	No. of projects	%
DC used	7	39
DC planned	5	28
IMS Meta-data/IEEE LOM used	0	0
IMS Meta-data/IEEE LOM planned	7	39
No metadata used/planned	1	6

Table 1: Metadata Standards and Specifications Planned and Used by Projects

Only 39% (seven) of projects had actually implemented Dublin Core at the time of the study, which took place two years after the projects were funded. In most cases, it was clear from responses that lack of resources rather than lack of willingness was the problem. The total number of projects intending to implement IMS Meta-data in some form was 33% of all projects, and 39% of the 18 looked at closely. Of the latter, one is planning to use IMS only, and provide a mapping to Dublin Core. Of the remaining six, five are projects that have already implemented Dublin Core, pointing perhaps to a level of understanding and expertise developed within those projects that had worked through the initial issues involved.

Reusability, granularity, aggregation levels
There was a spectrum of approaches also to reusability with regard to breaking resources down into smaller units. This spectrum, at one end, was exemplified by the INHALE project, which was developing an object database from its modules, so that users can repackage them or their constituent parts, edit these, and upload the changed objects back to the database for others to use. At the other end of the spectrum was the Biota of Early Terrestrial Ecosystems: The Rhynie Chert, which was developed to be used as one web-based package. It had one of the wider ranges of aggregation levels, ranging from *Course* down through *Modules* (sections) to *Learning Objects* and *Information Objects*, but had not considered how these might be individually reused. Two projects also developing complex, tutorial-style resources specifically stated that they did not want people "dropping in" to their resource below a certain level, and so had not provided metadata, nor designed their resources, to make this possible. Three projects produced non-reusable resources (see also below under 5.2.2 Reusability), due to their specific objectives, i.e. they produced resources designed around a specific online resource, service, or server. However, two of them hoped to develop reusable and interoperable resources in addition to their core output. The majority of projects were between these extremes, showing at least a willingness to consider the reusability of their resources. It would, however, have taken more time, money and expertise than was currently available to make this happen.

Reuse in VLEs
Thirteen of the 27 projects stated that their content is reusable within a VLE, or that they are working towards this end. Five specifically stated that this was not a goal, that their materials were developed for use only "as is". The remaining projects didn't answer the question. It seemed that a small number of them didn't understand it, which begs the question as to whether the others avoided it for that reason.

Conclusions from the survey
A good number of the 5/99 projects developed, or were hoping to develop, their content to make it reusable and interoperable. The major factor holding them back was the lack of awareness of the relevant issues at the time their project was funded. The contact from one project which was still in the planning stages, said that, although they have decided to implement four IEEE Learning Object Metadata (LOM) fields (equivalent to IMS Learning Resource Meta-data) in addition to their DC-based schema, they have found that their academic authors describe the LOM vocabularies as "useless", and they feel that they are being forced to use meaningless terms in the hope of a utopian future. And yet, they added, what other way forward is there, than to continue with working it out as we go along? Many of the project contacts were enthusiastic about the work of DNER&LO, as they wanted guidance and information in this area.

The evaluation criteria

Granularity and Aggregation Level
Granularity and aggregation level refer to the concepts, components and activities that make up resources and the way that these resources are combined. The IEEE LTSC (2002) defines aggregation level as the functional granularity of a learning object. Although granular resources do not necessarily have to be small in terms of file size, highly granular resources tend to be relatively small, discrete and focused on a single or simple concept. These granular resources, such as information objects or learning objects, can be combined, or aggregated, with other objects to form new resources such as units of study or information resources. IEEE LOM distinguishes four levels of aggregation:

1. The smallest level of aggregation, e.g. raw media data or fragments.
2. A collection of level 1 learning objects, e.g. a lesson.
3. A collection of level 2 learning objects, e.g. a course
4. The largest level of granularity, e.g. a set of courses that lead to a certificate.

For the purposes of DNER&LO, the LOM classification has be expanded to include the following categories. The study defined an aggregation as one or more, rather than more than one, except in the case of *Collection*.

Aggregation Level	Definition
Information Object.	A simple object that does not have a specific educational objective and is not situated within an educational scenario, e.g. an image, text file or reference.
Information Resource.	An aggregation of information objects, which does not have a specific educational objective, and which is presented as a cohesive unit e.g. an online encyclopaedia, e-book or e-journal.
Learning Object.	An object that demonstrates, or focuses on, a specific educational concept, e.g. a learning activity task or assessment.
Unit of study.	An aggregation of learning objects and information objects, also referred to as a lesson.
Module.	An aggregation of lessons and learning objects.
Course.	A large aggregation of lessons, modules and other related resources.
Collection.	An aggregation of two or more of any of the above types of resources, which does not have a specific educational objective overall, and which is not presented as a cohesive unit, but rather is tied together via a search or browse mechanism such as a catalogue or search engine e.g. a collection of digitised slides, a database of learning objects.

Table 2: DNER&LO Evaluation Criteria: Granularity & Aggregation Level

These aggregation levels may be split between those which are specifically oriented towards teaching and learning (*Learning Object*; *Unit of Study*; *Module*; *Course*) and those that are simply presenting information (*Information Object*; *Information Resource*; *Collection*). However, *Collection* includes collections of teaching & learning resources, while teaching and learning resources generally consist in part of information presenting resources. Only three projects (17%) produced solely information type aggregations. One of these was interested in investigating the use of its *Collection* of digital sound recordings in teaching and learning, but in a performance-based context, and as such, did not aim to produce any digital teaching and learning materials. The second provided a databank of digitised texts and intended the teaching and learning context to be provided by the end user. However, the third was a good example of the type of issue that arose in defining aggregation levels and content types: it had a stated aim of producing six teaching and learning "modules", The module examined, however, was given the aggregation level classification *Information Resource*, as it included no actual teaching and learning concepts or objectives, and was more in the nature of an online encyclopaedia. In fact, both *Information Resource* and *Collection* were added to the aggregation level list further into the evaluation process, as it became clear that, for the 5/99 projects, the teaching and learning aggregation levels weren't sufficient to define all the content types.

Of the nine content-producing 5/99 projects that weren't examined closely in this study, only one mentioned no plans for developing teaching and learning resources. Taken at face value this means that a total of 23 out of 27 projects (85%) were attempting to produce teaching and learning resources, rather than solely information based materials. The 5/99 projects, in this sense, represent a success for the JISC Teaching & Learning Programme in shifting the library-based emphasis of JISC collections.

Reusability

In defining a resource's level of reusability several factors need to be considered:

1. Technical format. Is a resource tied to a single delivery platform or technology?
2. Contextual dependency. Does the content of the resource reference other related, but external, resources? E.g. a resource may refer to a glossary or to the next module in a sequence.
3. Technical dependency. Is the delivery of the content technically dependent on other resources? E.g. HTML pages that are linked in a linear navigation sequence, interactive content that relies on server side scripts, Java applets with class files residing on remote servers.

For the purposes of DNER&LO, a resource's reusability was classified as follows:

Reusability	Definition
Reusable.	Can be delivered via a wide variety of platforms or technologies, do not reference related external content and are not technically dependent on other external resources e.g. LifeSign's video streams.
Somewhat Reusable.	May be restricted to a single delivery technology but which are still relatively reusable due to the ubiquitous nature of that technology e.g. HERON's digitised texts, which are PDF files.
Potentially Reusable.	Have the potential to be made reusable, i.e. they are delivered in a standard format, e.g. HTML, but are dependent on related resources e.g. the individual sections within 'The Biota of Early Terrestrial Ecosystems: The Rhynie Chert: A Teaching and Learning Resource'. These sections all contain links to other sections within the resource, including the glossary and bibliography.
Not Reusable.	Resources that are restricted to a specific delivery platform or technology, and/or are highly dependent on related resources e.g. Virtual Learning Arcade's simulations, which run on a specific server.

Table 3: DNER&LO Evaluation Criteria: Reusability

This was a difficult set of criteria to evaluate resources by, due to the complexity of factors involved in determining reusability. It caused the most discussion regarding defining and applying the classifications. More so than any of the other evaluation criteria, reusability was developed in an iterative fashion, as each sweep through examining the projects' content caused more food for thought in defining the somewhat fuzzy boundaries between the classifications.

To begin with, the highest level of *Reusability* was defined such that it was virtually impossible for any content being produced at present to fulfil, particularly within the 5/99 projects. It was decided that the most useful approach was to delineate between those projects that were producing reusable content via ubiquitous technologies, and those that were actively attempting to make their content platform/technology independent. The most highly reusable resources were developed by LifeSign, as it was their remit to make video-streaming as accessible and reusable, pedagogically as well as technically, as possible, and INHALE, for whom reusability, interoperability, and facilitating resource sharing were core aims of the project. The other two projects with resources classified *Reusable* only included a small number of auxiliary content at this level, their major output being a mix of the other three classifications. In fact, the largest cluster of projects were those that included some combination of *Potentially* and *Somewhat Reusable* resources (61%).

Subject specificity (Horizontal reusability)
Subject specificity was evaluated in order to determine to what extent 5/99 projects were allowing for horizontal reusability, which equates to *Generic* or *Interdisciplinary* subject specificity.
In defining subject specificity, no distinction was drawn between subject and discipline. For the purposes of DNER&LO, a resource's subject specificity was classified as follows:

Subject specificity	Definition
Generic.	Can be used for teaching and learning in any subject field or discipline e.g. Bristol BioMed's How-To Guide 'Putting videoed lectures on the Web'.
Interdisciplinary.	Applicable to teaching and learning in more than one discipline or subject e.g. 'The Biota of Early Terrestrial Ecosystems: The Rhynie Chert: A Teaching and Learning Resource', which was designed to for Honours Geology students but may be used in earth or life sciences, e.g. botany, zoology, geology, paleo-sciences, and archaeology.
Subject Specific.	Designed only for use within a specific subject or discipline e.g. the RDN Virtual Training Suite Tutorials, each of which supports a particular subject area or discipline.
Resource Specific.	Designed only for use with a specific resource e.g. FirePower: Learning & Teaching Materials for BeilStein CrossFire.

Table 4: DNER&LO Evaluation Criteria: Subject Specificity

This criterion was fairly easy to evaluate by, although it did involve some problems with determining the boundary between the truly *Generic* and the *Interdisciplinary*. In the end, *Generic* was always applied to those resources that directly related to teaching and learning (usually elearning), although it could be argued that they are subject specific to education. It was their usability by someone teaching in any discipline that made them *Generic*. In contrast, some *Interdisciplinary* resources were capable of covering quite a wide range of subject areas, while some were restricted to a few. In total, 15 (85%) of projects included at least some *Generic* or *Interdisciplinary* resources. Only three (17%) produced solely *Resource* or *Subject Specific* resources.

Vertical reusability
Vertical reusability refers to resources that may be used at more than one educational level. For the purposes of DNER&LO, a resource's vertical reusability was classified as follows:

Vertical Reusability	Definition
No.	Only appropriate for use at a single specific level of study.
Potential.	Not necessarily developed with vertical reusability in mind, but that may be used at different levels of study.
Yes.	Includes specific support for use at different levels of study e.g. Digital Egypt for Universities, which includes 'Guided Tours' aimed at different levels of understanding, including absolute beginners.

Table 5: DNER&LO Evaluation Criteria: Vertical Reusability

This was a relatively simple criterion to evaluate resources by. It involved determining whether or not a resource had been developed with explicit support for reuse at more than one level of education, or whether it had been developed explicitly for a particular level. Everything else was deemed to have *Potential* for vertical reuse. Only two projects included content that had *No* vertical reusability, and both of these included some resources with *Potential Reusability*. Fifty percent (nine) of the projects included some content that actively supported vertical reusability, one third of which were completely devoted to *Yes* defined content. In total, 85% (15) included some combination of *Potential* and *Yes*.

Conclusions

Considering that the 5/99 projects did not have the benefit of Grout & Ingram's (2001) guidelines for DNER projects at the time of planning, they show an encouraging degree of awareness and willingness around reusability of their resources: a total of 73% of the 18 closely examined projects were actively using or planning to use relevant metadata; about half were actively considering VLE reuse (and only about a fifth had excluded this possibility); 67% had content that was already reusable to some degree, or potentially reusable (and the 17% that produced non-reusable resources were meeting specific objectives in doing so); while 85% were producing some degree of (actual or potential) horizontally or vertically reusable content. There is much to build on. The JISC (2002b) has recently funded a new development programme, the X4L projects, specifically looking at reuse of elearning content, some of which are further developing 5/99 work.

In terms of developing reusable content, the major factor for success that this part of DNER&LO appears to highlight is the need for planning at the start of an elearning initiative for the considerable amount of effort and expertise that must go into creating truly reusable content. Defining the characteristics of the particular type of content being produced, and the consequent factors for reusability is a must and is becoming easier as more resources for supporting this become available. The process is bound to be evolutionary throughout a project's lifetime, as the resources themselves evolve, and as technology develops. The DNER&LO website (http://www.strath.ac.uk/Departments/CAP/dnerlo/index.html) is one place to watch as information on further project outputs will be announced there. The CETIS (Centre for Educational Technology Interoperability Standards) Special Interest Groups are another source of information, support and expertise regarding interoperability for learning technologies (http://www.cetis.ac.uk/). It is more possible than ever now for elearning developers to go some way

toward fulfilling the potential for learning technologies to enhance sharing, repurposing and reuse of their valuable teaching and learning resources.

Projects Mentioned in this Paper

Here is an alphabetical list of the 5/99 projects mentioned in this paper, with URLs:

- The Biota of Early Terrestrial Ecosystems: The Rhynie Chert. http://www.abdn.ac.uk/%7Egmi265/profiles/rhynie/index.htm [24th September 2002].
- Bristol BioMed Learning & Teaching. http://www.brisbio.ac.uk/bblt/ [24th September 2002].
- Digital Egypt for Universities. http://www.petrie.ucl.ac.uk/digital_egypt/Welcome.html [24th September 2002].
- FirePower. http://firepower.mimas.ac.uk/ [24th September 2002].
- HERON (Higher Education Resources On Demand). http://www.heron.ac.uk/ [24th September 2002].
- HOTBED (Handing On Tradition By Electronic Dissemination). http://www.hotbed.ac.uk/ [24th September 2002].
- INHALE (Information for Nursing And Health in a Learning Environment). http://inhale.hud.ac.uk/ [24th September 2002].
- LifeSign: Networked Moving Images for the Life Sciences. http://www.lifesign.ac.uk/ [24th September 2002].
- RDN Virtual Training Suite. http://www.vts.rdn.ac.uk/ [24th September 2002].
- Virtual Learning Arcade. http://www.bized.ac.uk/virtual/vla/ [24th September 2002].

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Acknowledgements

The authors would like to thank the CETIS Educational Content Special Interest Group for their assistance in developing the DNER&LO evaluation criteria. Many thanks also to the JISC, the University of Strathclyde's Computer and Information Sciences Dept. and CETIS for enabling this paper to be presented so far from home.